An exploration of the use of Community Based Participatory Action Research to create an innovative platform for engaging A level Biology teachers' in Biotechnology within the Biology curriculum in Zimbabwe

By

Elias Rurinda

213574317

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 A. Singh-Pillay**

December 2018

Abstract

This thesis presents community based participatory action research on the effectiveness of a professional development intervention (PDI) designed to engage high school biology teachers with biotechnology content and associated pedagogical knowledge. Recognizing the benefits that biotechnology has to offer in the Zimbabwean context the Zimbabwean government has called for increased public awareness of and engagement with biotechnology issues. Biology teachers should be ideally positioned to increase public awareness and engagement with biotechnology issues with the introduction of a biotechnology elective in the Advanced level biology curriculum. However, the poor uptake of the option at schools and the poor performance of learners in the biotechnology option provide motivation for this study.

This study explored the creation of a professional development intervention (PDI) platform in biotechnology education in Masvingo, Zimbabwe and reports on teachers' experiences of their engagement in the PDI. This qualitative study employed a case study design. Purposive sampling selected 25 practicing Advanced level biology teachers from schools in Masvingo. Data were generated via teachers' reflective journals, observations and focus group discussions. Vygotsky's zone of proximal development and Rogan and Grayson's theory of curriculum implementation underpinned the study at a theoretical level.

The findings reveal that professional learning communities can be an effective form of professional development for teachers during curriculum reform especially where there is little official support for teachers during the changes. The findings show that some teachers had no capacity to innovate, so a level zero was included in the Rogan and Grayson framework. A crucial aspect during curriculum implementation was found to be teacher well-being; without it there is no ability to innovate. Thus the Rogan and Grayson theory was extended to include teacher well-being, as a dimension for both the profile of implementation and capacity to innovate. In addition, biology teachers needed a psychologically and socially safe space in which they could share and reflect on their own teaching practice and gain support from peers. This resulted enhanced their confidence and pedagogical content knowledge. The findings show that sustainable teachers' professional development will rely on teachers' well-being and their commitment to quality teaching and their learners' well-being.

Keywords: Biotechnology, teachers, professional development, participatory action research, pedagogical content knowledge

Declaration

I, Elias Rurinda 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 writers. 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.

Signed: Date: 12/02/2019

As the candidate's supervisor, I, Dr Asheena Singh-Pillay, agree to the submission of this thesis.

Signed: __Date: 15/02/2019_________________

Acknowledgements

Numerous people and institutions had helped in this study:

- My special appreciation goes to my supervisor Dr. Asheena Singh-Pillay for her professional supervision throughout my doctorial journey. Her expert advice, guidance, constructive criticism and her encouragement made it possible for the completion of this thesis .I would always remember her and I quote "*Elias, I know you can do it work , work ,work*". Thank you doctor; you are a true mentor.
- Zimbabwe Ministry of Primary and Secondary Education for allowing me to create the PDI platform with the A level biology teachers in Masvingo province, observe lessons during the implementation phases of our professional activities and interview their teachers.
- Great Zimbabwe University and colleagues for financial support both during the data analysis phase, and for my visits to UKZN for consultation with my supervisor.
- Colleagues in the Department of Curriculum Studies, the Environmental Science section; Dr. D. Mashoko, D.T. Tshuma and J. Risiro for encouraging me to remain focused on my studies.
- Dr. J.P. Mukaro for advice, editing my thesis during this journey and continuous support and encouragement.
- Mr Chirikure for providing and driving me throughout the Masvingo province during the data collection phase and video recording of data during interviews.
- I also wish to relay many thanks to my family, especially my wife **Chiedza Rurinda** and our four children for their encouragement and support. Their tolerance and the sacrifices they made even when I was needed most, make me proud of them.
- My young brother Dr. Jairos Rurinda who would constantly remind me to work and support me morally and financially in this doctoral journey
- 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

To my loving wife CHIEDZA, and our four children BLESSING, BEVY, BELINDA V and BENALDO. It is my hope and belief that this thesis will inspire you to be committed, to persevere and achieve your goals.

AND

To my late father I say:

Muzivigwa, Netombo, Cherechere, Zivawako: Rest in eternal peace, we are proud of the legacy which you left us**.**

To my late mother who succumbed to breast cancer when I had embarked on this doctoral journey I say:

VaChivi, makarwa kurwa kwakanaka. You were a hard working determined and submissive mother who brought us up in Christian values. Your teachings and encouragement will always remain fresh in our minds years after your departure, your vision and the fear of God.

TABLE OF CONTENTS

List of figures

List of tables

List of Appendices

CHAPTER 1

INTRODUCTION

1.1 Introduction

This study was undertaken in the Masvingo province, Zimbabwe. A community based participatory action research (CBPAR) approach was used to create an innovative platform through which Advanced level (A level) biology teachers could be engaged in a professional development intervention programme to address biotechnology issues in the A level biology (9190) curriculum. This introductory chapter will describe the Zimbabwean context that gave rise to the study and justified the intervention. The research questions, aims and objectives are presented, the rationale and motivation for the study indicate why the study was attempted and the significance of the study is discussed.

1.2 Background to study and context

After gaining independence in 1980, Zimbabwe introduced many reforms in the education sector. The impetus for curriculum transformation was underpinned by both socio-economic and political imperatives (Zembere, 2018).

The first major educational reform was the unification of the separate education systems that had been in place prior to 1980, in order to remove anomalies and inequalities and make education accessible to all citizens. The unification led to the creation of the Zimbabwe School Examination Council (ZIMSEC) to administer and manage all primary and secondary education examinations in the country. The education system, in Zimbabwe, comprises early childhood education (0-6 years), primary education (7-12 years) and secondary education (12–18 years). The secondary education sector is made up of three phases; namely, Junior Certificate (Forms 1 and 2), Ordinary level (O level) which includes Forms 3 and 4 and Advanced levels (A- levels) which includes Forms 5 and 6. The A level science subjects currently offered in Zimbabwe include biology, chemistry, physics, mathematics and further mathematics.

The second reform, established by the Ministry of Primary and Secondary Education, was the formation of the central Curriculum Development Unit (CDU). The CDU coordinates the instructional review teams, which are responsible for the designing of curricula or syllabi, monitoring of curriculum implementation and cascading teachers' professional development for curriculum implementation (Ndawi and Maravanyika 2011). Put simply, this means that the CDU has dual responsibility of teachers' professional development and curriculum reform.

The second reform was also guided by the government's response to the impetus from the African Union to establish the Scientific Industrial Research Development Council and so put in place the Zimbabwe policy framework on biotechnology. The African Union sees biotechnology as a conduit for new advanced products and services in medical, agricultural, environmental fields in all Southern African countries (Gastrow, Roberts, Reddy and Ismail, 2016). Aligned with the African Union's vision for biotechnology, Section 13 of the Zimbabwe Science and Technology policy perceives biotechnology as a tool with enormous potential for providing new products and services in human health, and crop and livestock production (Buykgungor & Gruel, 2009). Biotechnology is thus seen as the panacea for food insecurity and improved environmental management in Zimbabwe, as it provides potential solutions to many of the economic, social, and environmental problems confronting Zimbabwe (Parawira, 2008). According to Dawson (2007), biotechnology processes have impacted personal lives and society at large, particularly in areas of sanitation, agriculture, food industry and medicine. Recognizing the potential benefits of biotechnology, the Zimbabwean policy framework for biotechnology (2006) has called for increased public awareness of and engagement with biotechnology issues. This means that teachers, students, and citizens at large need to be bio-tech savvy. Thus, the biotechnology policy framework calls for a platform through which the public can be engaged regarding biotechnology and bio-safety issues.

In carrying out its duty of transforming the Zimbabwean curriculum, the CDU replaced the advanced level Cambridge biology curriculum, which had been in place prior 1980, with a local advanced level biology curriculum (9190) in 2002. The Zimbabwean A level biology curriculum comprises 13 compulsory topics, which must be studied by all candidates and four elective options; namely, biotechnology, application of genetics, human health and diseases and applied plant and animal sciences. Candidates must select one option from the four electives offered to form the final component of the A level curriculum. Each elective option carries a weighting of 25 % of the overall marks in the A level biology examination. Biotechnology is also included in the compulsory 13 topics under genetic control and genetic engineering. The new A level biology curriculum is viewed as leverage for both increased public awareness of biotechnology, enhancing the number of student who pursue biotechnology studies at undergraduate or postgraduate level in Zimbabwean universities, thereby increasing biotechnology research in the Zimbabwean context. In the context of curriculum reform, the teacher is a key figure in the reform process and in its implementation (Ismail, 2017). Thus the CDU underscores the importance of the role of the A level biology teacher in the process of teaching and learning about biotechnology (Alsubaie 2016). In other words, the responsibility for creating awareness about and engagement with biotechnology for the public (that is students, parents and the community) lies largely with teachers of A level biology. Therefore, the means by which A level biology teachers achieve the goal of teaching learners about biotechnology is important. Given the emphasis of the role of A level biology teachers in the creation of public awareness about biotechnology, this study is located within the context of the biotechnology option.

The content of the biotechnology option includes the following five aspects: the scope of biotechnology; food biotechnology; medical biotechnology; agricultural biotechnology and industrial and environmental biotechnology. An outline of the biotechnology elective is depicted in table one below:

Table 1.1 Learning content of the new Biotechnology option topics in the Advanced level Biology Curriculum (9190)

Topic	Contents summary
1. The scope of Biotechnology	Term biotechnology, old and new biotechnology Techniques: synthesis of one therapeutic product. Government regulations on ethical issues arising from the development of biotechnology.
2. Food Biotechnology	Use of various microorganisms in food products. Cottage food biotechnology Application of biotechnology in the food industry Transgenic plants and animals for the food industry.
3.Medical Biotechnology	Antibiotics Antibodies Production of therapeutic products Molecular diagnostics and gene probes gene therapy
4.Agricultural Biotechnology	Gene bank, soil-less culture, use of microorganisms and chemicals for yield improvement. Tissue culture, Genetic engineering and transgenic plants and animals. Pest-resistant crop plants.
5.Industrial and Environmental Biotechnology	Water pollution: sewage and industrial waste disposal Biodegradation of Xenobiotic components, composting.

As mentioned earlier the CDU has the dual responsibility of teachers' professional development and curriculum reform. Furthermore, it is envisaged that curriculum implementation will be congruent to the goals and visions of the curriculum and the CDU. However, it is worth noting that while the CDU focuses on policy reform and policy formulation, research by Delport and Dhlomo (2010) has shown that it neglects its duties in terms of teachers' professional development for curriculum implementation. Studies by Mangwaya, Blignaut and Pillay (2016) and Mpofu and de Jager, (2018) both highlight that in Zimbabwe it is often taken as given that teachers will continually adapt to the changing curriculum terrain and its policies without support. In other words, there is a disjuncture between policy reform and teachers' continuing professional development, as is needed for CDU policy implementation. In light of the above point, it is significant to note that literature is replete with studies indicating that the success or failure of any curriculum reform hinges on teachers preparedness for implementation (Bantwani, 2010; Singh-Pillay & Alant, 2015, Wilson & Berne, 1999). Concurring with the aforementioned studies, Samuel (2014) elaborates that during curriculum reform teachers are not only confronted by new content, they also need to become skilled in innovative and effective ways of delivering the new curriculum content. In other words, teachers need to understand the new subject matter knowledge as well be skilled in the corresponding pedagogical knowledge needed to implement the reformed or new curriculum. Hence, teachers' readiness to implement a curriculum is critical in determining whether curriculum delivery will be successful and if its intended goals are achievable. Any curriculum reform demands new learning by teachers, but in the absence of support and guidance, implementation of the reform or curriculum change becomes challenging (Bantwani, 2010; Singh-Pillay & Alant, 2015; Wilson & Berne, 1999). Teachers need opportunities for professional development that will enhance their competency in subject matter knowledge as well as instructional methods, especially for rapidly evolving and continually changing subjects like the sciences (Liakopoulou, 2011; Alshehry, 2018).

The interconnectedness (or lack thereof) between curriculum reform and teachers' professional development for curriculum implementation is highlighted by the poor uptake of the biotechnology option by schools in Masvingo. According to the Ministry of Primary and Secondary Education (MoPSE), of the 399 registered high schools in Masvingo only 25 offer A level biology. Of these 25 schools, only four offer the biotechnology option (MoPSE, 2015). This means that only 10% of the schools offer biotechnology and 374 schools do not even offer biology at A level. The intimate relationship between teacher preparedness for curriculum implementation and student performance in the biotechnology option is exposed by Zimbabwe School Examination Council reports on the terminal examination over several years (ZIMSEC, 2005, 2010, 2013). These ZIMSEC reports highlight the repeated dismal performance and ill-preparedness of A level students who opted to pursue the biotechnology option in the examination. According to these reports, students do not attempt to answer many questions, have a poor understanding of terminology, and cannot apply theory to local contextual issues (ZIMSEC, 2013). The poor performance of students in the biotechnology option at the final examinations has an impact on the registrations of students for university biotechnology programmes and has resulted in their near collapse in Zimbabwe. The collapse of the biotechnology programmes is attributed to poor student uptake as well as students' poor foundational knowledge in biotechnology, lack of human resource and infrastructure at the universities (Parawira and Khoza, 2009). Couched differently, these factors show clearly that the espoused vision of the government to create public awareness of and engagement in biotechnology by introducing biotechnology into the A level biology curriculum (9190) has failed. These factors have continued for the past 16 years and have contributed to the near demise of A level biology in Zimbabwean schools. Furthermore there are few reports in the literature on studies concerning teachers' professional development for the A level biology curriculum implementation within the Zimbabwean context.

The dilemma of curriculum implementations depending on teachers' professional development in biotechnology, the poor uptake of the biotechnology options and learners poor performance in the biotechnology option raises the following question: what explicit action is needed to capacitate A level biology teachers' subject matter knowledge and pedagogical knowledge in order to attract students to pursue the biotechnology option, improve learner performance and public awareness of and engagement with biotechnology? In an effort to address the dilemma this study explores the creation of a professional development intervention (PDI) platform using community based participatory action research (CBPAR) to assist A level biology teachers with relevant subject matter knowledge and pedagogical knowledge needed for the implementation of the biotechnology option in the Advanced level biology curriculum (9190) in Masvingo, Zimbabwe.

1.3 The purpose and objectives of this study

The purpose of the study was to initiate and establish a professional development intervention (PDI) platform for A level biology teachers with regard to the biotechnology option by engaging in community based participatory action research (CBPAR). It is envisaged that through the PDI, teaching and learning materials could be developed to support the teaching of the biotechnology option, thereby increasing the uptake of the biotechnology option at schools in the province and, ultimately, increasing public awareness of and engagement in biotechnology.

Thus, the above main objective of this project is to create a platform for a professional development intervention program to engage A level biology teachers with the content and pedagogy needed to implement the biotechnology option in the A level biology curriculum. The main objective was broken down into aims given as sub-objectives listed below:

1.1. To find out A level biology teachers' professional development needs in terms of the biotechnology option.
1.2. Explore how A level biology teachers experience the teaching and learning of biotechnology through the professional development intervention platform created using community based participatory action research.
1.3. Ascertain if engaging in the biotechnology professional development intervention altered teachers' implementation of the biotechnology option in their classes.

1.4 Research questions

The main research question informing this study is:

How can a platform be created for a professional development intervention programme to engage A level biology teachers with regard to the necessary content and pedagogy to implement the biotechnology option in the A level biology curriculum?

The sub-research questions are:

1.1. What are A level biology teachers' professional development needs in terms of the biotechnology option?
1.2. How do A level biology teachers experience the teaching and learning of biotechnology in the professional development intervention platform created using community based participatory action research?

1.3. Has engaging with the biotechnology professional development intervention altered their implementation of the biotechnology option in their classes? This leads to two further sub-sub-questions:

1.3.1. If so, how

1.3.2. If not, why

1.5 Rationale for the study

The repeated poor results of students in the biotechnology option for a level biology reported in the Zimbabwean School Examination Council Report (ZIMSEC, 2005, 2013) as well as the poor uptake of A level biology in schools in Masvingo over the past 16 years has aroused a deep curiosity within me. I am curious about the nature of the teaching within the option, how student learning can be supported and how to create real awareness of and engagement with biotechnology. Prior to my appointment as a lecturer at Denge University (pseudonym) 12 years ago, I was a resource teacher in Masvingo. In my role as a resource teacher, it was my responsibility to develop teaching resources (materials) for biology teachers. I also trained teachers on how to use the resources provided. However, the resource unit collapsed due to lack of funds which hindered the availability of teaching resources as well as the teaching of A level biology. Hence, A level biology teachers in Masvingo no longer have access to support in terms of professional development or teaching resources and material. Consequently, A level biology teachers have had to become self-reliant and self-efficient and develop their own materials for teaching.

I am, furthermore, an avid supporter of the inclusion of biotechnology in the A level biology curriculum (9190), due to my own qualification in biotechnology. I see including biotechnology in the A level biology curriculum as an opportunity to improve the daily lives of all Zimbabweans in terms of sanitation, agriculture, food security, and medicine as well as offering career paths for students. My awareness of the goals of Zimbabwe Policy framework on biotechnology, my experience as a trained A level biology resource teacher in Masvingo province, as well as the gap identified in literature concerning empirical studies of teachers' professional development for curriculum implementation in Zimbabwe have all motivated me in the desire to create the kind of platform envisaged by the policy. I have decided to work towards a change in the current situation concerning the biotechnology option by engaging in community based participatory action research (CBPAR) and to employ it in the establishment of a professional development intervention (PDI) platform to engage and enhance the teaching of biotechnology option. It is envisaged that this PDI platform will enhance the teaching and learning of biotechnology in schools and create awareness of and engagement by the public in biotechnology issues, thereby developing a community of practice (CoP) (Wenger, 2011). According to Fullan (2006), a community of practice is defined as a group of people who are motivated by a vision of learning (in this case biotechnology learning) and who are committed to support one another to build knowledge and promote deep learning (via CBPAR) at different levels (amongst teachers, learners and the community). The study is meant to provide A level biology teachers in the province with more information about the biotechnology option, so as to help them have informed dialogues on how to implement it effectively. A CoP promotes collaborative cultures, ones that focus on building capacity for continuous improvement that enable a new way of working and learning. It is envisaged that the CoP will ultimately increase awareness of and engagement in biotechnology issues within the broader Masvingo community. CoP's are dynamic; they are not confined to a particular area or community, and they propagate to different levels or strata in the community and so the community of learning expands. Therefore, I envisage that the CoP created in Masvingo province will ultimately spread to other provinces in Zimbabwe.

1.6 Significance of the Study

This study will be beneficial in its response to Section 6.7 of the National Biotechnology Policy, which high lights the lack of public understanding of biotechnology and the issues surrounding it.

A significant aspect of CBPAR is inherent in its name. The active involvement of the community and the participative nature of the study should contribute to more awareness of the opportunities available for forging learning communities. At a methodological level, this study expects to contribute in a number of ways to the body of knowledge on the use of CBPAR in the field of education, by documenting how to create an innovative platform for a PDI and tracing the innovative approaches in continuing cycles of analysis – implementation – reflection. CBPAR has been used frequently in the medical field, but rarely in education (Micheal et al, 2017).

Furthermore, the PDI programme will benefit A level biology teachers' engagement with the basic principles of teaching and learning in biotechnology option. Much needed teaching and learning support materials will be developed during the PDI programme to benefit A level biology teachers. After gaining some experience in material production, the biology teachers will be empowered to develop their own biotechnology teaching and learning materials or to seek support among their CoP. Such carefully designed biotechnology teaching and learning materials could be powerful tools for enhancing the quality of teaching in the biotechnology option; thereby influencing teachers to offer this option and fostering student learning.

By meeting the needs of stakeholders, awareness of biotechnology issues should be perpetuated amongst the learning community. This in turn, would promote and encourage discussion of biotechnology at high school science clubs, thereby raising learners' awareness, interest in the topic. These actions would empower beneficiaries to make informed decisions on modern biotechnology issues that affect them at a personal, social and economic level.

This PDI platform and the attendant CoP it enables will provide powerful possibilities for collaboration leading to learner-centered and research-oriented biotechnology teaching. By creating professional learning communities (PLCs), a community of continuous support will be available to A level biology teachers as they engage with the curriculum. Therefore, two key contributions will be the provision of technical training to A level biology teachers and dynamic learning opportunities for students. Furthermore, embarking in participatory action research will help teachers to become reflective practioners and to teach in a more nuanced fashion.

1.7 Research methodology

This qualitative case study explores the creation of an innovative PDI platform to engage A level biology teachers with regard to content and pedagogy needed to enact or implement the biotechnology option of the A level biology curriculum in Masvingo, Zimbabwe. A case study enables the researcher to gain greater insight into and understanding of the dynamics of a specific situation (Creswell2010, p. 76). In this research the case is the creation of a PDI programme and engaging A level biology teachers as collaborative participant in participatory action research within the province of Masvingo. Sampling was purposive, as, I wanted to "hand-pick the cases to be included in the sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought" (Cohen, Manion & Morrison, 2009, p.156), namely A level biology teachers and subject heads.

Further, the study embraced the critical paradigm. Cohen, Manion, and Morrison (2011) argue that the critical paradigm aims to not only understand or describe a phenomenon or situation but also to liberate or make changes in situations where there are inequalities or imbalances in the system. In this case, the intention was to effect positive changes in teacher practices in terms of the biotechnology option. Aligned with the critical paradigm a community based participatory action research (CBPAR) research design was used to generate data. Fundamentally, participatory research focuses on addressing educational challenges faced by teachers, learners and the community at large. This design requires key players to work together with the researcher to find appropriate means of addressing these challenges (Mitchell, 2011, cited in van Laren, Mitchell, Mudaly, Pithouse-Morgan & Singh, 2012). In this study, data were generated through reflective diaries, interviews, observations, focus group interviews, photo narratives and document analysis. By using multiple methods for data generation I was able to address the research questions from different perspectives, thereby triangulating data and thus enhancing trustworthiness of the findings.

1.8 Limitations of the Study

Limitations include threats to trustworthiness. One such threat could have been respondents' bias. For instance, the respondents may say what they think the researcher wants to hear and paint only positive pictures of a situation that may not be completely positive. With respect to data collection by document analysis, some documents were incomplete and selective, so that only certain aspects of the professional experiences were documented. Nevertheless, despite the incompleteness and unevenness of some of these documents, they were supplemented by the interview data, the focus group discussion data as well as the data from photo narratives in this study.

Another limitation was that some potential 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.

1.9 Conceptual frameworks

The study is underpinned by Vygotsky's (1978) zone of proximal development (ZPD) and Rogan and Grayson's (2003) theory of curriculum implementation. Vygotsky (1978) believed that children learn by following the example of an adult, or more knowledgeable other. The ZPD is the gap between the actual development level of the student and the potential level that the student can reach. This zone or gap can be crossed through mediation by a more competent peer. Vygotsky used the term scaffolding to describe the facilitation offered by more competent peers. This theory emphasizes the collaborative nature of learning and it can also be applied to the professional development of teachers. The theory suggests that the learner (in this case the teacher) must be actively involved in the learning process. Such learning can occur within a professional learning community. Rogan and Grayson's (2003) theory of implementation is based on three main constructs; namely profile of implementation, capacity to support innovation and support from outside agencies. For my conceptual framework I will focus on only two constructs, namely profile of implementation and capacity to support innovation. I will not focus on support from outside agencies as this is where the planned professional development innovation program lies.

1.10 Findings

Two themes emerged from the data concerning research sub-question one, namely professional challenges and contextual challenges prior to the teachers embarking on the PDI programme. Professional challenges comprised four sub-themes, namely lack of subject matter knowledge and pedagogical content knowledge, lack of professional support and the need for a safe nurturing space, use of equipment available and teacher pacing and syllabus coverage. Contextual challenges consisted of lack of support at school level and lack of resources. The professional and contextual challenges identified from the data had a bearing on the 'profile of implementation' and teacher well-being.

The reflective journals that the A level biology teachers had maintained during the unrolling of the PDI together with transcripts from the video recordings of the focus group discussion were used to answer research sub-question two. Vygotsky's zone of proximal development was used to note shifts in the teachers' leaning during the PDI. Two major themes emerged from the analysis of data; safe collaborative learning space and teachers as learners. The data confirms firstly that a safe nurturing space is needed for PDI to be effective and secondly that there is an affective domain attached to PDI, which is linked to teacher efficacy or confidence and their learning.

Data generated through lesson observation, interviews, and reflective journals are presented to answer the third research sub-question. Although sixteen teachers carried out the PDI in their schools and maintained reflective journals, only four teachers teaching the biotechnology option volunteered to have their lessons observed, for their teaching portfolio to be subjected to document analysis and to be interviewed after the observations. Some skills developed during the PDI were also more generally applicable in teaching biology.

Since all 16 A level biology teachers indicated that their engagement in the biotechnology PDI altered their delivery of the curriculum in their class the third part of the research question did not need to be answered. The participating teachers' presentation of the curriculum was altered affectively, socially and cognitively.

1.11 Outline of the study

The overall outline as well as organizational pattern of this thesis is presented in this section. The thesis comprises eight chapters, with contents as follows:

Chapter1: **Introduction** provides the context for the study, central research question and sub-questions, significance of the study and limitations.

Chapter 2: **Literature Review.** Differing perspectives amongst scholars on relevant aspects of professional development in science education are reviewed. I also review literature on curriculum implementation and biotechnology curricular, with particular on Zimbabwe.

Chapter 3: **Conceptual Frameworks** which inform the study were presented and discussed. The conceptual frameworks draw on Vygotsky's (1978) zone of proximal development and the Rogan and Grayson (2003) theory of curriculum implementation. The different models and practices of PDI platforms and the ways in which they are used in different countries are also explored in this chapter. The theoretical framework informing CBPAR is also presented.

Chapter 4: **Methodology:** The qualitative interpretive methodology that was used to carry out the study is presented and discussed. The approach, design, instruments and sampling procedures are also presented. This chapter also includes a discussion on how data would be analysed, along with considering how the validity and triangulation of data were to be achieved.

Chapters 5 to 7 are all concerned with the presentation of data and discussion of findings.

Chapter 5 considers **research sub-question 1**. I present and discuss the results which emerged for the question: *What are the A level biology teachers' professional development needs in terms of the biotechnology option?* Data from the examiner's report and preliminary survey questionnaires, as well as the initial meeting with teachers and stakeholder are analysed.

Chapter 6 presents data and findings for the **second research sub-question**: *How do biology teachers engage with the teaching and learning of biotechnology in the PDI platform created using CBPAR.* In answering this, I presented data from reflective journals completed by A level biology teachers, as well as data from the learning communities on instructional material production. Data from biotechnology lesson observation were also presented and discussed.

Chapter 7 presents data to answer the **third research sub-question**: *Has engaging with the biotechnology PDI altered their implementation of the biotechnology option in their classes? If so, how? If not, why?* In this chapter I present findings on how teachers use participatory action research (PAR) in the teaching and learning of biotechnology. Findings on the gains in knowledge on the biotechnology option and skills achieved through the five phases of PAR are also discussed. Instructional materials produced are tried and the findings are also presented in this chapter.

In Chapter 8 **Summary of Findings, Conclusion and Recommendations,** I present the conclusions which were drawn, reflect on the use of Rogan and Grayson's curriculum theory and steps that can be taken to improve and sustain the biotechnology PDI platform that was created. I also indicate possibilities for future research endeavors as well as recommendations for future policy and practices.

1.12 Conclusion

In this chapter I presented the introduction and background of the study. The purpose and rationale for the study were highlighted. The key research questions were given, and methodology to be employed for this study was alluded to. Finally, the structure of the thesis 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. The next chapter is thus a review of literature relevant to the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review was guided by my first two research questions: *What are A level biology teachers' perceived professional development needs in terms of the biotechnology option?* and *How do A level biology teachers experience the teaching and learning of biotechnology in the PDI platform created using CBPAR?* The literature will form the backdrop for the creation of an innovative platform for engaging A level biology teachers in biotechnology related to the biology curriculum in Zimbabwe. While the literature surveyed is arranged into six categories. These categories are not isolated or discrete units; rather, they are intertwined and form the essential components needed to create an innovate platform for this study. The six categories are

- Teachers' knowledge for teaching,
- Curriculum support and innovation,
- Teachers as agents of change,
- Differing perspectives amongst scholars on professional development,
- Professional learning communities (PLC), and
- Participatory action research(PAR)

The first category clarifies what constitutes biology teachers' content knowledge (CK) and pedagogical content knowledge (PCK). The second category explicates what curriculum innovation is and elucidates the significant role teachers have to play in such innovation. The third category brings to the fore the valuable role of teachers as agents or drivers of change during curriculum reform and innovation. The fourth category makes visible the differing scholarly perspectives on professional development, in terms of embracing change for professional development and professional development interventions to support teachers to teach biotechnology education. The fifth category, PLC, serves as a building block for the creation of the innovation platform for engaging A level biology teachers in biotechnology within the Zimbabwean biology curriculum, whilst the last category, PAR, is what teachers will engage with in their classrooms and during the PDI.

2.2 Teachers' knowledge for teaching

For quality, teaching to occur, Shulman (1986, 1987) asserts that a teacher needs to possess content knowledge; pedagogical knowledge and curricular knowledge. Each one of these categories is unpacked next.

2.1.1 Content knowledge and subject matter knowledge

Content knowledge (CK), as proposed by Shulman (1986, p. 9), refers to "the amount and organization of knowledge per se in the mind of the teacher". Shulman (ibid) further contends that subject matter content knowledge goes beyond knowledge of facts or concepts of a particular domain. It also requires understanding of the structures in the subject matter, which includes both the substantive structures, or "the variety of ways in which the basic concepts are organized to incorporate its facts" and the syntactic structures, "the set of ways in which truth or falsehood, validity or invalidity are established" (Shulman (ibid). To teach effectively teachers need good subject matter knowledge (Goldschmidt & Phelps, 2009). Resonating with the aforementioned points, Bertram (2012) posits that it is the understanding of fundamental concepts and how the concepts are related and organized that enables teachers to use their subject matter knowledge for teaching. Along the same lines, it is worth noting that Taylor and Vinjevold (1999) point to teachers' poor grasp of the knowledge structure of science as the major factor inhibiting efficient teaching and learning in the science subjects. According to Shulman (1986) there is a 'pedagogical price' to be paid when the teacher's subject matter competency is compromised by lack of proper training. Put simply, this means that teachers who have been inadequately trained in subject matter content knowledge are also likely to lack varied pedagogical strategies. From the above points it can be deduced that teachers are unable to assist their students comprehend what they themselves do not understand (Loucks-Horsley & Matsumoto, 1999). Therefore, research on teacher learning highlights the need for professional development to help teachers understand, amongst other knowledge and skills, subject matter content knowledge (Birman, Desimone, Porter & Garet, 2000; Putman & Borko, 2000; Loucks-Horsley & Matsumoto, 1999; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008). Content-based professional development is essential for teachers' learning, particularly in science subjects where many of the teachers possess inadequate subject matter content knowledge. Strengthening science teachers' content knowledge should therefore be a key element of any professional development programme (Kriek & Grayson, 2009).

2.1.2 Pedagogical Content Knowledge for Life/Biological Sciences

As argued by Shulman (1987) content knowledge alone is not adequate for teaching; teachers need to further acquire subject knowledge specifically related to teaching; that is pedagogical content knowledge. Shulman, (1987) defined pedagogical content knowledge as a "special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (1987, p, 10). In this way, Shulman emphasized teachers' combination of content knowledge with pedagogical knowledge as central to teaching. Likewise Loughran, Berry and Mulhall (2012) assert that PCK does not simply involve use of a teaching procedure because it works, but it is about integrating knowledge of pedagogy with content, so that the content will be better understood by learners. As expressed by Loughran *et al*. (2012), for the development of PCK, teachers need to possess good conceptual understanding of the subject content. Thus, according to Loughran *et al.* (2012, p.7) a teacher demonstrates when using strategies such as illustrations, examples, explanations or concept maps to explore concepts within a specific topic in order to challenge students' thinking. Use of such strategies during teaching helps learners understand concepts better, bringing to the fore any possible misunderstandings and difficulties (Loughran *et al*., 2012).

In line with the principles of PCK, the Zimbabwean A level biology curriculum explicitly lays down what the learners need to demonstrate when learning the biology concepts. The curriculum document specifies that in the process of making meaning and achieving understanding of concepts and ideas in biology, learners must:

- build a conceptual framework of science ideas;
- organize or reorganize knowledge to derive new meaning;
- write summaries;
- develop flow charts, diagrams and mind maps; and
- recognize patterns and trends.

The curriculum document further sets down other skills that the learners must attain in the process of learning biology. These include the ability to:

- analyse information or data;
- recognize relationships between existing knowledge and new ideas;
- critically evaluate scientific information;
- identify assumptions; and

• categorize information,

The assumption shown here by the curriculum statement is that teachers have already acquired the desired PCK to facilitate these skills during their teaching. In reality though, some of the teachers may be lacking not only in their PCK, but also hold only a superficial conceptual understanding of many of the concepts, which hinder their facilitating the kind of learning envisaged in the curriculum documents. As pointed out previously, teachers also need to have the appropriate knowledge and strategies by which to teach process skills through science investigations. As an example, Appleton Christenson, & Furlong, (2008) noted that during the introduction of outcomes-based education in countries like South Africa and Australia, teachers were faced with challenges in shifting from the traditional way of presenting science facts to a constructivist-based pedagogy in order to better develop learners' understanding of science concepts and phenomena.

According to Appleton *et al.* (2008), during curriculum change science teachers' PCK needs reconfiguration through teacher learning in various professional development models and programmes. This means that teachers need more than deep conceptual knowledge; they need pedagogical content knowledge.

2.1.3 Curricular knowledge in Life Sciences

Curriculum knowledge, as explained by Shulman (1986, p. 9) includes a "complete set of programs designed for the teaching of a particular subject and specific topics". Curriculum knowledge also includes a range of instructional materials for teaching specific subjects and topics (Shulman, 1986). Shulman identified two important components of curriculum knowledge essential for teaching; namely, lateral curriculum knowledge and vertical curriculum knowledge. Lateral curriculum knowledge pertains to teacher's awareness of the topics or issues being discussed simultaneously in other classes while vertical curriculum knowledge entails knowledge of topics taught in the same subject area in the earlier and later years in school (Shulman, 1986).

To be able to create links between students' prior knowledge and new knowledge in biology, teachers are expected to develop links across the different school years, that is they need to be familiar with similar topics taught at different stages. To be specific, at advanced level, the subject of biology builds on knowledge and skills acquired earlier from the Zimbabwe Junior Certificate and the ordinary levels (O levels). Teachers also need to have vertical curriculum knowledge of the within the advanced level years. This is needed so that when teaching Form 5 they can develop concepts and skills and so lay a solid foundation for development of knowledge and skills later in Form 6. Without this curriculum knowledge, teachers are unlikely to be able to facilitate learners achieve the objectives as laid out in the advanced level biology curriculum document. Hence, teachers need to have proper knowledge of the curriculum in order to implement any new demands.

In a study conducted by Behar and Gordon (1995) to assess how teachers used their knowledge of curriculum during the implementation of a new innovative model of curriculum, it emerged that teachers' lack of curriculum knowledge, as well as their ability to use curriculum knowledge affected the implementation of the new curriculum model. According Behar and Gorden (1995), any diversion from the traditional curriculum to an innovative new form of curriculum requires appropriate reconceptualization of the teaching role; requires that all teachers share a common perspective of what the new curriculum entails; requires administrative support and instructional guidance. Development of teachers' curricular knowledge should therefore be an integral part of teachers' professional development, especially during curriculum reform.

In his definition of curricular knowledge, Shulman (1987) included not only the knowledge of topics, but also the knowledge of the variety of instructional materials available. Various scholars believe that it is the lack of understanding of the primary principles of the curriculum that prevents effective use of curriculum materials by teachers (Lieberman & Wood, 2001; Singer, Marx, Krajcik, & Chambers, 2000). Therefore, to be effective in supporting implementation of innovations, professional development should incorporate instructional planning, with discussion of underlying principles of the curriculum (Penuel, Fishman, Yamaguchi, & Gallagher, 2007). It is generally expected that curriculum reform will bring about changes in teaching strategies, approaches and techniques (Vacirca, 2008). At the outset, teachers need to be aware of the philosophies behind the new curriculum (Stein, McRobbie, & Ginns, 1999). Correspondingly, teachers require knowledge of new curriculum in order to change their philosophy (Brady & Kennedy, as cited in Barnes, 2005). These changes in philosophy and knowledge have to occur through teacher development; failing which, the implementation of new curriculum becomes unfeasible (Givens, as cited in Barnes, 2005).

2.2 Curriculum Support and Innovation

Educational reform projects have sometimes been failures. Van Driel, Bulte and Verloop (2005) postulate that such failures occur because teachers are unable to implement the curriculum in the manner envisaged by the curriculum developers. They add that "curriculum developers assume they know how the curriculum must be changed and expect teachers to adapt their classroom behaviour accordingly" (Van Driel *et al*., 2005, p. 303). In the same vein, Singh-Pillay and Alant (2015) contend that teachers are the direct contact between the intended curriculum change and the school itself. Therefore, teachers' readiness and preparedness to deal with curriculum reform are the keys to ensuring that the ideals of the new curriculum are realised with minimum difficulties. Further, Singh-Pillay and Alant (2015) emphasize that the ability of the teacher to engage in curriculum innovation is determined by the degree of support (i.e. professional development) they receive. Put simply, this means a gap exists between teachers' capacity to innovate, and the expectations of curriculum developers. Closing such a gap so that teachers possess the capacity to implement an innovation successfully depends on the kind of support they receive. It is this identified gap that this study seeks to address, by creating a platform for innovation in respect of the biotechnology option in the advanced level biology curriculum (9190).

From the argument above it is clear that curriculum innovation is inherent in the fluid curriculum terrain encountered by teachers; they need to be prepared to teach in changing times and changing contexts. According to Tytler, Symington and Smith (2011), innovation in education is characterized by a distinct change process. They add that this change process connects new knowledge production, creative solutions and new alliances. Drawing on the work of Smith and Gillespie, (2007), Tytler *et al*. (2011) provide an expanded definition of innovation, incorporating 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 relative. Third, what counts as innovation at one school, may not be applicable in another. In other words, innovation is context specific and purposeful. Fourth, innovation should be an attempt to respond to the needs of a school, or to improve educational programmes (Tytler *et al.*, 2011, p.14). This implies that there must be congruence between the proposed innovation and the context in which it is to be used. In other words, the context dictates what type of innovation is possible. It follows that in order to contextualise the delivery of the curriculum so as to meet the needs of their school and learners, teachers must be able to draw on their professional development support training, in order to adapt and adjust their teaching and assessment practices. Ferrari, Cachia and Punie (2009) argue that the fundamental element in educational innovation is 'the teacher'. Furthermore, if teachers are crucial to the innovation process then "support mechanisms should be implemented to make sure they can fulfil expectations and respond to requests" (Ferrari *et al.,* 2009, p.22). Concurring with this view, Pintò (2005, p.2) asserts that teachers "require and expect from those directing curriculum change, realistic guidelines and practical suggestions for their classrooms". The implementation of any new practice is the sole responsibility of the teacher (Rogan, 2007). Therefore, scholars like Rogan (2007) and Hewson (2007) regard teachers as the drivers of curriculum reform and as agents of change.

Complementing the preceding discussion, Rogan (2007) highlights that some kind of support is needed for teachers to move through the zone of feasible innovation (ZFI); in changing from their routine practices to an ideal practices. Teachers can be supported in learning new teaching techniques by being involved in discussions or collaborations and by receiving training (Rogan, 2007). The teacher must be able to understand how to innovate. Rogan (2007) asserts that the ZFI is designed to operate at a micro-level; in other words at a classroom level.

My research work rests on the assumption that if teachers receive adequate support via the proposed professional development intervention (PDI) programme to engage with the biotechnology content, if they enact different teaching and assessment strategies, if they collaborate with colleagues and form professional learning communities, then these actions are likely to increase their capacity for innovation. My idea links with ideas embedded within Rogan's (2007) zone of feasible innovation (ZFI), which indicates that by receiving support in some form (in this case, via my professional development intervention) teachers will acquire ideal practices (new practices) that will allow them to use an innovation successfully. Rogan's ZFI corresponds to Vygotsky's ZPD, in that they both require peer to peer learning.

2.3 Teachers: Agents of Educational Change

If teachers are not involved in educational reform, then as asserted by Hewson (2007) the envisaged changes cannot transpire. Teachers are the direct contact between the intended change and the school itself. In other words, teachers are the implementers of any change that filters through from the education policy makers. Hameed (2013) concurs with Hewson is stating 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 do not understand how to implement the intended 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). This means that teacher agency is an important element for change and innovation to occur. Ellsworth (2000) states that for educational change to occur, there must be a strategy to be followed. He proposes a model of change, shown in Figure 2.1.

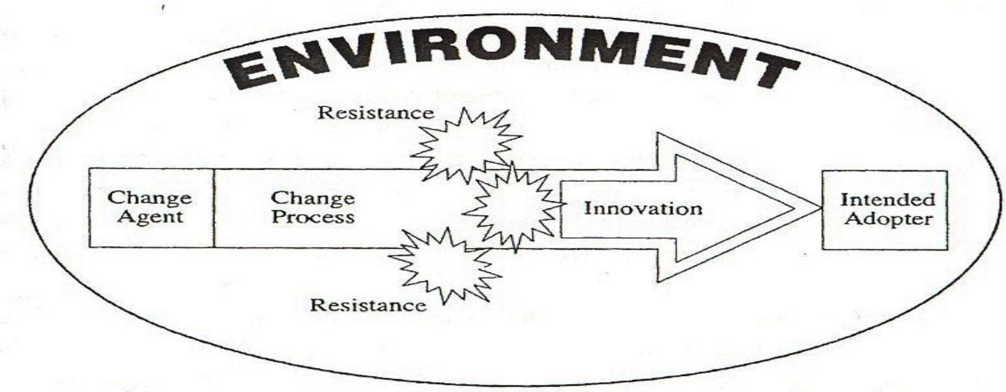


Figure 2.1: Ellsworth model of change. Ellsworth (2000, p.27)

Ellsworth (2000) suggests that change occurs in a two-way process of communication. He adds that a one-way approach to change would be unethical and is unlikely to be successful. The two-way process of communication is evident when the adopter becomes the change agent. I argue that change is difficult to achieve because teachers are expected to implement change, but have little or no guidance from the CDU in the form of professional development. I base this argument on my personal experiences, as well as research undertaken by, among others, Powell and Anderson (2002), Van Driel *et al.* (2005), Scholtz, Watson and Amosun (2004), Lamie (2004), Pintò (2005) and Singh-Pillay and Alant (2015), who all highlight the importance of continuous professional development for teachers during curriculum reform.

Ellsworth's model of change shows that resistance to change can exist. Such resistance would be evident among teachers who had not received adequate professional development, and so were not implementing the curriculum, such as with the poor uptake of the biotechnology option. The innovation phase of the change process is where teachers would draw on knowledge and teaching methodologies gained during appropriate professional development, and so they would implement the curriculum successfully. Therefore in this study I intend to engage jointly with stakeholders in the development of a CBPAR intervention programme to engage with practising biology teachers on the biotechnology option, thereby developing a professional learning community (PLC). There are differing perspectives amongst scholars on professional development in science education that need to be considered in order to assist me in the design of the professional development innovation intervention programme. These are discussed next.

2.4 Differing perspectives amongst scholars on Professional Development in Science Education

Scholars construe the concept of teachers' professional development differently; hence there is no single universal definition of teachers' professional development. One conception, held by Ferraro (2000) and Guskey (2000) considers teachers' professional development to be those processes and activities engaged in by teachers that enhance their professional career growth. The activities and processes would be aimed at enhancing the professional knowledge, skills and attitudes so as to improve the quality of teaching and students' learning (Kennedy, 2016, Ferraro, 2000; Guskey, 2000). Teachers' professional development is also regarded by Bell and Gilbert (1994) as a teacher learning process comprising the three facets of professional, social and personal development. In his description, Ferraro (2000) places emphasis on individual development as well as continuing education. In a similar vein, Hargreaves and Fullan (1992) view teacher learning as involving self-reflection. This means that teachers' professional development goes beyond the meaning of simply in-service training; it also includes developing insight into one's own pedagogy and practice and an understanding of one's own needs. It is thus implicit that teachers need to take ownership of their learning and development.

Another idea held by other researchers is to consider teachers' professional development as an ongoing process of learning and development. Fullan (1991, p. 326), for example, defines teachers' professional development as "the sum total of formal and informal learning experiences throughout one's career from pre-service teacher education to retirement". Huberman (2001) also views teachers' professional development as having different stages that start from the novice stage to retirement. Bell and Gilbert (1994) describe teacher development as being part of an ongoing change process that should occur continuously. By implication, Fullan; Huberman; Bell and Gilbert (all ibid) consider professional development of teachers as a sequence of lifelong or ongoing opportunities for teachers to learn, which may be either formally or informally structured. Teachers' professional development is thus conceived as a process of teacher change. Along these lines, Day (1999, p. 34) defines teachers' professional development "as a process by which, alone and with others, teachers review, renew and extend their commitment as change agents to the moral purpose of teaching; and by which they acquire and develop critically, knowledge and skills, through each phase of their teaching lives." In addition, Hargreaves and Fullan (1992) contend that professional development involves more than changing teachers' behaviour, that it also involves changing the person whom the teacher is.

In view of teachers' professional development being considered a learning process, several researchers suggest a shift from the concept of 'professional development' to 'professional learning'. For instance, on the one hand Fraser, Kennedy, Reid, and McKinney (2007, p. 157) draw a distinction between these two concepts. They posit that professional learning represents processes that, whether spontaneous or deliberate, individual or social, effect changes in the professional knowledge, skills, attitudes, beliefs or actions of teachers. Teachers' professional development, on the other hand, may refer to the wide-ranging changes that occur over an extended period of time resulting in qualitative shifts in aspects of teachers' professionalism (Evans, Ali, Singleton, Nolan and Bahrami 2002 p.124). Bell and Gilbert (1994, p.493) view professional development for teachers as teachers learning, rather than other people or organizations getting teachers to change. The narrow perception that professional development activities are merely formal training courses linked to gaining a qualification (has been criticized by Friedman and Phillips, (2004). Thus a new paradigm has emerged, which shifts professional development from the notion of simply enrolling for courses and attending training, to a broader concept of lifelong or continuing learning (Day & Sachs, 2004; Fraser *et al*., 2007).

In the context of a broader professional view, it is clear that development of teachers by someone else is not sufficient; teachers must become learners. They must be self-developing and self-motivated, particularly in times of curricular reforms. Fullan (2001, 2007) emphasizes that professional development for teachers is not merely about workshops and courses but that learning should be an ongoing process, which occurs daily in the life of a teacher. This view suggests that, although participation in professional development activities is critical for teachers' professional growth, that alone may not adequately provide teachers with all the skills needed for the demands of frequent educational reform. To respond effectively to changes in education, teachers need everyday professional learning. They need to consider their professional development as a lifelong learning process (Gore *et al.*, 2017, Friedman & Phillips, 2004).

During profession development, the intention of teacher change is always to improve student learning (Guskey, 2002). In essence, curriculum reform brings about changes in teachers' practices as they assume new roles. Professional development programs bring about change in the classroom practices of teachers, in their attitudes and beliefs, and in the learning outcomes of the students (Guskey, 2002). According to Guskey (2002) the majority of teachers perceive professional development as a way to improve their competence and enhance student learning outcomes, a view also held by other researchers, for example Fullan (1991) and Hargreaves (1998). Furthermore, Guskey (2002) contends professional development appeals to many teachers because they believe it will enhance their knowledge and skills, and contribute to their growth, thereby improving their teaching effectiveness. Guskey (ibid) however cautions that professional development programs that fail to meet such expectations are unlikely to influence any changes in teachers' practices. The perception here is that change is identified with learning, and is regarded as an intrinsic and expected feature of the professional activity of teachers. This idea of teacher learning has culminated in the concept of ongoing lifelong learning, whereby teachers become reflective practitioners through professional development (Fullan, 1991; Day, 1999).

Other key perspectives of teacher change developed earlier by Clarke and Hollingsworth (2002) included:

- Change as adaptation – teachers adapt their practices to changed conditions.
- Change as personal development – teachers seek to change in an attempt to improve their performance or develop additional skills or strategies.
- Change as local reform – teachers change something for reasons of personal growth.
- Change as systemic restructuring – teachers enact the changed policies of the system.

• Change as growth or learning – teachers change inevitably through professional activity; teachers are themselves learners who work in a learning community.

Various models have been developed to explain how teachers change through professional development. Regardless of when change occurs through professional development, the significant idea is that a professional development activity should seek to alter and expand teachers' knowledge, skills and beliefs; which will in turn positively influence their classroom practices, creating a change in instruction that will foster better student learning and improved outcomes. Smith, Hofer, Gillespie, Solomon, & Rowe (2003) proposed three major factors that influence the type and amount of change teachers undergo during professional development. These include:

• ***Individual factors*** **–** their experience, background, and motivation about teaching as they come into the professional development.

• ***Professional development factors*** **–** the quality and amount of professional development attended.

• ***Program and system factors*** **–** the structure of and support offered by the program, adult education system, and professional development system in which they work, including teachers' working conditions, which are defined as their access to resources, professional development and information (Smith *et al*., 2003, p. 2).

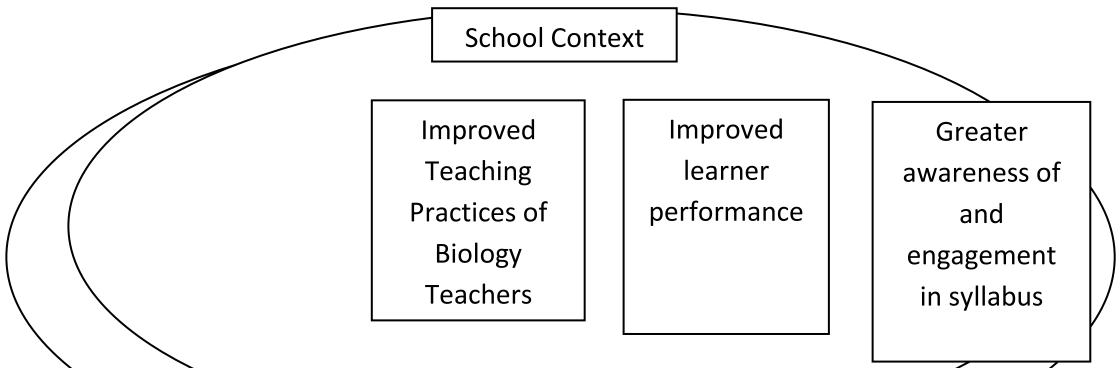
In a study to investigate the most influential of the individual factors, Smith *et al.* (2003) found that motivation to attend the professional development activity was amongst the most significant individual aspects influencing teacher change. They established that teachers with a strong desire to learn changed more following professional development (Smith *et al*., 2003). Teachers' motivation to engage in professional development is thus considered a significant determinant of potential teacher change (Bell & Gilbert, 1994; Smith & Gillespie, 2007). Teachers' motivation to engage in professional development has a direct influence on teachers' classroom practices (Anderson, 2000; Guskey 2002). It is the teacher's intrinsic drive towards self-improvement that makes them gain more knowledge during professional development (Komba & Nkumbi, 2008). In other words, no amount of pressure from educational managers can result in teacher change. Instead, each individual teacher has to perceive professional development positively and be willing to learn new knowledge and skills (Komba & Nkumbi, 2008). Alexander (2008) believes that motivation can be stimulated by quality professional development programmes, influencing teachers to attempt new unfamiliar instructional practices in their classrooms, thus fostering change.

Harvey (2005, p. 5) cites other potential driving factors for teachers to engage in professional learning, which ultimately promote change in teachers' practices. Some of the factors motivating professional learning include:

- **Pedagogical content knowledge** – the opportunity to improve teaching competencies and skills and by the acquisition of knowledge in specific subject areas.
- **Serving and enabling students** – the desire to relate to learners more meaningfully and help them learn better.
- **Educational philosophy** – the exploration of beliefs and values in education and the exploration of educational issues and motivated by the desire to reform educational practice in the school and classroom.
- **School support** – teacher release time and remuneration and leadership, management, and collegial support.
- **School/system expectations** – registration requirements.

Kriek and Grayson (2009, p.185) attribute the current appalling position of science education in Southern Africa to "teachers' limited content knowledge, ineffective teaching approaches and unprofessional attitudes". They are of the opinion that to effect long-term improvements in the performance of learners in science, focus must be placed on strengthening teachers. This view is aligned with that of Supovitz and Turner (2000, p.965), who contend 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". This highlights the need for science teachers to be involved in effective professional development. Supovitz and Turner's (2000) model on the relationship between professional development and learner achievement is depicted below in Figure 2.2

.



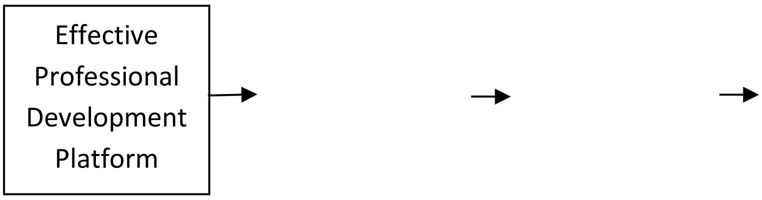


Figure 2.2 Adapted model depicting theoretical relationship between professional development intervention and greater awareness of and engagement in biology (Supovitz & Turner, 2000).

Effective professional development has a carryover effect it results in improved teaching and learner performance.

Hewson (2007) asserts that programmes of professional development for science teachers must encompass four attributes, as given below. The programme should:

- Involve the teacher and their practical and theoretical activities, the learners and their learning, and the educational system.
- 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.
- Recognize the teacher as an adult learner who must be involved in continuous development throughout their professional teaching career.
- Incorporate the uniqueness and distinctiveness of science and have integrated into it the epistemologies, methodologies and knowledge of the natural world.

Hewson (2007) adds that programmes for professional development in science teaching should be designed with two focal points in mind; the programme and the people. The programme refers to the actual professional development, the developers of the programme and what they have decided is to be part of the initiative (Hewson, 2007). He adds that the people refer to the science teachers. They should be integral to the process of professional development itself (Hewson, 2007).

High quality professional development will, as postulated by Sherron and Fletcher (2008), encourage enhanced teaching in the classroom; which will in turn promote higher levels of learner performance and achievements. The views of Sherron and Fletcher, concur with

Guskey's (2002) assertion 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 desirable 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 transpire in the order shown in Figure 2.3 below.

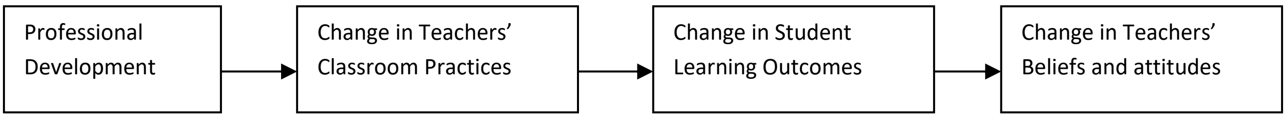


Figure 2.3: **A model of teacher change** (Guskey, 2002, p.383)

Guskey (2002) explains that by changing teachers' classroom practices, the performance of the learners in the classroom can improve, which can in turn lead to the beliefs and attitudes of the teachers changing with their greater engagement with curricular material. Through effective high quality professional development the classroom practices of teachers change as they try out new teaching methods for particular topics in science. When this newly adopted teaching approach encourages and promotes enhanced learning for learners, who in turn performance better, the teacher then takes note of this and adopts this new teaching approach, abandoning the old style of teaching. So this process changes the attitudes and beliefs of the teacher (Guskey, 2002). "Practices that are found to work are retained and repeated. Those that do not work or yield no tangible evidence of success are generally abandoned" (Guskey, 2002, p.384). In support Steyn (2008) suggests 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.). This concurs with research by Sherron and Fletcher (2008) among teachers and learners in Texas, where they 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. Guskey (2002) supports this, stating that change is dependent on whether the performance of learners is improving. This notion is supported by Rogan (2007) and Rogan and Aldous (2005) who states that change should occur in steps, considering all the elements that are part of the change.

McDonald and Dominguez (2015, p.17) state that "the ability of a science teacher to incorporate and teach science concepts in their classrooms requires (not only) content knowledge but also skills of how to teach these concepts". Research shows that teachers lack of knowledge on science has implications for the career choices that learners will make, and this has a larger impact on their development as citizens. This raises questions about the quality and relevance of continuous professional development available to teachers. Hameed, (2013) postulates there is a need for continuous in-service training or professional development in this field. Reddy (2011, p.18) states "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." 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 of teachers 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. However, spaces and opportunities for Reddy's envisaged professional development is limited within the Zimbabwean context. This deficit resonates with Rogan's (2007) view that developing countries lack the capacity to introduce and sustain change.

For teachers to be positive implementers of biotechnology education they require professional development that will give them the knowledge and methods of how to implement curriculum change. The appropriateness of any professional development is what determines whether or not teachers are able to implement change. The professional development itself must be designed to "enhance the professional knowledge, skills and attitudes of teachers" (Guskey, 2000, p.16). Facilitators of professional development need to take cognisance of what they want as the goals and objectives of programmes, which Guskey (2000) asserts must be clearly articulated for a successful programme. He postulates that professional development must be intentional and progressive, towards these goals. Guskey (2000) offers three steps that can be followed for effective professional development.

1. Begin with a clear statement of purposes and goals:

   It is critical that clarity of goals is evident from the outset. Part of this statement must include how teachers will be able to relate the knowledge gained to their own school situation.

2. Ensure that the goals are worthwhile:

   The goals must relate to the goals of their own school situation. If this can be done then the goals can be viewed as worthwhile.

3. Determine how the goals can be assessed:

   The goals must be analysed and assessed so that the facilitators of the initiative can gauge if they have achieved the goals. The evaluation of the goals must follow particular criteria and criteria must be decided on before the programme commences.

The three steps for effective professional development proposed by Guskey (2000) articulate with ideas put forward by Rogan and Grayson (2003) and Rogan (2007). In considering the zone of feasible innovation (Rogan, 2007) highlights the classroom situation because any change towards ideal practices must be at a micro-level which the teacher can implement it in the classroom. Rogan and Grayson (2003) identify the importance of outside influence, which could be professional development, as a vital factor in the successful implementation of an innovation. Thus, monitoring of teacher professional development by the CDU is essential to the successful implementation of a new practice or innovation.

The concept of teachers' professional development or professional learning is broad and so the boundaries remain unclear. The lack of a collective definition from the available literature may be an indication of a need for further research in understanding precisely how teachers develop. Nonetheless, the view shared amongst many authors is that teachers' professional development has as its purpose the continuous improvement of teachers' knowledge and skills, and so it should, therefore, be ongoing. A number of authors place emphasis on self-initiated professional development, which is about teacher's internal desire for growth (Beatty, 2000 and Bulelwa, 2014). Similarly, calls have been made for teachers to engage intimately with the learning process. The position taken by these authors is that teachers should not be viewed as objects to be changed (Samuel, 2014). This view clearly contrasts with that of many teacher developers who simply aim to 'change' teachers' practices. When teachers' professional development is conceived as a mutual process, with both the teachers and the developers contributing, it is likely to result in meaningful and successful learning.

2.5 Professional Learning Communities and Communities of Practice

A Community of Practice (CoP) is defined as a "collection of people who engage on an ongoing basis in some common endeavor in response to common interest or position, and play an important role in forming their members' participation in, and orientation to, the world around them" (Eckert, 2006, p. 7). In terms of organizational structure, communities of practice develop informally through shared common passions to achieve the same purpose or goal (Wenger, 2000). Members voluntarily participate in the process, but managers make attempts to align different people with similar needs. According to Wenger (2000), executives must be able to identify potential communities of practice that may perpetuate organizational goals; develop infrastructure components that support sustainability; and develop nontraditional approaches for evaluating them.

Organizations with developed CoPs have a set structure in which work is completed using human capital to create knowledge. Although CoPs were initially designed for use in the business world, Eckert (2006) states that CoPs exist anywhere that people work together in groups for a common purpose or goal, for example church groups, dog clubs, book clubs, drug cartels, nuclear families or schools. To develop a CoP, two fundamental conditions must occur over time: shared experience and commitment to shared understanding (Eckert, 2006). Communities of Practice can thus exist in the work place or the common place of life. In either instance, people join for the common good of the group.

The term professional learning community (PLC) was coined by Hord (1997). Numerous other authors have since contributed to an understanding of learning in such a community (Lieberman & Wood, 2001; Stoll, Bolam, McMahon, Wallace, & Thomas, 2006; Lieberman & Pointer Mace, 2010 Botha, 2012; Yap, 2015; Tan & Caleon, 2016). Professional learning communities are characterized by an ongoing willingness among members to reflect on their practice and discuss issues that arise (Mitchell & Sackney, 2000; Toole & Louis, 2002, cited in Stoll *et al.,* 2006, p. 223). Professional learning communities are inclusive; everyone has a voice. They seek to foster and facilitate career-long learning and professional development. In these communities teachers may engage in participatory action research in order to solve classroom problems with research (Lieberman & Pointer Mace, 2010). In professional learning communities, teachers not only learn through discussion but also aim to produce artifacts that can stand professional scrutiny and contribute to the body of knowledge in their sphere (Shulman, 2004).

Both communities of practice and professional learning communities share the common goal of improving the overall systemic operation of the organization. Furthermore, both communities must have leadership support, time, and resources dedicated to sustainability, and intentional sharing of knowledge among group members that enhances growth through professional inquiry. However, despite these similarities subtle differences exist between the two. For example, in education the primary purpose of a PLC would be to improve student learning, while CoPs may focus on a wide array of goals besides student learning. An important distinction between the two models is that CoPs would not traditionally engage in shared leadership. On the one hand, the primary operational definition of a CoP is to develop and disperse knowledge, so it precludes the group members from engaging in leadership activities. Scholars observe that even though it may be possible for a CoP to establish its purpose or goal to define how leadership should function within an organization, its purpose is not to actually support leadership activities. On the other hand, the purpose of PLCs is to improve student learning, nurture professional inquiry, and provide opportunities for teachers to influence the decision making process (DuFour, 2004). Consequently, a professional learning community can also be a community of practice, but not vice versa.

2.6. Participatory Action Research as a Professional Development Model

Participatory action research (PAR) is driven by three district elements: namely, a shared ownership of the research project, a community based analysis of social problems, and an orientation towards community action (Kemmis 2010; Shea, Pouderier, Tomas, Jeffrey and Kiskotagan, 2013). Along similar lines, Baum, MaCDougal, and Smith, (2006) contend that PAR differs from conventional research in three important ways. First, it focuses on research where the purpose is to enable action through reflection. Second, participatory action research emphasizes relationships, so advocating for power to be deliberately shared between the researcher and the researched. Third, participatory action research is sensitive to the research context. With participatory action research, researchers and community members collaborate on exploring mutual interests and issues (Gaventa, 1988; Chambers, 1999) in an exchange that is more democratic and collaborative than conventional research. Participatory action research brings together action and reflection theory and practice, and develops practical solutions to pressing community issues (Reason and Bradbury, 2006). Participatory action research does not generate knowledge for the sake of knowledge nor seek universal laws or scientific principles; rather, it produces reflective knowledge that helps people to 'name' and, consequently, to change their world (Rousseau, 2015).

Sixteen principles of participatory action research that were outlined by McTaggart (1989), include an active approach to improving social practice through change; congruence on authentic participation; collaboration; establishing self-critical communities; and involving people in theorizing about their practices. In addition, PAR requires that people put the practices, ideas, and assumptions about institutions to the test, it involves record-keeping requires participants to objectify their own experiences, it involves making critical analysis, and it is a political process. McTaggart (1989) articulated that participatory action research starts with small cycles and groups and allows participants to build records, while encouraging or even requiring participants to give a reasoned justification of their social (i.e. educational) work to others.

Selenger (1997) identified seven components to the participatory action research process. The first component acknowledges that the problem originates in the community itself and is defined, analysed and solved by the community. Secondly, the ultimate goal of PAR is the radical transformation of social reality and improved lives of the individuals concerned; thus, community members are the primary beneficiaries of the research. Thirdly, participatory action research involves the full and active participation of the community at all levels throughout the research process. The fourth component of participatory action research encompasses a range of powerless groups of individuals, the exploited, the poor, the oppressed and the marginalized. Selenger (1997) cited the fifth component of participatory action research as the ability to create a greater awareness in individuals' own resources that can mobilize them for self-reliant development. Participatory action research is thus more than a scientific method, in that community participation in the research process facilitates a more accurate and authentic analysis of social reality. Lastly, participatory action research allows the researcher to be a committed participant, facilitator, and learner in the research process.

2.7. Conclusion

In this chapter, I presented a review of the literature related to this project. The literature reviewed highlights the disjuncture between curriculum formulation and it mediation; that is training for its implementation. The disjuncture poses multiple challenges for teachers. Teachers feel uncertain and over whelmed during curriculum reform process as, although, they play a minimal role in the construction of these educational changes, they are, nevertheless, required to implement the changed curriculum. Studies that were reviewed indicate that if teachers are not included in the planning of an educational change they will not take ownership of it, nor will they implement it as envisaged. The literature reviewed is replete with studies that call for the teacher to be viewed as an important agent of change and be given the opportunity to fully extend in this role, as teachers are the forefront of curriculum implementation. Some of the challenges teachers encounter during curriculum reform include lack of motivation, lack of confidence, lack of content knowledge and lack of school resources; however, they are tasked with teaching a new content-rich section of the curriculum. Previous studies that were reviewed reveal the lack of effective professional development to be a key factor that impinges on teachers' implementation of the curriculum. Effective professional development is the cornerstone of teachers reaching their potential, and enhancing their capacity to innovate as they teach. The next chapter pays attention to the theoretical framework that guided the study.

CHAPTER 3

CONCEPTUAL FRAMEWORK

3.1. Introduction

Community based participatory action research (CBPAR) underpins this study. Within this umbrella frame of CBPAR there are a number of theories that guide the study, principally Vygotsky's (1978) zone of proximal development, Rogan and Grayson's (2003) theory of curriculum implementation and Rogan's (2007) zone of feasible innovation. Table 3.1 below shows how the frameworks will be used to address the research questions that guide the study.

Table 3.1: Research question

Research question	Framework
What are A level biology teachers' perceived professional development needs in terms of biotechnology subject matter knowledge and pedagogical content knowledge?	CBPAR
How do A level biology teachers experience the teaching and learning of biotechnology in the PDI platform created using CBPAR?	Vygotsky's zone of proximal development
Has engaging in the biotechnology PDI altered their enactment of the biotechnology option in their classes? If so, how If not , why	Rogan and Grayson's theory of curriculum implementation Rogan's Zone of feasible innovation
What steps can be taken to improve and sustain the biotechnology PDI platform created?	CBPAR

In this chapter I will first unpack the theoretical implications of community based participatory action research (CBPAR) to set up the professional development intervention (PDI) programme. This is followed on a discussion on Vygotsky's zone of proximal development (ZPD), Rogan and Grayson's theory of curriculum implementation and Rogan's zone of feasible innovation (ZFI). 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. Finally the chapter ends with a conclusion.

3.2. Community Based Participatory Action Research

Community-based participatory action research (CBPAR) is an approach in which researchers undertake research in partnership with those affected by the issue being studied. It has the purpose of taking action or effecting social change. It can also incorporate those who will use the results to change practice and inform policy (Minkler, Blackwell, Thompson & Tamir, 2003). CBPAR is thus research *with* communities rather than research *on* or *about* communities. In this regard, 'community' has been described as a group of people sharing a common interest (Mayan & Daum, 2016). Cultural, social, political, health, or economic interests link the individuals, who may or may not share a particular geographic association. The CBPAR approach is widely recognized as being highly effective for enhancing relevance and value to health research, but has not been used frequently in education settings (Mayan & Daum, 2016, Jull, Giles & Graham, 2017). CBPAR combines research with education, co-learning, and action to democratize the knowledge production, thus affecting the relevance and quality of the knowledge and the likelihood that it will be used and so influence change (Camar, 2015). The core values include collaboration, with contributions from everyone present, and co-learning; promoting systems development; capacity building; and empowerment. CBPAR will be discussed in greater detail in the next chapter.

3.3. Vygotsky's Zone of Proximal Development

Vygotsky, a Russian psychologist and educator, believed firmly that historical, cultural and social factors play an important role in the development of cognition and that knowledge is socially constructed. He also believed that past experience has an influence on new learning experiences. Vygotsky (1978) believed that children learn by following the example of an adult or more knowledgeable other. Vygotsky developed a theory of Zone of Proximal Development (ZPD) with regard to learning. The ZPD is the gap between the actual development level of the student and the potential level that the student can reach. The way in which this zone or gap can be crossed is through mediation by a more competent peer. In the context of the current research, teachers have prior knowledge while they are operating in their professional community, which they apply when confronted by new situations. A teacher gains knowledge as she or he develops, by way of social interactions with peers. The more experienced teacher can act as the more competent peer. Vygotsky used the term scaffolding to describe the facilitation offered by a more competent peer. This theory emphasizes the collaborative nature of learning and can be applied to the professional development of teachers. It suggests that the learner, in this case the teacher, must be actively involved in the learning process. Such learning can occur within a professional learning community.

Donald, Lazarus and Lolwana (2002) define the ZPD as that space that lies just beyond a person's present understanding, as illustrated below in Figure 3.1.

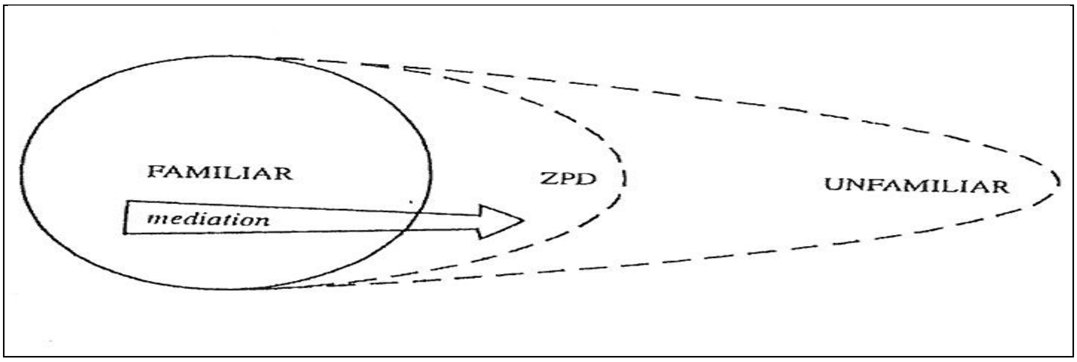


Figure 3.1: Zone of proximal development (ZPD) (Donald *et al*., p.71)

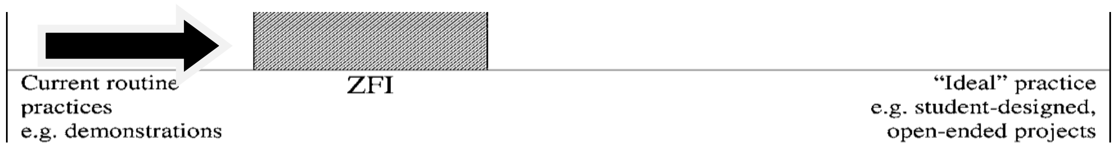
Donald *et al*. (2002) explain that the ZPD that space where someone cannot quite understand something alone, but has the potential to do so through proximal interaction with another person who has the capacity. Thus, the ZPD is the critical space in a persons' current understanding where, through face-to-face mediation, a new level of understanding can be fashioned. It is therefore the space where potential development of knowledge can occur. 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, 2002, p.240). Her argument in favour of the ZPD is that it encourages learning. Rogan adapted Vygotsky's ZPD to develop the ZFI.

3.4. Rogan Zone of Feasible Innovation

Rogan (2007) argues that changes in educational systems are necessary, however he contends that in developing countries the capacity to bring about change and the ability to sustain the change is lacking. Rogan (2007) proposes that the Zone of Feasible Innovation (ZFI) can be used to facilitate innovation or change. 'Innovation" in this study refers to the implementation of the biotechnology option together with a variety of teaching practices in biotechnology 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". As was shown in the previous chapter, the literature supports the view that professional development for teachers is a complex process. Integration of biotechnology education into the curriculum, therefore, requires a multi-pronged approach. The need for innovation and outside support in the form of professional development is therefore critical. Accordingly, Rogan's ZFI is useful, because the professional development I plan to offer is a professional learning community of practice, which can provide outside support to practicing teachers. If practicing teachers engage with this outside support they can build capacity for change. Rogan (2007) asserts that the ZFI is a function of the capacity available to support the innovation. He calls for (p.457) "outside support" that is needed for progress or change to occur. The professional development I will be offering provides such support with the aim of increasing the teaching capacity of teachers so that the innovation (successful teaching of biotechnology education) can occur.

Rogan (2007) speaks of the ZFI existing in a continuum of practice. In a continuum of practice there is a gradual movement from routine practice to more ideal practices, the ZFI will widen as the capacity to support the innovation increases. The ZFI is the area where practicing teachers will engage with new practices through activities arising from the intervention offered, which are at the beginning beyond their normal routine practice. These new practices will enhance the professional development of teachers and move them through the ZFI closer to the ideal. That is to be practicing teachers who are able to teach biotechnology successfully, and in so doing implement the new curriculum. Figure 3.2 which is based on Rogan (2007), suggests that practices that are not yet routine or current practices, are not beyond what would be feasible in time. "The ZFI assumes an acceptance of the final goal (ideal practices) and regards teachers' 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 rather than it being a rapid progression.

Teachers engage in professional development "Rurinda intervention" (a professional learning community that provides teachers with professional development)



Teachers are unable to teach Biotechnology education effectively due to inadequate professional development

Teachers are able to provide a high standard of biotechnology education after engaging in "Rurinda intervention"

Figure 3.2 The location of a ZFI on a continuum (Adapted from Rogan, 2007, p.450)

Central to the ZFI is Rogan and Grayson's (2003) theory of curriculum implementation, which is described next.

3.5 Rogan and Grayson's theory of implementation

Rogan and Grayson's (2003) theory of implementation was adopted to underpin the current research because, as the person providing a PDI programme to practicing biology teachers, I consider myself to be an outsider among the them; I no longer work for the education department. In order to trace the implementation of the professional development programme during phases 3 and 4 of data capture (see Chapter 4, section 4.6) I will deploy Rogan and Grayson (2003) theory of implementation.

Rogan and Grayson (2003) built on the work of Vygotsky by applying his learning theory, discussed above, to professional development of science teachers. Rogan and Grayson's theory of implementation (2003) is based on three main constructs; specifically, the profile of implementation, the capacity to support innovation and the support from outside agencies. For my conceptual framework I will focus on only the first two constructs, the profile of implementation and capacity to support innovation. Support from outside agencies is where the planned professional development innovation program lies. These constructs are interdependent and each one needs to inform the others. Each construct comprises four levels as reflected in Table 3.2.

Table 3.2 Constructs and their dimensions

Construct	Dimensions of the construct
Profile of implementation	1. Classroom interaction

	2. Science practical work 3. Science in society 4. Assessment
Capacity to support innovation	1. Physical resources 2. Teacher factors 3. Learner factors 4. School ecology and management

The *construct Profile of Implementation* is an attempt to understand and express the extent to which the ideals of a set of curriculum proposals are being put into practice. According to Rogan and Grayson (2003) the profile of implementation is viewed as a 'map' of the learning area and so it offers a number of possible routes that could be taken to reach a number of destinations. It includes four sub-constructs, which are the nature of classroom interaction (what teachers and learners do in relation to one another); use and nature of science practical work; incorporation of science in society; and assessment practices. The profile of implementation is about how the policy, in this case the professional development support programme, is put into practice. The profile of implementation can help the curriculum planner at school level to determine where they are in the curriculum changes.

Table 3.3 reflects the levels for the profile of implementation. The two initial levels for the profile of implementation encompass the period of becoming aware of and preparing to implement the new curriculum, followed by the levels characterized by mechanical and routine use. The highest levels are when the teacher begins to take ownership of the curriculum and may enrich it by making major modifications, representative of sophisticated learner-centred practices. In moving through the levels, there is an increasing growth towards learner-centred approaches and away from teacher-centred ones. However, unlike earlier developmental models, the Rogan and Grayson profile does not imply 'progressing' from one level to another, and it is therefore not linear. Rather, the higher levels are inclusive of the lower practices. Hence the levels are not prescriptive of what should be done at any given point in time, but rather suggest the mastery and use of an ever-increasing repertoire of teaching and learning practices. This implies that a teacher may, for example depending on a particular situation, jump from level 2 practices to level 4 practices and back to level 3. It is important to note that level 4 practices are not superior to a level 1 practice, they are merely different and applicable depending on circumstances. Thus, for instance teacher-directed demonstrations may be appropriate for large classes. The final levels are when the teacher begins to take ownership of the curriculum and may enrich it by making major modifications.

Table 3.3 Levels of Profile of implementation

Level	Classroom practice	Science practical work	Science and society	Assessment
1	**Teacher:** -presents content in a well organized way -has a lesson plan -uses textbook effectively -engages learners with questions	**Teacher:** -uses demonstrations to develop concepts -uses specimens found in local environment for illustration	**Teacher:** -uses example and applications from everyday life	**Teacher:** -uses written tests with mostly recall type questions, some questions are higher order thinking -tests marked and returned promptly
	Learners: -stay attentive and engaged -respond to and ask questions	**Learners:** -observe -ask and answer questions	**Learners:** -stay attentive and engaged -ask and answer questions	**Learners:** -mostly apply rote learning -sometimes apply higher order thinking
2	**Teacher:** -Textbook used in conjunction with other resources -Engages learners with questions to encourage deep thinking	**Teacher:** -Uses demonstrations to promote a limited form of inquiry	**Teacher:** -Uses specific problems or issues faced by local community	**Teacher:** -Uses written test with 50% of questions requiring higher order thinking -Some of the questions are based on practical work
	Learners: -Use additional resources to compile own notes -Engage in meaningful group work	**Learners:** -Assist in the planning and performing of demonstrations -participate in cook book practical work -communicate data using graphs and tables. -ask and answer questions	**Learners:** -with teacher assistance explore the explanations of scientific phenomena by different cultures	**Learners:** -Apply practical knowledge -apply higher order thinking
3	**Teacher:** -probes learners' prior knowledge -structures learning activities on relevant knowledge and problem solving techniques -introduces learners to the evolving nature of scientific knowledge	**Teacher:** Designs practical work to encourage learner discovery of information	**Teacher:** -Facilitates investigations	**Teacher:** -Uses written tests -tests include seen and unseen guided discovery type activities -includes other forms of assessment besides tests
	Learners: -Engage in minds-on activities -make own notes on the concepts learned from doing activities	**Learners:** -Perform guided discovery type practical work in small groups -write a scientific report -can justify conclusion in terms of data collected	**Learners:** -Actively investigate science application in own environment	**Learners:** -Apply practical knowledge -apply higher order thinking

4	**Teacher:** -Facilitates learners as they design and undertake long-term investigations/project -assists learners to weigh theories that attempt to explain the same phenomena	**Teacher:** -Facilitates learners with design and data collection strategies -Facilitates learners on data interpretation and conclusions	**Teacher:** -Facilitates learners with the community project and identifying the needs	**Teacher:** -Creates opportunity for different types of assessment -facilitates in compilation of portfolio
	Learners: -Take major responsibility for own learning	**Learners:** -Design and do own open investigations -reflect on designing and collected data -interpret data	**Learners:** -Undertake long term community based investigation -apply science to specific need in community	**Learners:** -Include open investigation of community project in assessment -create portfolio to present best work

Adapted from Rogan and Grayson (2003)

Rogan and Aldous (2004) argue that each level includes a mix of "low and high level activities" but a teacher moves to include higher level activities when such new practices are integrated into his or her teaching repertoire, thereby moving from teacher-centered practices to more learner-centered practices. Once the current level of the teacher is determined, a plan of action can be tailored by the school management or PLC of how the teacher could be supported to reach the required higher level. In drawing up of such a plan the context of the school is considered. The gap between the teacher's current level and the higher level that the teacher strives for or has the potential to reach is the ZPD (Vygotsky, 1978). Vygotsky suggests that learning only takes place when instruction proceeds just ahead of the learner's current level of development. Rogan (2007) refers to this gap as the ZFI as it is analogous to Vygotsky's ZPD. Rogan (2007) contends that during implementation of the curriculum teaching strategies will be effective if they proceed with the ZFI, that is just ahead of the teacher's current level. The conceptual framework will be used during data analysis.

The construct *Capacity to Support Innovation* is an attempt to understand and elaborate on the factors that are able to support, or hinder, the implementation of new ideas and practices in a system such as a school. It should be recognized that not all schools have the capacity to implement a given innovation to the same extent. Possible indicators of the capacity to support innovation construct fall into four groups as shown above in Table 3.2: physical resources, teacher factors, learner factors and the school ecology and management. Physical resources are certainly a major factor that influences capacity; poor resources and conditions can limit the performance of even the best teachers and undermine learners' efforts to focus on learning. A second factor pertains to the teachers' own background, training and level of confidence, and their commitment to teaching. As has been found in other parts of the world, lack of subject matter knowledge by teachers is a major problem in Zimbabwe (Mupa & Chinooneka, 2015). Change is essentially a learning process, entailing willingness to try out new ideas and practices, to improvise, to be exposed to uncertainty, and to collaborate with and support one another. One of the starting points in Bell and Gilbert's (1996, p. 16) model of teacher development is an awareness on the part of teachers that being isolated from their colleagues is a problem. A third factor relates to the background of the learners and the kind of strengths and constraints that they might bring to the learning situation. For example, learners might come from a home environment where there is no place for them to do homework, and no one to support and help them in their studies. Furthermore, family and cultural commitments might mean an absence from school for significant periods of time. A fourth factor, or set of factors, pertains to the general ecology and management of the school. Research has shown that the leadership role of the principal is crucial for implementation (Berman & McLaughlin, 1976 Hall & Hord, 1987; Fullan, 1991). A shared vision as to how the innovation will play out depends largely on the leadership of the principal and the support offered to the teacher. As the innovation begins to become a reality, the role of the principal also begins to take on new dimensions. Change has to be realistically planned and subsequently monitored. Those charged with the implementation of change need to be supported in a variety of ways, and need to be enabled for mutual communication and collaboration. These four factors together paint a picture of the capacity of a school to innovate.

The two constructs, profile of implementation and capacity to support innovation, from Rogan and Grayson's (2003) theory were used as a tool to gauge how the professional development innovation program was implemented. The study specifically focused on the level at which the teacher was operating at for each dimension of each construct. As mentioned previously each construct has 4 dimensions. There are outlined below in Table 3.4.

Table 3.4 Profile of the capacity to support innovation

Level	Physical resources	Teacher factors	Learner factors	School management and ecology
1	-Basic building but in poor condition -Toilets and running water available -Electricity in some rooms -Some textbooks but not enough for all	-Teacher is under-qualified for the position -Teacher does have a professional qualification -Teacher absenteeism is low	-Learners have some proficiency in language of instruction -Some learners do not receive enough food at home -School has feeding scheme	**Management**: -A timetable, class list and other routines are in evidence -The presence of the principal is felt in the school at least half the time -Staff and subject meetings are held at times

	-Some basic science apparatus -No science laboratory or laboratory is present but is not in working condition	-Teacher spends more than half the time teaching	-Learners have socio-economic problems -Learners receive very little academic support at home	-Attendance register for teachers exists **Ecology**: -Teaching and learning occurs most of the time -Teachers and learners return on time after the break -School governing body exists -School is secure
2	-Adequate basic building - good condition -Suitable furniture -Electricity in most rooms -Textbooks for all learners -Reasonable amount of apparatus for science	-Teacher has minimum qualification for position -Teacher is motivated and diligent -Teacher participates in professional development activities -Teacher has good rapport with learners	-Learners attend school on a regular basis -Learners are well-nourished -Learners are given activities -Teacher has good relationship with learners- respect	**Management**: -Teacher attends school regularly -principal is present in school most of the time and there is regular contact with staff -Timetable properly implemented -Extramural activities are organized in such a way they do not interfere with scheduled lessons -teachers and learners who shirk their duties are held accountable **Ecology:** -Responsibility for making the school functional is shared by teachers , management and learners -SGB operates well -School functions all the time
3	-Good building-enough classrooms and science laboratories -Running water and electricity in all rooms -Textbook for all learners and teachers -Sufficient science apparatus -Additional subject reference books for teachers -reasonably equipped library -Secure premises -Well-kept grounds	-Teacher is qualified for position - has sound understanding of subject -Teacher is an active participant in professional development activities -Conscientious attendance of class by teacher -Teacher makes extra effort to improve teaching	-Learners have access to a safe place to study -Learners come from supportive home environments -Learners can afford extra books and tuition -Parents show an interest in their child's progress -Learners have access to IT	**Management:** Principal takes strong leadership role, is visible during school hours Teachers and learners play an active role in school management **Ecology**: Everyone in the school is committed to making it work -Parents play an active role in the school development
4	-Excellent buildings -More than one well equipped lab -Library is well resourced -Adequate curriculum materials and other textbooks readily available. -Good teaching and learning resources -Activity grounds -Good copying facilities	-Teacher is over qualified for post, has excellent knowledge of content - Teacher is very committed to teaching -Teacher shows willingness to change, improvise and collaborate -Teacher shows local and international leadership in professional development activities	-Learners take responsibility for their learning -Learners are willing to try new kinds of learning	**Ecology:** -There is shared vision -School plans for, supports and monitors change -Collaboration of all stakeholders **Management**: There is a visionary but participatory leadership at school

Adapted from Rogan and Grayson (2003)

3.6. Link between theoretical constructs and this study

The poor uptake of the biotechnology options and learners poor performance in the A level examination indicate that A level biology teachers are experiencing challenges related to effective teaching and assessment in the biotechnology option. Rogan’s ZFI, Vygotsky’s ZPD and Rogan and Grayson’s theory of curriculum implementation, when fused together illuminates the way towards a renewed approach to the teaching and learning of the biotechnology option. This fusion of theories is applicable to my study because it calls for effective curriculum implementation, curriculum innovation and effective professional development as the foundation for effective teaching and learning of the biotechnology option. Curriculum innovation and effective professional development, if they are context relevant, can provide teachers with the requisite skills and knowledge to be effective teachers of the biotechnology option. In turn, this will positively affect and address the difficulties learners face as they are taught the biotechnology option.

In this study, the implementation of the biotechnology option was examined using only two constructs of the Rogan and Grayson (2003) curriculum implementation model for the theoretical framework; the level of curriculum implementation and the capacity to innovate and their sub-constructs. Therefore I came up with a modified analytical framework to gauge systematically the implementation level as well as exploring its links to school and teacher quality factors as represented by the capacity to innovate. Figure 3.3 shows how the constructs proposed by Rogan and Grayson (2003) were modified and used in an attempt to understand and explain the implementation process of the Zimbabwe A level biology curriculum (9190) with respect to the biotechnology option.

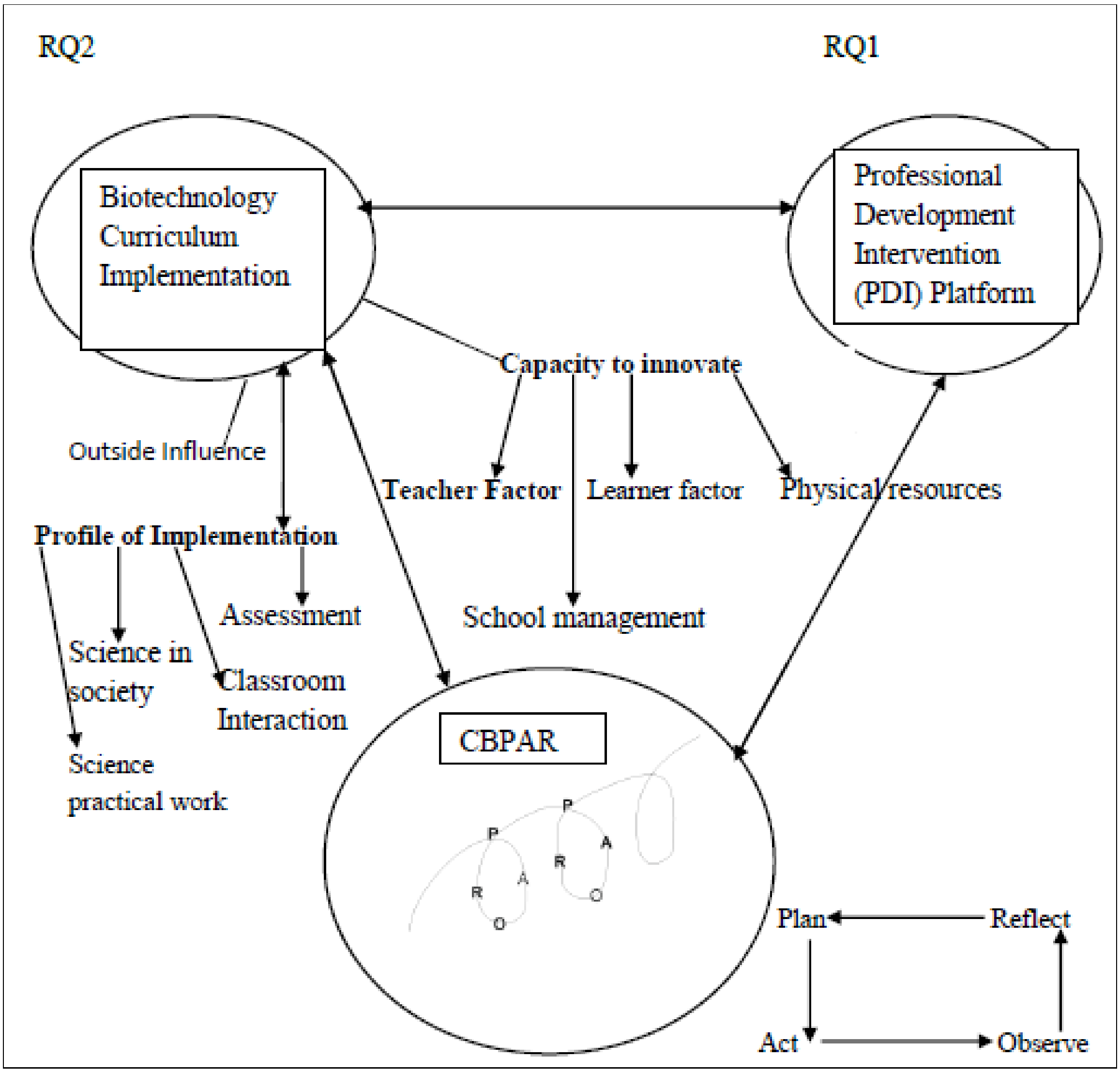


Figure 3.3 Modified Analytical Framework

In this study, the biotechnology curriculum implementation, professional development intervention platform and the community based participatory action research are the major constructs used, with the capacity to innovate and profile of implementation as sub-constructs. Under the capacity to innovate, the major factor explored was the teacher factors. The analytical framework for this study as in Figure 3.3 was used to analyse the data and it was derived and modified from that by Rogan and Grayson (2003) theoretical framework of curriculum implementation.

3.7. Conclusion

This chapter paid attention to the theoretical constructs that frame the study. CBPAR undergirds the development of the professional development intervention program to capacitate A level biology teachers in respect of the biotechnology option. To establish the learning that occurred during the PDI, Vygotsky's zone of proximal development was used. To ascertain the implementation of the PDI in practice, Rogan and Grayson's theory of curriculum implementation was used. The links between the theoretical framework used and the study were also clarified. The next chapter will focus on a discussion of the research design and methodology which was selected for this study.

CHAPTER 4

METHODOLOGY

4.1 Introduction

The previous chapter described the conceptual framework that underpins this study. That framework together with the nature of the research directed the choice of research methodology suitable for establishing a PDI program as well providing a discursive space for community engagement and obtaining in-depth information from the participants. According to Henning, Van Rensburg and Smit, (2004) research methodology consists of various techniques used in generating data that will produce answers to the research questions of the study. In agreeing with the above notion of research methodology, Creswell (2013) adds that research methodology entails the procedures through which researchers go about their work of describing, explaining and predicting phenomena. This chapter discusses the research paradigm, design methods and procedures that were used to establish the potential of community based participatory action research (CBPAR) as a professional development intervention platform, in order to revisit the biotechnology option in the A level biology curriculum (9190) in Masvingo Province, Zimbabwe. This platform should enhance the effective implementation of biotechnology option, an optional component of the A level biology curriculum. The methodological approaches and the methods selected will be described and justified.

The research paradigm is discussed first, which then leads into the rational for adopting a qualitative research approach in the study, and how this was adopted in the research design. The location of the study and sampling techniques used are outlined. The research instruments, and the procedures used for data collection and its analysis are described. Then issues around research rigor and ethics are considered. Finally, a summary of the chapter is presented in the last section.

4.2 Paradigm

Paradigms, according to Weaver and Olson (2006, p. 460), are “patterns of beliefs and practices that guide the way we do things, or more formally establishes a set of practices”. Cohen, Manion and Morrison (2011, p.23) interpret a paradigm to be the “philosophical intent or motivation for undertaking a study”, while Mackenzie and Knipe (2006, p.193) assert that it is the choice of paradigm that directs the intent, motivation and expectations of a research project. In effect, this means that the paradigm directs the thought patterns and actions undertaken in a study, from its inception. Therefore, paradigm selection must be undertaken during the initial stages of the study. Accordingly, it is essential to clarify at the outset the paradigm adopted in a study because it directs the structure of and methodological choices in the inquiry.

Paradigms serve as a lens through which a phenomenon may be viewed (Cohen, Manion, Morrison, 2011). The literature commonly refers to positivist, interpretive and critical paradigms. Cohen *et al.* (2011) explain these three paradigms as follows. Positivism strives for measurability and objectivity and the construction of laws and rules of behaviour. The interpretive paradigm aims to understand and interpret the world in terms of the participants while the critical paradigm focuses on change, empowerment, transformation and emancipation. The paradigm which framed this study was therefore the critical paradigm. Cohen *et al*. (2011) argue that the critical paradigm aims not simply to understand or describe a phenomenon or situation but to also liberate or make changes in situations where there are inequalities or imbalances in the system. The ontological position of the critical paradigm accordingly directs this study to adopt a community based participatory action research (CBPAR) approach, because the aim of the research is to create a PDI platform that will increase public awareness and engagement in biotechnology. Fundamentally, CBPAR here focuses on addressing educational challenges faced by learners, teachers and the community at large. Such an approach requires these key players to work together with the researcher to find appropriate means within a familiar context that will address these challenges (Mitchell cited in van Laren *et al.,* 2013). The emphasis of participatory research is not only on change in practice, but, as Bergold and Thomas (2012) assert, the aim is to produce new insights in the partnership between the researcher and participants These authors, furthermore emphasized that participatory research demands a high level of cooperation and willingness on the part of the participants to disclose their personal views of the situation, and their interpretations and experiences. In addition, a participatory research approach allows for in-depth, thick, rich descriptions generating words, vivid descriptions and insightful personal comments that will facilitate understanding of the phenomena under investigation within a particular context. The basic assumption is that existing practices are inadequate or can at least be improved upon, so that new practices are necessary (Barab and Squire, 2004). In my study greater public awareness and engagement in biotechnology issues will ultimately result in positive changes in teacher practices relating to teaching and learning of the biotechnology option in the A level biology curriculum. The focus is, therefore, on not only curriculum change but also on creating a platform for engaging with biotechnology issues and developing a professional learning community of practice to facilitate implementing the biotechnology option in the curriculum. Curriculum change is a learning process that requires teachers to also change or transform in order for its implementation to be successful.

In my study positive changes in teacher practices would be effected, thereby bringing about transformed teaching and learning of the biotechnology option in the A level biology classroom. The focus was on how the practices of A level biology teachers changed in order to implement the biotechnology option in the curriculum. The above idea resonates with those from Samuel (2014) and Singh-Pillay (2010), who both assert that curriculum change entails re-skilling of teachers. Hence, it is a learning process for teachers. In effect, this means that curriculum change requires teachers to make changes in their content knowledge (CK) and pedagogical knowledge (PK) so that their practice can transform to embrace the requirements of the new curriculum. In other words, for curriculum implementation to be successful teachers are required to change, that is transform, their practice. Such changes in the teacher practices are necessary because sometimes the diminished capacity of a teacher (in terms of CK and PK) restricts the implementation of curriculum change or innovation. In the creation of the PDI platform the notion of the critical paradigm is embraced, which according to Robson (2011, p.39), "is not only to explore, describe or explain but also to facilitate action, to help change or make improvements, to influence policy or practices".

4.3 Qualitative research approach

There are three research approaches in common use; namely, qualitative, quantitative, and mixed methods. This study embraced a qualitative research approach. "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, 2007, p.50). Qualitative research focuses on how individuals and groups view and understand the world and construct meaning out of their experiences (Creswell 2010, p. 50). According to Merriam (1998), qualitative research is an approach that recognizes that meaning emerges through interaction and these interactions are not standardized from person to person as in quantitative research, thus allowing the researcher to study issues in detail, without predetermined categorized analysis. Qualitative research is therefore a particular approach to inquiry based on a particular set of assumptions about the nature of reality itself. The purpose of qualitative research is primarily to understand the social phenomenon from participants' perspectives. In this research understanding would be acquired by analysing the many contexts of the participants and by narrating participants' meanings for these situations and evens, as recommended by Tichapondwa (2013).

In qualitative research, data is collected from a few cases or individuals, which means that findings cannot be generalized to the larger population, and that research quality is heavily dependent on the individual skills of the researcher. Furthermore, the volume of data generated makes analysis and interpretation time consuming.

Despite these shortfalls qualitative design was applied as it enabled issues to be examined in detail and depth. By using a qualitative approach, I was able to obtain rich and in-depth understanding of how to create a platform for engaging A level biology teachers in biotechnology using participatory action research.

4.4 Research design

A research design is a summary of the various procedures that a researcher employs to collect, analyse, interpret and present his or her research data (Durrheim, 2004). In other words the research design is the plan of how the researcher will systematically collect and analyse the data that is required to give valid solutions to research problems.

In this study, I opted for a case study design. Yin (2003, p.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". The hallmark of case study approach, according to Lapan, Quartaroli, and Riemer (2012) and Cohen, *et al.*, (2011, is that it provides thick descriptions of participants lived experiences of, thoughts about, and feelings for, a situation using multiple data sources. It focuses on individual actors or groups of actors and seeks a deep understanding of their perceptions of events. It is descriptive and detailed, with a narrow focus, and combines both subjective and objective data.

The term case study is often synonymous with qualitative methods. To study "cases" seems to imply looking closely and being drawn into the world of alternative perception and different views about common and shared tasks and workplace contexts. In the case study method, the reporting systems employed are descriptive of real events through note-taking, diaries, interviews, observations and documenting the behaviour of participants (Maree, 2007, Neuman, 1997).

A case study design was used here as it enabled me to gain a good insight and understanding of the dynamics of the biotechnology option, teachers CK and PK needs, the poor uptake of the biotechnology option in schools and learners poor performance in it within Masvingo. The case in this study was practicing A level biology teachers, the subject manager for ZIMSEC A level biology, and the high school headmasters in the Masvingo province whose schools were offering the A level biology curriculum (9190).

4.5 Location of the study

The study is located in the Masvingo province of Zimbabwe. Masvingo is one of nine provinces in Zimbabwe, as shown below in Figure 4.1.

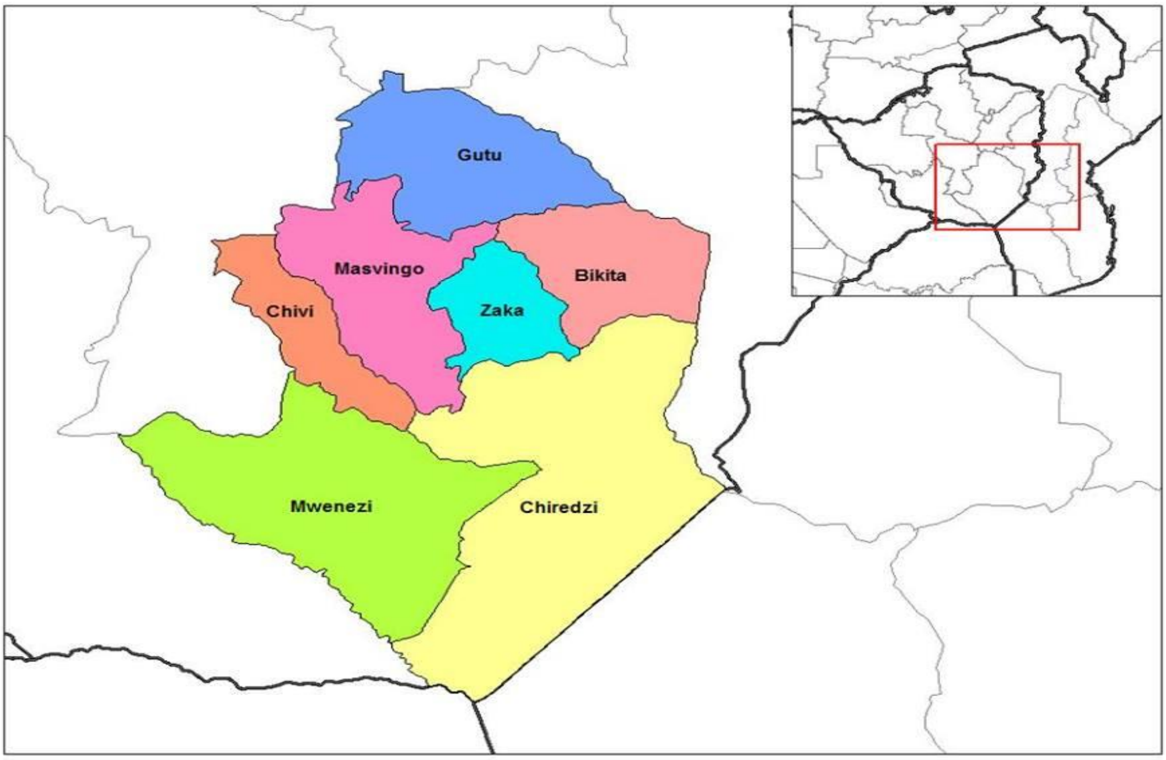


Figure 4.1 Map of Zimbabwe

The Masvingo province is largely populated by members of the ***Karanga*** tribe, who are the most populous tribe in Zimbabwe, and are a sub-group of the Shona speaking tribes that also include the *Zezuru*, *Manyika and Ndau*. Masvingo province, prior to 1982 was known as Victoria province. It is in the drier lowveldt area in the south of Zimbabwe, where the economy rests primarily on cattle ranching, mining and sugar cane growing; there are some communal areas where subsistence farming is carried out. There are 339 registered secondary schools in Masvingo; some of which are private schools run by church organizations, or private individuals, others are run by rural councils, but the majority are run by the government (Masvingo Ministry of Education, primary and secondary schools records, 2015). For administrative purposes, Masvingo province is divided into seven local government council district areas; namely, *Bikita, Chiredzi, Chivi, Gutu, Masvingo, Mwenezi*, and *Zaka.* Table 4.1 below shows the number of schools in each district that were involved in the study.

Table 4.1 Secondary school distribution in Masvingo

District	Registered schools	Satellite schools	Total
Bikita	30	10	40
Chiredzi	21	20	41
Chivi	33	8	41
Gutu	54	17	71
Masvingo	52	9	61
Mwenezi	21	22	43
Zaka	41	1	42
TOTAL	252	87	339

Source: Zimbabwean Ministry of Education records (2015)

Not all the schools in the table offer the ZIMSEC biology curriculum at A level; the number of high schools per district currently offering this biology curriculum are shown below in Table 4.2.

Table 4.2 Number of High Schools per district currently offering ZIMSEC A level biology curriculum (9190) in Masvingo Province.

District	High Schools offering ZIMSEC biology curriculum for A level (9190).

Bikita	3
Chiredzi	4
Chivi	2
Gutu	7
Masvingo	5
Mwenezi	2
Zaka	2
TOTAL	25

Source: Zimbabwean Ministry of Education records (2015)

The low percentage of schools offering A level biology comes to the fore via Table 4.2 above.

4.6 Sampling

Sampling is "a process of selecting a subject or sample unit from a large group or population of interest" with the purpose of answering the research questions, as defined by Tashakkori and Teddlie (2010, p. 356). In addition, Gay, Mills & Airasian (2009, p.113) note that qualitative sampling is the "process of selecting a small number of individuals for a study in such a way that individuals are good key informants who contribute to the researcher's understanding of a given phenomenon". Purposive sampling was used to select practicing A level biology teachers, from schools offering A level biology in Masvingo. 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, p.138) mention that in purposive sampling "the researcher selects particular elements from the population that would be representative or informative about the topic of interest". The criterion for selection of participants in this research was that they were practicing teachers who taught advanced level biology in their schools. These selected biology teachers potentially possessed rich and valuable information that would assist in answering the research questions of the study. Each school reflected in Table 4.2 had at least one A level biology teacher. Thus, 25 A level biology teachers were invited to the initial meeting that addressed the need for CBPAR and identified the needs for the teachers regarding the type of PDI for the biotechnology option.

Headmasters from all high schools in Masvingo were invited to attend the initial stakeholder meeting to engage in CBPAR, not only those that offered biology at A level. I envisaged that headmasters whose schools did not offer A level biology might be interested in offering A level biology and the biotechnology option once they engaged in CBPAR. Further, I invited five lecturers of biotechnology from a university in Masvingo, as they were also keen to engage in the PDI. These lecturers hoped that with appropriate input more students would take on and pass the biotechnology option at school, and then pursue biotechnology at university.

To a lesser extent this study used convenience sampling. Cohen *et al*. (2011) maintain that convenience sampling involves choosing the nearest individuals to serve as participants. The rationale for this sampling technique was that all the participants were based in schools within the Masvingo province, where the study was conducted and were easily accessible to me because I worked there.

It is significant to note, that even though only 25 A level biology teachers had been targeted and invited to the initial meeting of stakeholders, 40 teachers from Masvingo attended the initial meeting. This was unexpected. It highlighted teachers' interest in developing a PDI platform.

4.7 Data generation

Data generation for a qualitative inquiry involves the use of different techniques and methods, thus "qualitative research is a multi-method approach" (Denzin & Lincoln, 2000, p.5). In accordance with that idea, Cohen *et al*. (2011) indicate that qualitative data arise from many sources, such as interviews, observations, documents, photo narratives and reflective diaries.

As mentioned previously in Chapter 1, this study employed CBPAR to create a PDI program to address the poor uptake of the biotechnology options in schools, improve learner performance in the biotechnology option and contribute to creating greater public awareness of biotechnology in Masvingo. To embark on this CBPAR project data was collected in five phases as reflected in Table 4.3 which follows next.

Table 4.3 Data generation plan

phase	Data generation plan	Data source	Justification of method
1	Setting the stage: Invitation meeting	Stakeholders (A level biology teachers, headmaster, lecturers)	Initiation of research project- identify stakeholder, their needs
		Video recording of meeting: focus group discussion Researcher reflective diary	For reflection - planning next stage
2		Video recording of meeting: focus group discussion	For reflection

	Planning the intervention: Material development meeting for PDI	Reflective journal: Researcher	To reflect on the intervention planned–identify how it can be improved, what change must occur, how to further support teachers for example in content, teaching methods, and assessment
3	Enrolment of PDI	PDI – video recording: observation of training	For reflection on enrolment- note successes and challenges
		Focus group discussion	
		Researcher and participant- reflective journals	For reflection, further planning, refinement of PDI
4	Enactment of PDI	Reflective journal: Biology teachers will reflect on their experiences of innovating in biotechnology education. The purpose is for practicing biology teachers to introspect on their innovative methods of teaching.	"...means of enabling teachers to conceptualize the nature of their own professional development ..." (Moon, Michaels & Reiser, 2001, p.368).
		Observation of lesson: Document analysis: Teaching portfolio-lesson plans/tests	To establish the application of innovation in respect of content, teaching strategy and assessment in biotechnology option
		Interview: Two individual face to face interviews will conducted with biology teachers on their experiences of PDI and its enactment These will be conducted with participants before and after their lesson is taught	"...logical gaps in data can be anticipated and closed" (Cohen *et al.*, 2007, p. 353).
5	Invitation Meeting	Meeting: video recording of focus group discussion	For overall reflection from phases 1 to 5. Development of model: For Biotechnology awareness in Zimbabwe

From the data generation plan in the table, it is worth noting that in each phase reflection was occurring at two levels. This means that reflection was about, firstly, my own learning about the practice (i.e. enactment of PDI by teachers) and then about our mutual learning in the process of creating the innovative platform via CBPAR. The key differences between CBPAR and conventional methodological approaches lie in the location of power in the research process (Cornwall & Jewkes, 1995). CBPAR is participatory to the extreme; it is based on the people's role in setting the agendas, participating in the data gathering and analysis and controlling the use of outcomes. The epistemological standpoint of CBPAR therefore opposes that of other schools such as empiricism, logical positivism and structuralism which reject the social value bias in what is considered to be scientific research. CBPAR also constitutes an epistemological shift by emphasizing the fundamental importance of 'experiential knowing'. According to Fals-Borda (2001), this means that it is through the actual experience of something that we intuitively apprehend its essence; we feel, enjoy and understand it as reality. Reason and Bradbury (2006) also pointed out that PAR articulates an extended epistemology, which involves the reclaiming of three broad ways of knowing; that is, thinking, feeling and acting. CBPAR as a methodology in this study was used to form a professional development platform, which is characterized by the need to transform the A level biology teachers practice in terms of the biotechnology option and thereby improve learner performance in the option, and to encourage the majority of teachers and schools to offer the biotechnology option. This platform was also meant to deepen the biology teachers' subject matter knowledge, and their pedagogical content knowledge on biotechnology, including sharpening of classroom skills for teaching and learning this option.

Teachers who participated in this study requested that the team involved in the PDI be referred to as 'Biotechnology option teaching and learning communities' (BOTLC).
As reflected in Table 4.3 above data was generated in five phases; each phase is discussed next.

Phase one*: *Setting the stage for CBPAR: needs survey

This first phase was diagnostic, in which problems were identified, reflected upon and a solution was proposed. In the entire phase the emphasis was on joint participation- whereby stakeholders were to work together to address the identified problem in order to bring about change in practice. The stages are shown in the diagram below in Figure 4.2.

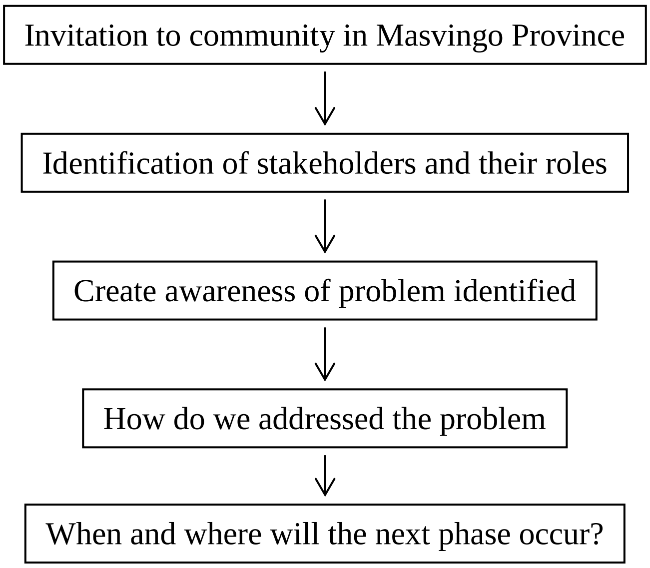


Figure 4.2Steps involved in phase one

A meeting was held at Victoria High School on 16 October 2015 and was attended by 65 people (40 teachers and 20 stakeholders made up of headmasters, heads of departments, officials from

MoPSE and 5 lecturers of biotechnology from a university in Masvingo). The meeting took the form of a focus group discussion. The purpose of the meeting was to

- Create awareness of the current dilemma in respect of the poor uptake of the biotechnology option at schools in Masvingo,
- Create awareness of the learners poor performance in the A level exams in biotechnology,
- Identify stakeholders strengths and needs,
- Decide what was to be done to increase engagement in biotechnology option in Masvingo province,
- Decide how they were to be involved,
- Decide where and when the intervention would occur, and
- Agree upon a date for the next phase.

I started the meeting by providing a brief discussion on learner performance in the biotechnology option. As reported in the Zimbabwe School Examination Council Report (ZIMSEC, 2013), teachers lack content knowledge (CK), pedagogical knowledge (PK) and have poor assessment practice when they engage learners in the biotechnology option. Thereafter I invited comments. Guidance from ZIMSEC (2013) undergirded my need to be proactive and formed part of my plan of action. The meeting discussion was video recorded. Video recording was used as it can capture non-verbal data, such as body gestures, facial expression, and tone, that audio recordings cannot or which the observer may miss (Asan & Montague, 2014). Another advantage of using video recordings is that it allows for repeated viewing and checking, and more importantly for reflection. The video recording of the meeting, together with my reflective diary served as data sources for phase 1. The video recording of the discussions were transcribed and sent to stakeholders for member checking as validation. The transcripts were later subjected to content analysis.

Phase two: Planning the intervention: The way forward-materials development

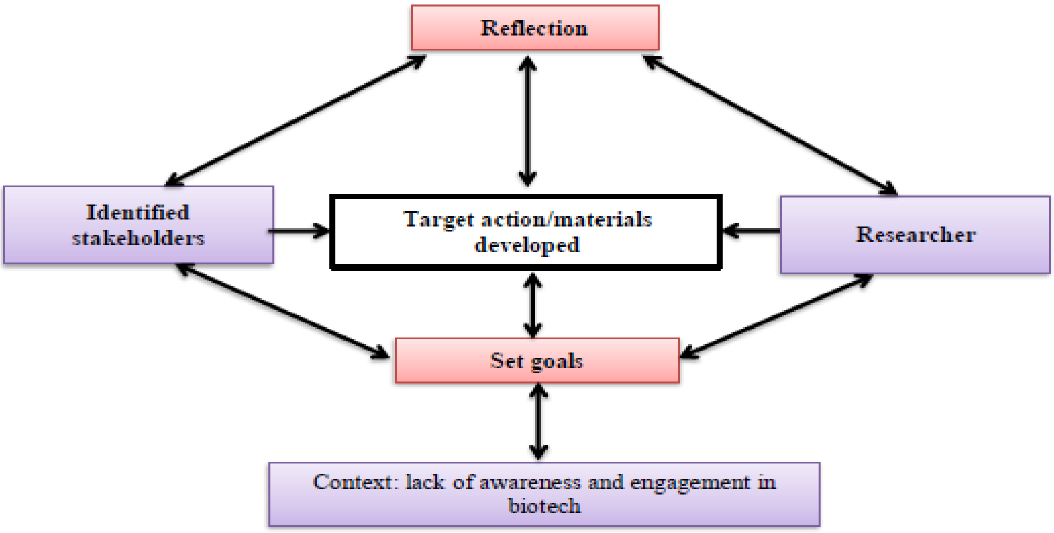


Figure 4.3 Planning the intervention

In the second phase, the consenting stakeholders met in December 2015 when schools had closed, to begin developing materials for the proposed intervention; materials were to be developed based on the needs identified in phase one. Only 35 of the stakeholders from phase one met at this stage; 25 were teachers from schools offering the A level biology, 5 were lecturers of biotechnology at a university in Masvingo and the other 5 were headmasters in-charge of science. At this materials development meeting those present decided to refer to our group as 'Biotechnology option teaching and learning communities' (BOTLC). In this way the professional learning community of practice (BOTLC) was formed. The teacher stakeholders voluntarily chose to join one of the five learning areas they had identified in phase one (Scope of biotechnology, Agricultural biotechnology, Food biotechnology, Medical biotechnology, Industrial and Environmental biotechnology) to work collaboratively with lecturers of biotechnology and the researcher. Each lecturer chose one topic out of these five areas to lead and support material development. Five teams were thus formed and the headmasters were each requested to join one of the five teams. Each team met regularly (three times per term) in order to assist one another in preparing the contextualized materials for teaching and learning the biotechnology option. These teams met between December and April. For each team's work discussion on planning, action and reflection was video-recorded. In the second phase the collaborative nature of CBPAR came to the fore, as shown by the joint participation in materials development to address the problem that had been identified in phase one. Materials that targeted content knowledge, pedagogical knowledge and assessment were developed to support teachers in their delivery and engagement with the biotechnology option.

Phase three: Enrolment of stakeholders via PDI

The 25 teachers, who had been guided by the 5 lecturers in terms of the needs identified in phase one and had developing teaching and assessment materials in phase two, met again during the school holidays in April 2016. The headmasters did not want to participate in phases 3 and 4 of data generation.

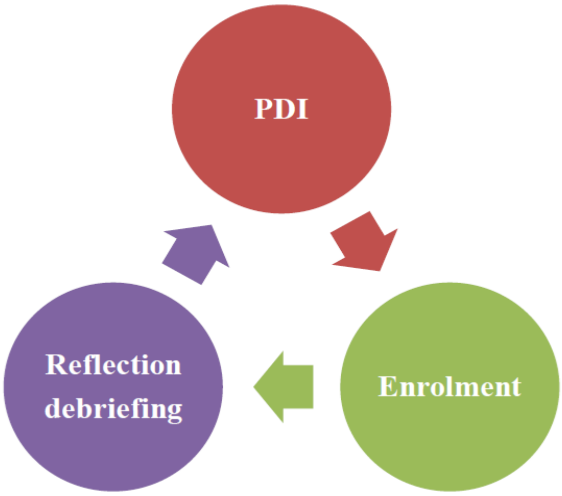


Figure 4.4 Enrolment of stakeholders in PDI

The enrolment sessions in April involved teachers working with the materials developed. Teachers were taught how to use the materials developed in their teaching. They were involved in hands on learning, demonstrations, investigations, field work, exposed to different pedagogy that could be used to teach each of the 5 topics in the biotechnology option. These enrolments sessions were video recorded. Teachers maintained a reflective journal of their experiences during their PDI enrolment. Teachers also participated in a focus group interview at the end of the enrolment session.

Phase four: Enactment of PDI

During the last phase, nine of the A level biology teachers withdrew from the study due to their having been transferred to other provinces, or their no longer teaching A level biology (having been moved to teach other subjects at their schools). Sixteen A level biology teachers engaged in enacting PDI in their respective schools during the third term of 2016, for which they had maintained reflective journals (see Appendix J for an exemplar). Of these 16 teachers, only four consented to have their lessons and teaching portfolios observed and to be interviewed. The following four data generation methods were used in this phase namely:

- Reflective Journal
- Observations of lessons,
- Document analysis of teacher portfolios including lesson plans and tests, and
- Interviews.

Next I discuss the aforementioned data generation methods used during phases 1 to 4.

4.7.1. Reflective Journals

Keke (2008) mentions that a reflective journal is a tool that allows people to gain a greater and more in-depth understanding of experiences than is ordinarily so. According to Phelps (2005) reflective journals provide an in-depth insight into the process of learning and have the ability to facilitate reflective learning. In a research context, Creswell (2013) maintains that reflective journals provide participants with the opportunity to critically reflect on learning experiences that are to be studied.

The participants in this study reflected on their experiences of innovating in biotechnology education,of engaging with the PDI materials for the biotechnology option, and their experiences of curriculum implementation. They were provided with a template which they used to document their reflections of curriculum innovating. The template was framed according to the constructs of the zone of feasible innovation.

4.7.2. Observation of lessons

Of the 16 A level biology teachers who continued through the phases, 4 volunteered to have their lessons observed. Lessons were observed using an observation schedule, which was designed according to the conceptual framework. See appendix Table 12 for the observation schedule. The data were collected through observations of two biotechnology lessons at 4 schools. The lessons were video-recorded and transcribed. Data from lesson observations were analysed using the analytical framework, as given in Table 4.4, which includes two of the original three constructs from Rogan and Grayson (2003) specifically “Profile of implementation" and "Capacity to innovate". For both constructs, some sub-constructs were also modified from those on the original framework, as shown in Table 4.5 and 4.6

Table 4.4 Analytical frameworks

Construct	Description of construct	Sub-construct
Profile of Implementation	Concern how a biotechnology lesson is conducted in a classroom.	(a) Teaching and learning activity. (b) Interaction in a classroom. (c) Biotechnology in society. (d) Assessment.
Capacity to innovate	Schools capacity to support or encourage biology teachers to implement the biotechnology option.	(a) Physical resources. (b) Teacher factors. (c) Learner factors.

Table 4.5 Sub-Construct of profile of implementation

Sub-Construct	Level and its descriptor
Teaching and learning activities	(1) Lecture methods, No teaching materials are used. (2) Activities include some hands-on activities using teaching and learning materials tasks. (3) Biotechnology practical work teacher facilitate outcomes not shared through discussion. (4) Practical work including observation.
Interaction in a classroom	(1) Teacher interacts with students nor encourages .the interaction between students in class. (2) Teacher not follows up the answers or the outcome of students tasks or cook. (3) Teacher actively interacts with his or her students as well as encouraging the interaction between students. (4) Teacher actively interacts with his or her students in a whole class and individually.
Biotechnology in society	(1) In the lesson, no linkage between biotechnology and daily life is mentioned. (2) In a lesson the linkage between biotechnology and daily life is use mentioned life out providing any facts or examples. (3) In the lesson facts or examples are provided in terms of application of biotechnology in daily life. (4) Linkage between biotechnology and daily life is mentioned based on the concrete a relationship between students' immediate learning situation or environment and application of low technology.
Assessment	(1) No form of assessment is seen. (2) Assessment is superficial only a few simple questions which do not cover lesson content.

	(3) Continuous or formative individual or group type of assessment oral or written exercise tests to achieve objectives but not verified. (4) Assessment under taken by well-structured questions according to the blooms taxonomy focusing on individual students.

Table 4.6 Observation schedule

Dimension	Descriptors	Remarks	Level
Classroom practice	Teaching method		
	Lesson plan		
	Use of textbook		
	Use of media		
	Learner engagement		
Practical work	Practical work		
	Method used		
	Teacher role		
	Learner involvement		
	Local environment		
	Equipment availability		
	Improvisation		
Science in society	Everyday examples		
	Involves local community		
	Learner involvement		
Assessment	Type of assessment		
	Type of questions		
	Portfolios		
	Amount of work done		
Personal well being	Feeling experienced		
	Teacher agency		

4.7.3 Document analysis

According to Yin (2009), document analysis entails studying documents to understand their content, so as to provide specific details that corroborate information from another source. In document analysis, both primary and secondary documents can be used. According to Cohen *et al.* (2011) primary documents provides direct or firsthand evidence about an event, object, person, or work of art, while secondary documents are documents complied by authors who have read a primary document. In this study primary documents were analysed. Sixteen A level biology teachers' teaching portfolios containing their lessons plans, assessments (i.e. tests, practicals, assignments, etc.) pertaining to the biotechnology option were analysed (see Appendix H for the protocol used).

According to Cohen *et al*. (2011) document analysis has the following advantages:

- It is less time-consuming than questionnaires, as it relies on data selection rather that data collection.
- It is cost-effective as the data does not need to be first generated and all that is needed is for the document to be analysed.
- The researcher's presence has no influence on what is documented.

4.7.4. Individual Interviews

Cohen, Manion and Morrison (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". Two interviews were conducted with each of the four practicing teachers, one before and one after the observed lesson. I chose semi-structured interviews as they provided me with enough flexibility to probe participant responses, to seek clarity and ensure participants' responses answered my research questions, as recommended by Maree (2009). The interview protocol is given in Appendix I. These interviews were audio recorded. The recordings were transcribed and sent to the participants for member checking to ensure accuracy and validity. The interview protocol was piloted with teachers from Harare, in order to check the quality and clarity of the questions and obtain the overall idea of the time taken for the interview.

Phase five: Reflection on action

After the enactment of the PDI at their schools all stakeholders were invited to a meeting to reflect jointly of the PDI undertaken, plan for its improvement, evaluate the PDI in terms of teamwork, undertake further planning, evaluate learner's performance in the biotechnology option and make plans for proliferation of the PDI to other provinces in Zimbabwe. The meeting was attended by the original 25 teachers who had participated in the PDI platform, 5 lecturers of biotechnology and 5 headmasters and the researcher. This meeting began with the teachers sharing their experiences of enactment of the PDI for biotechnology education in their respective school, and their experiences on the enrolment during the PDI. This was to initiate discussion and refinement of the PDI.

4.8 Data analysis

Data analysis refers to the "process of making sense and meaning from the data that constitute the findings of the study" (Merriam, 1998, p.178). Ezzy (2002, p.83) defines data analysis as "reviewing each unit of analysis and categorizing it according to the predefined categories". The data in my study were analysed using qualitative data analysis.

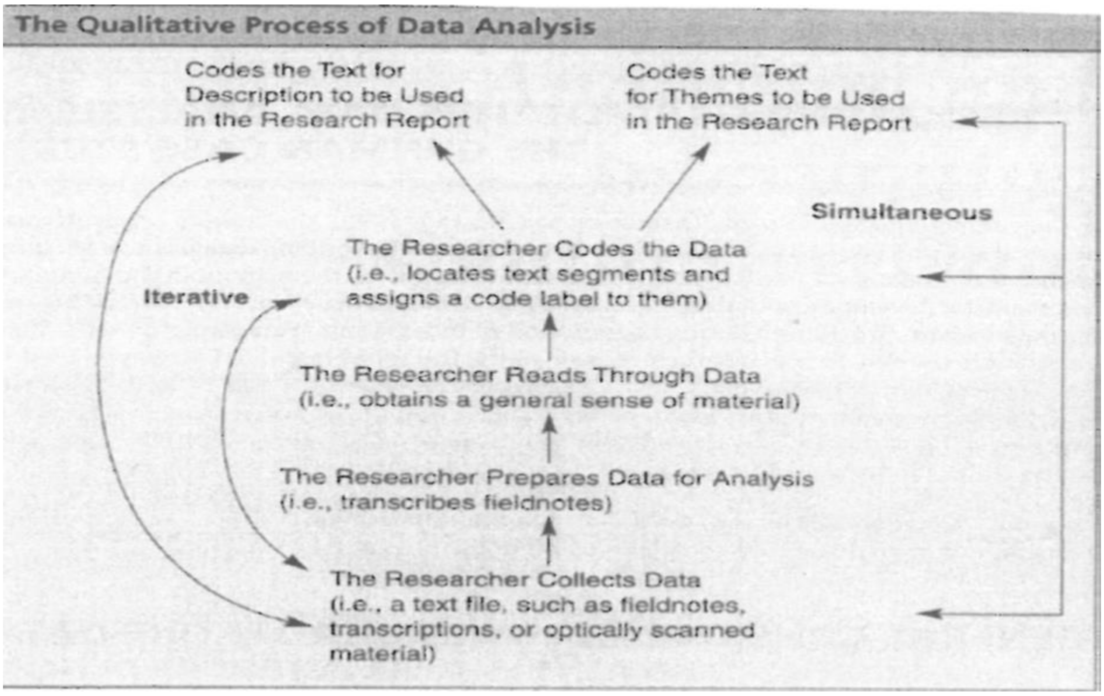


Figure 4.5 Diagrammatic representation of data analysis (from Creswell, 2012, p.137).

Figure 4.5 above reveals that analysis of qualitative data is not a linear process, but is a cyclic, iterative process. The figure also illuminates that analysis is a recursive process as one part can refer the researcher back to a previous part. Further, the process of qualitative data analysis is holistic, because each step in the process influences 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 focus group interviews, my thoughts reverted to what participants had written in their reflective journals, and I was able to find a link between the two. In this way, my analysis was recursive. As I read the reflective journals of participants, I made notes of possible questions that I could include in the interviews, thus making my data analysis holistic.

In this study the interview and focus group discussion data analysis was done continuously during the data collection process, as all the conversations had been recorded. The audio recordings of interviews were listened to several times before transcribing them. Transcripts were verbatim (see Appendix K). Thereafter each interview transcript was read and re-read several times. The reflective journals were also 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, as recommended by De Vos (2004).

In my study, I employed content analysis. Content analysis involves the organization of the data into categories (Ezzy, 2002) and the process of summarizing and reporting written data (Cohen, *et al.*, 2011). In my study, coding was used to categorize the data that had been 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), which according to De Vos (2004, p.344) “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 (2004, pp.345-346) describes these three types as follows:

- Open coding: “the process of breaking down, examining, comparing, conceptualizing and characterising data”,
- Axial coding: “a set a 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. 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. I searched for those that had “internal convergence and external divergence” thus each code was consistent within itself but distinct from 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 & Rossman 2006, p.165). Major themes were then separated into sub-themes so that they would be more convenient to analyse. For example, *the theme of the challenges experienced by practicing A level biology teachers when they taught the biotechnology option (prior engaging in the PDI via CBPAR)* was divided into two sub-themes namely, *professional challenges* and *contextual challenges*.

Finally, the data was engaged with critically and links within the data were established. The professional development needs of A level biology teachers was analysed so that relevant materials and support could be provided to them during the PDI program. Participants’ accounts of their experiences during enrolment of the PDI were analysed.

The conceptual framework was used to guide the data analysis process, particularly during the enactment of the PDI programme. This means that Rogan and Grayson’s (2003) theory of implementation was used to interrogate the classroom observation. The dimension for the profile of implementation and capacity to support innovation (reflected in table 3.3 and 3.4 respectively from chapter 3) were used to structure the observation schedule and the data analysis as per table 4.4. The descriptors for each dimension were used as a lens to ascertain the level at which the PDI had been implemented. The same procedure was applied for capacity to support innovation.

4.8. Rigor of the research

Rigor entails all the steps taken in the study to ensure thoroughness or consistency. Every research study is subject to an open critique and evaluation. Without this, the value of the study, soundness of its methods, accuracy of the findings and the quality of assumptions made or conclusions reached could be questionable (Long & Johnson, 2000, p. 30). Results from the data collected and analysed in my study were exposed to criticisms from other researchers in the field of study. In this study, to prevent bias and improve trustworthiness in this study, data were collected through document analysis, focus group discussion, reflective diaries and photo narratives. This allowed for triangulation of data. Triangulation, involves the examination of evidence emanating from different data sources and then combining it to create a succinct justification for the themes. The responses from the participants, documents and observations will produce comprehensive information that can be cross-checked for consistency. Triangulation of data increases credibility and dependability of findings (Creswell & Miller, 2000, p. 126).

I also engaged in member checking. Creswell and Miller (2000) suggest that member checking is related to participant reflection, and "consists of taking data and interpretations back to the participants in the study so that they can confirm the credibility of the information and narrative account. A popular strategy is to convene a focus group of participants to review the findings, or have the participants view the raw data and comment on their accuracy" (p. 127). For this study, member checking was applied during all stages of data generation. All transcripts were sent back to participants to confirm that the transcript reflected their true responses. Member checking was essential to ensure that participants expressed their views accurately on the phenomenon being explored, and to avoid misinterpretation by the researcher. I found member checking to be important, because of the possibility of mishearing what had been said and to ensure participant views were captured accurately.

4.9. Ethical issues

According to Durrheim and Wassenaar (2002), the code of ethics for research is concerned with the researcher's attempt to value human rights. There are number of ethical considerations that must be observed when doing research among humans, because it may be invasive and complex (de Vos *et al*., 2005). One ethical aspect is gaining access to a site or participants or both, which means dealing with various gatekeepers at each research stage, as is explained next.

Prior to conducting this study, formal permission to conduct research was first obtained from UKZN's research office, which included the ethics committee, and the Masvingo Provincial Office of the Ministry of Primary and Secondary Education. Permission to conduct research was then obtained from the relevant school principals in the Masvingo province. Once I had gained the headmasters' consent to conduct research at their schools, I finally sought permission from individual A level biology teachers to include them in this study. Whilst requesting the teachers' permission, I informed them verbally about the background and purpose for the study and the tenets of CBPAR. Participants were also made aware that they could choose to withdraw from the study at any time, and they would also be guaranteed confidentiality and anonymity. I also informed teachers about how I intended to collect data. See Appendices A to G for these permission letters.

During this study I have come to realise that gaining access is an incremental process of dealing with various gatekeepers at each stage of the research. For example even though the principals of 25 schools had granted me access to their schools and each of the A level biology teachers had consented to participate in the study, participants from two schools withdrew during the enactment of the PDI.

4.10 Conclusion

The study was designed to establish a PDI platform using PAR for A level biology teachers in Masvingo province for the teaching and learning of biotechnology option. The research design was based on that developed by Rogan and Grayson (2003). Data for the actual PDI platform were generated using focus group meetings, interviews with education officers and other key stakeholders. Data obtained from the focus groups, lesson observation, photo narratives and journals as well as interviews were analysed qualitatively for emerging themes. The next three chapters present data and findings concerning the three research questions.

CHAPTER 5

TEACHERS' PROFESSIONAL DEVELOPMENT NEEDS IN TERMS OF BIOTECHNOLOGY OPTION

5.1 Introduction

In this chapter, the qualitative data generated prior to the teachers embarking on the PDI programme is presented in order to answer research question one, which is: *What are A level biology teachers' professional development needs in terms of biotechnology option?* Data from the focus group discussion at the initial stakeholders meeting, reflective journals (see appendices I and K) and my reflective journal is presented, analysed and discussed. Two themes emerged from the data, professional challenges and contextual challenges. Each theme had subthemes as reflected below.

Professional challenges:

- Lack of Subject matter knowledge and Pedagogical content knowledge
- Lack for professional support and need for a safe nurturing space
- Use of equipment available
- Teacher pacing and syllabus coverage

Contextual challenges

- Lack of support at school level
- Lack of resources

In the next section, I present a table reflecting the challenges encountered by each participant before I discuss the two themes and their sub themes. For each theme, I present data from the focus group discussion followed by supporting literature. Thereafter I present my own reflections from my journal. The chapter ends with a conclusion.

Table 5.1 Challenges encountered by A level biology teachers prior to their engagement in the PDI.

A tick **(✓)** indicates that the participant experienced that theme as a challenge and a cross indicates that the participant did not experience that theme as a challenge.

Participant	Professional challenges				Contextual challenges	
	Lack of SMK &PCK	Skills using equipment	Lack of PD support	Teacher pacing/syllabus coverage	Lack of support at school	Lack of resources
1	✓	✓	✓	X	✓	✓
2	✓	✓	✓	✓	✓	✓
3	✓	X	✓	X	✓	✓
4	✓	✓	✓	X	✓	✓
5	✓	✓	✓	✓	✓	✓
6	✓	✓	✓	✓	✓	✓
7	✓	✓	✓	✓	✓	✓
8	✓	✓	✓	X	X	✓
9	✓	✓	✓	✓	✓	✓
10	✓	✓	✓	X	✓	✓
11	✓	✓	✓	✓	✓	✓
12	✓	✓	✓	✓	✓	✓
13	✓	✓	✓	✓	✓	✓
14	✓	✓	✓	X	✓	✓
15	✓	X	✓	✓	✓	✓
16	✓	✓	✓	✓	✓	✓
17	✓	✓	✓	✓	✓	✓
18	✓	✓	✓	✓	✓	✓
19	✓	✓	✓	X	X	✓
20	✓	✓	✓	✓	✓	✓

5.2. Professional challenges

In this section I present the four subthemes, Subject matter knowledge and pedagogical content knowledge, lack of professional development support and the need for a safe nurturing space, use of available equipment, and lack of knowledge on pacing and syllabus coverage

5.3.1. Subject matter knowledge and pedagogical content knowledge

In this section, I focus on the subject matter knowledge that A level biology teachers need to have at their disposal in order to engage effectively with the biotechnology option.

Content analysis of the transcript from the stakeholder meetings reveals that all teachers (20) and stakeholders require professional development in five key areas namely,

- Scope of biotechnology
- Enzymes and immobilization
- Medical biotechnology: biosensors, gene therapy, antibodies and bio-safety issues, human growth hormones, and vaccines
- Environmental biotechnology: Roles of microorganism in the extraction of heavy metals and pollution
- Agricultural biotechnology: the relevance of agriculture to a land-scarce nation

The excerpts from the focus group discussion are revealing, as shown by the following excerpts:

> *I'm uncertain about teaching this option, all 5 sections in the syllabus my knowledge is limited I wasn't trained in biotechnology, it a challenge, I don't know the content how can I design activities? (P4)*

> *I don't feel I can handle teaching the content in the 5 sections of this option, I cannot respond to learners questions, I just teach and tell them go home and learn the notes- I cannot explain it (P6).*

> *I will have to read about each topic, learn it before I can try to teach, to read on all sections is very demanding physically and intellectually I still don't know how to teach the learners abstract concept (P5)*

> *I'm not confident to teach this option as I don't know the content … I don't want to look like a fool in front of my learners… so how can I know how to teach it, if what I'm doing is correct (P30)*

> *We were not consulted about the option, there is no training, how can we teach if we are not trained to teach… (P20)*

I have a few learners in my school who want to do the option but the teacher discourages learner from taking the option as he is ill equipped to teach it (P40)

It was apparent from the preceding excerpts that teachers found it challenging to teach the biotechnology option within the A level biology curriculum. Their views indicated that they struggled to find innovative strategies to teach content to learners. It is clear that teachers are faced with immense challenges when they lack subject matter knowledge (*don't feel I can handle teaching the content, have to read about each topic, I'm not confident to teach)* to engage with the biotechnology option. For these teachers teaching the biotechnology option is a "*challenge*" as they need to understand and learn unfamiliar content (*I wasn't trained in biotechnology;* I *will have to read about each topic, learn it ...)*. With regard to the preceding excerpts the interplay between teachers lack of subject matter knowledge and pedagogical knowledge comes to the fore (don't *know the content*. *How to teach it, if what I'm doing is correct).* This means that these teachers cannot make use of their subject matter knowledge to organize and use content knowledge more effectively for their students to understand the biotechnology option. In the absence of subject matter knowledge it is extremely difficult to transform content knowledge into lessons and lesson activities (*I don't know how to teach it; I'm uncertain about teaching this option; how to design activities).* With regard to the preceding point, it has been shown that teachers' knowledge base strongly influences all aspects of teaching, such as preparation, planning and making decisions regarding the choice of content to be learnt (De Jong, Veal, & Van Driel, 2002 and Sprinkle, 2009). Likewise, (Fuhrman, Jacob & Needham, 2010) maintain that confident knowledgeable teachers are clear about their instructional goals, are knowledgeable about the content, use a variety of teaching strategies and make real world applications (Sprinkle, 2009). Due to the lack of subject matter knowledge teachers were unable to respond to the needs of learners (*discourages learner from taking the option*), addressing the needs of students who are struggling (*cannot respond to learners questions)* and changing the way the information is presented (*tell them go home and learn the notes)* in order to make it more understandable. As Armstrong (2015) argues, a teacher's knowledge of subject matter affects his or her ability to teach effectively.

The excerpts above provide a glimpse into the teachers' efficacy, that is, their confidence in their ability to assist learners. The teachers feel uncertain (*not confident, don't feel I can handle teaching the content)* and are overwhelmed (*very demanding physically and intellectually)* by both subject matter knowledge and pedagogical knowledge (or a lack thereof). The teachers' poor levels of efficacy raise the question of their impact on learners learning and their performance in the examinations, as well as the poor uptake of the biotechnology option.

5.3.2. Lack of professional development support and a need for a safe nurturing space

All the teachers in this study indicated that they had received no professional development from either the CDU or MoE. Furthermore, they highlighted the need for a collaborative nurturing space that contributes towards effective teaching and learning, as can be seen in the excerpts below:

> *This option was introduced, we were not trained or workshopped to teach it, we are battling, no one care about how we cope with no resources, support or content. We need a group to be formed to support us in teaching this option, it must be a place where I can share my lack of knowledge without being judged (P6.)*
>
> *Many of us are the only biology teachers at our schools, it is difficult to get support from the school management team, they do not understand the nature of the subject that you need equipment for practicals, that it cannot occur in the classroom only. I do what I can, what I cannot do in the curriculum I leave out, I cannot change practice without support. Having support is necessary during curriculum reform. I find it difficult to know the depth required, I feel isolated, ignored at my school. No one cares that biology is also extinct at schools – something needs to be done urgently. (P15)*
>
> *We don't know how to handle this curriculum, we don't know what is expected off us, and had no training for implementation. (P5).*

The excerpts also highlight the immense challenges teachers encounter in the absence of continuous teachers' professional development (*we were not trained or workshopped to teacher*) and the resultant professional isolation they encounter. The absence of support from the CDU and MoE highlights the emotional dejection teachers' encounter during curriculum reform (*no one care about how we cope with no resources, support or content).* The loneliness teachers experience also gets illuminated (*only biology teacher*), when they lack support within their school context (*difficult to get support from the school management team)* and lack the opportunity to share or discuss their work with others in their school (*difficult to know the depth required, I cannot change practice without support)*.

The isolation and lack of support that teachers encounter restricts the opportunity for feedback (*where I can share my lack of knowledge*) and impinges on their teaching (*I cannot change practice without support)*. The lack of support within the school environment and the CDU restricts opportunities to engage in dialogue with colleagues about teaching practice. As a result of the lack of support during curriculum implementation, from both the school and CDU, teachers experience professional isolation and consequently feel that no one cares about what they are doing. This finding resonates with those from Molapo (2015) and Ostovar-Nameghi and Sheikhahmadi (2016), who found that teachers felt isolated when support for curriculum reform was absent in their institutions. Mestry (2017) argues that for curriculum implementation to be effective, school managers must lead the support for teachers so they can perform according to the vision and standards set out in the curriculum. Further, Mestry states teachers cannot implement the curriculum alone; they need support, in the form of material resources, human resources, time and emotional resources. The above findings highlight the need for teacher support and empowerment during curriculum reform.

The excerpts below illuminate the teachers' needs concerning curriculum implementation:

> *Need to interact with universities so we can gain the knowledge and skill needed to teach it, TPD does not exist, so hope can we cope (P2)*
>
> *…to sell the idea to the people or to the Eos or Ministry of Education because if it is started by the Ministry we will not face many hassles, we will have support in terms of resources and will be able to teach the option (P5)*
>
> *…should work on something where teachers would occasionally meet ... production of low cost materials… I get no support at school (P3*)
>
> *…we need a team approach to teach these aspects of biotechnology option* (P12)

Teachers' need for professional development support on curriculum implementation becomes clear in this data: *interact with universities, need a team approach, group to be formed to support us, no support at school*. From the excerpts above, it is evident that the successful implementation of the biotechnology option will only be effective if teachers are adequately prepared and supported to teach the option (*gain the knowledge and skill needed to teach it, resources and will be able to teach the option)*. Borko (2004) provides evidence that professional development programmes can help teachers to increase their knowledge and change their instructional practices in order to support student learning. Teachers need to be empowered to develop further expertise in subject matter content, technologies, and other essential elements that lead to high standards or quality teaching (Korkko, Kyro-Ammala, & Turunen, 2016; Witte & Jansen, 2016).

In a similar vein, studies by Singh-Pillay and Samuel (2017); McLaughlin and Talbert (2006) as well as by Louis and Marks, (1998) reveal that teachers become more effective in supporting their own learning as well as their learners' learning when they work collaboratively to improve their practice. Teachers in this study are displaying a sense of collective responsibility when they call for peer led support (*team approach),* and a safe learning space (*where I can share my lack of knowledge without being judged)* to enable them to improve their subject matter knowledge, pedagogical knowledge and empower themselves. They do not get subject specific support like that at their schools. Professional development is necessary to keep the teacher up-to-date with the continuously changing practices, and student needs (Evers *et al*., 2016).

5.3.3. Learning how to use equipment available

Eighteen teachers indicated they needed assistance with the equipment or apparatus available at their school as is visible in the excerpts below:

> *I don't know how to use some of the equipment available at my school, I'm afraid to ask for help, my headmaster will be angry (P15)*
>
> *What if I damage it, or its doesn't work in the lesson, how embarrassing it will be, I rather not use it so I avoid practicals (P11)*
>
> *It's so difficult to try and follow the instruction when I want to use the apparatus to demonstrate something to learners, I become so nervous, I want to die (P24)*

The anxiety and fearfulness (*afraid, headmaster will be angry*) teachers feel when they are not skilled in using use the necessary apparatus or equipment erodes their self-esteem and well-being (*embarrassing, so nervous, I want to die).* It is evident that these teachers' low self-esteem about using equipment during practical work impacts on how they engage with practical work (*I rather not use it… so I avoid practicals).* The above finding resonates with findings from the Muwanga-Zake (2008) study in South Africa, which indicates that the main reason for not using available equipment is that teachers are deficient in practical skills and do not understand the scientific concepts they are supposed to teach.

5.3.4. Lack of knowledge on pacing and syllabus coverage

Thirteen teachers indicated that they struggle with pacing their lessons and syllabus coverage, as reflected in the excerpts below:

> *I tend to spend more time on topic or aspect I know, then I run out of time and skip the topic I don't know well (P21)*

> *I don't know how to manage my classroom time, I lose a lot of time as learners take long to grasp, so I have to leave out many topics in the syllabus (P32)*

The above excerpts illustrate that some teachers have poor time management and syllabus coverage (*tend to spend more time*) because of their poor content knowledge (*skip the topic I don't know well).* The above teachers' lack of attention to pacing does not allows for an even distribution of classroom time that favors a variety of activities and syllabus coverage.

5.4. Contextual challenges

In this section, I present the two subthemes, lack of support at school level and lack of resources.

5.4.1. Lack of support at school level

Eighteen teachers bemoaned inadequate support at school level from principals, heads of departments and colleagues. Many teachers indicated that they felt isolated and alienated as they were the only teachers of biology at their school as is visible in the excepts below.

> *It is so difficult I'm the only teacher of biology in my school, you cannot talk to the principal and ask for help in terms of teaching. (P13)*

> *Principals do not assist or support, they do nothing to improve the lack of professional development by the MoE, we are stuck in the classroom all day, with no resources, in our free period we serve relief, there is no time factored for professional development. (P3)*

> *I am all alone, I'm the only biology teacher at my school, when I seek help from the school management they always say they don't know the subject and cannot assist, who do I turn too? This PDI is a blessing to us. (P5)*

The isolation teachers encounter when they are the only teacher teaching biology at their school comes to the fore in these statements.

5.4.2 Need for resources

The scarcity of resources is a factor that affects the learning, teaching and uptake of the biotechnology option within the 9190 curriculum. Teachers were unanimous in their need for resources to be able to teach the option, as is visible in the excerpts below:

> *Not having enough information to teach… (P14)*
>
> *There are no option booklets available… like for the other options (P13)*
>
> *Schools do not have laboratories… there is no instructional assistance (P10)*
>
> *Classes are large, discipline is poor textbooks are too few – 5 learners to a text (P6)*
>
> *Relevant resources for practical and textbooks are not easy to get (P11)*
>
> *Biotechnology is a new phenomenon, we need developed materials to assist us, I'm not qualified for biotechnology (P4)*

The onerous working conditions that teachers have to endure (*large classes, discipline is poor, no option booklets*) are brought to the fore in the above excerpts. From the excerpts above it is evident that resources is not confined to material (*no option booklets… textbook*) but extends to infrastructural resources (*no laboratories… resources for practical work*) as well. Whilst effective teaching is not dependent on the presence of state-of-the-art infra-structure (Butts, 2010), the paucity of material resources is a factor that contributes to ineffective teaching in schools (Hoy, Miskel, &Tartar, 2013). The above excerpts show that teachers have to cope with the problem of poor basic resources every day. Chingos and West (2010) argue in this regard that the quality of learning materials such as textbooks is an important ingredient in improving instruction, and planning and designing assessments. In the absence of basic resources, they maintain that it is difficult for teachers to improvise or innovate. So without adequate resources for these biology teachers, how can appropriate teaching and learning occur? The primary purpose of the teaching and learning process is to bring a significant change in behavior through active participation and critical thinking by the learner. This cannot take place without the availability of learning and teaching support material (LTSM) (Afework & Asfaw, 2014). LTSM is regarded as a core component for effective curriculum delivery in the classroom. Provision of LTSM supports the interaction between teachers and learners, with the aim of improving learner performance (World Bank, 2008; Fleisch, Taylor, Herholdt & Sapire, 2011).

Given the nature of the biotechnology A level option, the lack of physical infrastructure (*no laboratories… resources for practical work*) will negatively impact its teaching and learning, as learners will be unable to engage in essential hands-on practical work. The lack of material and physical resources this affects the quality of teaching and learning that occurs; hindering the acquisition of process skills and the application of biotechnology learning to daily life. With such poor material and physical resources learners do not have the opportunity to grasp the relevant knowledge and skills, as prescribed in the curriculum. When resources such as textbooks are readily available to learners, learning is more pleasant because they offer a reality of experience, which stimulates self-activity and imagination on the part of the learner (Nyamubi, 2016). The lack of resources impinges the goals of the stated policy of creating awareness and public understanding of biotechnology. Lemons *et al*. (2015) maintain that teaching needs to occur in an environment suitable for teaching the subject. In this regard Najumba (2013) indicates that learners from schools that are well equipped with relevant educational facilities, such as instructional materials, textbooks, libraries and even laboratories, do much better in standardized examinations than do those from schools without such resources. The lack of basic resources further compounds teachers' lack of didactical and pedagogical skills and so raises serious questions about their working conditions, morale and motivation.

5.5 Personal reflection on the stakeholder meeting and needs of stakeholders'

Content analysis of my reflective diary indicates my key thoughts on the stakeholder meeting and the needs identified there, as follows.

- I was surprised that teachers from schools not offering the A level biology and biotechnology option also attended the meeting.
- The lack of support for teachers over curriculum implementation from within the school context is appalling; it isolates teachers, makes them feel alone, and helpless in implementing and innovating with the curriculum.
- Most of the A level biology teachers did not feel confident in their ability to teach the option.
- A need for assistance with the implementation of A level biology, besides the biotechnology option.

- A dire need for support in terms of what to teach (materials needed to teach) as well as how to teach (support in terms of pedagogy) for the biotechnology option.
- Teacher efficacy and well-being and its impact on learner's performance.
- A need for safe nurturing space, which could be offered through the PDI programme.
- A need to enlist the help of colleagues from the university biotechnology team to aid with material development and enrolment for the PDI.

At a theoretical level the confounding questions are: How do I get practicing teachers to embed their own professional development in their daily work in order to study their own practice and talk about it in a safe and nurturing manner? How do I get school managers to be supportive of teachers in their schools during curriculum implementation in order to improve teaching and learning?

5.6 Conclusion

In this chapter I used data from the focus group discussion at the stakeholders' meeting and my reflective diary in an attempt to answer research question one: *What are A level biology teachers' professional development needs in terms of biotechnology subject matter knowledge and pedagogical content knowledge?* Content analysis of the data illuminated that teacher's needed support in five areas. Specifically they needed subject matter knowledge, resources, both in teaching material and infrastructure, had impinged on their teaching of the biotechnology option, and there was a dire need for peer lead professional support in order to create a safe nurturing space for sharing issues leading to more effective teaching. The professional and contextual challenges identified in the data has a bearing on the 'profile of implementation' and teacher well-being. The next chapter presents data and analysis related to the second research question related to the PDI platform.

CHAPTER 6

TEACHERS' EXPERIENCES IN BIOTECHNOLOGY OPTION IN THE PDI PLATFORM CREATED USING CBPAR.

6.1 Introduction

This chapter attempts to answer the second research question, which is: *How do A level biology teachers experience the teaching and learning of biotechnology in the PDI platform created using CBPAR?* Data from the reflective journals that A level biology teachers maintained during the enrolment process of the PDI, together with transcripts from the video observations and focus group discussion were used to answer research question two. As mentioned previously in Chapter 3 Vygotsky's zone of proximal development (ZPD) was used to note shifts in A level biology teachers' learning during the PDI. The ZPD is the critical space in a persons' current understanding where, through face-to-face mediation, a new level of understanding can be fashioned. Two major themes emerged from the analysis of data pertaining to research question two, namely safe collaborative learning space and teachers as learners. I discuss each of these themes further in the remainder of the chapter. For each theme, I present data from the transcripts of the video recording of the enrolment process as well as data from the teachers' reflective journals, along with supporting literature. Thereafter I present my reflections from my journal. The chapter end with a conclusion.

6.2 Safe collaborative learning space

All 25 participants agreed that the PDI platform had created a safe learning space for the A level biology teachers in Masvingo. The following excerpts testify to these views;-

> *I didn't feel humiliated to ask question, the atmosphere is relaxed, you don't feel stupid to ask when you don't know* (P8: video observation – focus group discussion)

> *I could try out new methods of teaching the sections I have problems with, to colleagues without fear or embarrassment, what we are doing in this PDI is connected to our real practices of teaching, it about our needs* (P 19: video observation – focus group discussion)

Excerpts from the biology teachers' reflective journals affirm the above views.

> *This was a good safe opportunity to learn how to teach differently, to work with colleagues, working together is productive and enjoyable I never did this before, I always work in isolation as schools are so far apart. But now I know differently, the meeting organised by Science Education In-service Teacher Training (SEITT) programme is one sided – just information hand out it is not about our needs (*P12: reflective journal).

> *We now have a safe space to monitor and support ourselves and each other – this is something I never experienced previously. At school there is no time allocated for us to meet, share ideas on our teaching to improve both our teaching and our learners results. Now this PDI has created a learning space* (P7: reflective journal).

From the excerpts above it is evident that these teachers value (*didn't feel humiliated… embarrassment, don't feel stupid… support*) the safe learning space provided by the PDI. The above data also highlights that this safe space positively influences the learning that occurs during PDI (*try out new methods of teaching the sections I have problems with)*. It allows for sharing of teachers' practices and concerns about their work. This space is connected to *our real practices of teaching and our needs.* The safe space *engenders* trust, allows for sharing of expertise, trying out new ideas or skills and thereby allows for the growth of the teacher in terms of pedagogy and efficacy. Furthermore, the PDI encourages collaboration with colleagues *(work in isolation… support ourselves and each other)* and is tailor-made to suit their needs *(one sided – just information hand-out it is not about our needs).* Thus it can be inferred that the learning experienced within the PDI is different from that learning teachers had encountered within formal professional development *(never experienced previously)* organized by the SEITT.

The above excerpts confirm that professional development extends beyond providing opportunities to "increase content knowledge and pedagogical skill", it has an affective dimension as well. The affective dimension is concerned with the emotional response of participants to the space or environment provided for learning during professional development. Figure 6.1 below, captures the positive responses (smiling faces) of the participants to the PDI. In other words, within this shared space teachers are engaged both cognitively and emotionally through activities such as sharing and discussion, application of and reflection on their own and their colleagues' practice. The safe space allows for effective professional development and for a learning community to flourish.

Figure 6.1 Collaborative learning during enrolment process of the PDI

6.3 Teachers as learners

This theme is subdivided into two sub-themes; namely, content knowledge and teaching strategies.

6.3.1 Content knowledge

Content knowledge is the facts, concepts, theories, and principles that should be taught and learned according to the curriculum for the biotechnology option. As highlighted in the previous chapter, teachers identified the following areas where they needed professional development:, Scope of biotechnology, Enzymes and immobilization, Medical biotechnology (biosensors, gene therapy, antibodies and bio-safety issues, human growth hormones and vaccines), Environmental biotechnology (roles of microorganism in the extraction of heavy metals and pollution) and Agricultural biotechnology. Analysis of the video observation and focus group discussion transcripts show how teachers' content knowledge had changed.

> *The sad thing is there was no support for teachers of biology before this PDI from the SEITT program, now we have formed our own network and we can all grow, I confident about the content, I am now getting learners to develop an interest in biotechnology and its offered at my school.* (P17: video observation – focus group discussion)

> *What I like is that this intervention is made to suit us – it pays attention to what we need help with, I can teach all 5 area now without feeling uncertain, my confidence to teach biotechnology has increased, I can walk into a class and not feel the tension and anxiety I used to experience before the PDI.* (P15: video observation – focus group discussion)

The excerpts from the reflective journals attest to the above views.

> *Before the establishment of the PDI platform on, I avoided the biotechnology content as I did not know it. I did not study biotechnology, I never encouraged learners to take this option because I couldn't teach it, now I'm confident as I was given the chance to learn the content in a step by step process, in a safe space with other teachers who supported my learning. I now know how to use newspaper articles as resource to support my teaching for example in the teaching of environmental biotechnology, I can develop my own resources to improve my teaching and help my learners* (P11: reflective journal).

> *There is no one to collaborate with at school – I'm just by myself – so I struggled and struggled with the biotechnology content. During this PDI I learnt the content from those 5 sections and now if I'm stuck I call on our team to bounce off ideas and other experts to assist like the food and medical technologist from my community.* (P5: reflective journal)

What comes to the fore in the above excerpts is that the PDI was designed to increase knowledge, skills, and practices associated with these teachers' professional needs (*what we need help with*). Consequently these teachers encountered a change in their content knowledge (*avoided biotechnology content….improve my teaching with …I learnt the content.*) while working collaboratively in the PDI. Embedded in the above excerpts is the idea that teachers learn best when working in collaboration (I *can call our team to bounce off ideas*). The preceding idea is aligned to Vygotsky's perspective of constructivism, which illustrates that learners learn better when they work in groups than when working alone. It is through such collaborations with more skilled persons that teachers learn and internalize new concepts and the tools needed to teach. The idea is that after completing the task once, jointly, next time the teachers should be able to complete the same task individually, and through that process, the teacher's ZPD for that particular task will have been raised (Campbell, 2008). The upper edge of the ZPD is the point where a previously less skilled individual (i.e. the 25 A level biology teachers involved in the PDI), after cooperatively networking with a more knowledgeable person, has been enabled to now carry out the task alone. In other words, ZPD is the region between what the A level biology teacher in this PDI could accomplish when given necessary assistance and what he or she previously knew in terms of the biotechnology content.

6.3.2 Teaching strategies

Teaching strategies refer to methods used by teachers to help learners understand the desired course content. During the PDI, Teachers were exposed to different teaching strategies as can be seen in the excerpts from the video observations and focus group discussion below:

> *I can now confidently try the following teaching strategies in my class: demonstrations, group work, role playing, field trips that I learnt and tried during the PDI* (P2: video observation – focus group discussion)

> *The PDI platform had an impact on my teaching of biotechnology; yes I have certainly changed the way I taught after I was involved in the PDI platform and after having got a bit more feedback during the CBPAR. It was a case of doing a whole rethink of how best to get the lessons on biotechnology across to the learners. I don't think I put in any effort previously, now I design my own assessments to suit my context and learner. I constantly try new ways of teaching, it is exciting, I feel inspired as my learners performance is improving* (P6: video interview – focus group discussion)

The excerpt from the reflective journal supports the above sentiments.

> *I was so set in chalk and talk I refused to use any innovative ways of teaching now that I have tried out how to use field trips, demonstration, practicals, during the PDI I'm confident – this was a safe way of learning with and from colleagues. Rurinda's research is really making a difference to my attitude towards teaching the biotechnology option, if it was not for this PDI I would have used the same boring method to teach all my classes. When there is no official professional development for practicing teachers you get stuck in your ways and change is not something you can do alone. This PDI is an excellent learning platform; it is safe to show you do not know (*P1: reflective journal).

It can be gathered from the above excerpts that teachers were exposed to many different teaching strategies (*field trips, demonstration, practicals, role playing and context based activities)* during the PDI, which they were inspired to try out in their classrooms (*I'm confident to try …teaching strategies*). A key component of this PDI is that teachers learned by observing and modeling, without being mocked or embarrassed. The Figure 6.2 below reflects a facilitator demonstrating how a biotechnology section ought to be taught.

:

Figure 6.2: Enrolment during PDI

6.3.3. Teaching/ enrolment during the PDI

The data shown above confirm that the PDI in this study helped teachers grow professionally and improve their teaching practices, thereby providing more opportunities for learners to learn effectively. These findings correspond with those of DuFour and Eaker (2008), who assert that PDIs are a means of improving a teacher's instructional practice and learning. Furthermore, the data elucidates that opportunity for teachers to participate actively and collaboratively in professional learning communities is an essential component of high-quality professional development. This concurs with the findings from Van Driel and Berry (2012), as cited in Borko *et al.* (2010). Thus, it can be argued that through face-to-face mediation and collaboration new levels of understanding were acquired by teachers in terms of their content knowledge and pedagogical knowledge, which improved their confidence levels. Hence a shift was noted in the teachers' ZPD level. After their engagement in the PDI, almost all the teachers said they were very confident in teaching any section of the biotechnology option.

6.4 My reflections on teacher enrolment during the PDI

Initially, the A level teachers had lacked confidence with regard to the biotechnology content and pedagogical knowledge necessary to teach it effectively. Some teachers had at the start of the intervention displayed resistance to trying out new methods of teaching, but the resistance was eroded by the safely encouraging atmosphere that had been created jointly. Once teachers realised they were not being judged, they participated freely and eagerly in the activities; they flourished and improved their CK and PK.

BOTLC should become an official body to provide support and professional development to teachers of biology in Masvingo, as teachers are eager to learn from each other and try out new strategies in their class. However, the question arises about how we should propagate this kind of professional development capital amongst practicing teachers in other provinces in Zimbabwe?

6.5 Conclusion

This chapter attempted to answer research question two using data from video observation of the PDI enrolment process and teachers' reflective journals. Two themes emerged; namely, safe collaborative learning space and teachers as learner. The data confirms, primarily, that safe nurturing spaces are needed for PDI to be effective, and secondly that there is an affective domain attached to PDI, which is linked to teachers' efficacy and confidence and their learning. Additionally, the data reveals that during PDI teachers are positioned as learners and so they require a safe space in which to share, experience, try, critique, and reflect on their practice. This safe space allows for a shift in the teachers' ZPD. The next chapter focuses on research question three.

CHAPTER 7

IMPACT OF BIOTECHNOLOGY PDI PLATFORM, TEACHERS' ENACTMENT

7.1. Introduction

Curriculum reform always expects teachers to make paradigm shifts, change their teaching practices and to learn new things (Yoo & Carter, 2017). However, for change to occur it is important for professional development to involve active learning and reflection (Clarke & Hollingsworth, 2002; Desimone, 2011). This chapter presents data to answer research question three: *Has engaging in the biotechnology PDI altered their enactment of the biotechnology option in their classes? If so, how and If not, why?* Data generated through lesson observations, interviews and reflective journal, are presented to answer the research question. As mentioned earlier in Chapter 4 (Section 4.6), 16 teachers carried through the PDI in their schools and maintained reflective journals, but only four teachers teaching the biotechnology option volunteered to have their lessons observed, for their teaching portfolio to be subjected to document analysis and to be interviewed after the observations. Some skills developed during the PDI were also more widely applicable to the teaching of biology beyond biotechnology.

This chapter is organized as follows. First data is presented in the form of tables, then the first part of research question three is answered, followed by answers to the second part of the research question and, finally, the chapter ends with a conclusion.

7.2. Summary of data generated

In this section, four tables are presented. These tables capture a summary of findings on the profile of implementation for four biotechnology teachers whose lessons were observed, a summary of their capacity to innovate, a summary of teaching strategies and assessments used observed in their lessons, followed by a table capturing a synthesis of reflections from 16 A level biology teachers on how their practice had been altered due to their engagement in the PDI.

The summary in Table 7.1 was derived by completing the profile of implementation for each of the four teachers (given by pseudonyms) enacting the PDI programme when teaching the biotechnology option at their schools. These four teachers' lessons were observed, they were interviewed and their teaching files were subjected to document analysis. See Appendices M to P for the completed profile of implementation for each of the four teachers.

Table 7.1 Summary of findings on profile of implementation for biotechnology teachers.

Level	Classroom practice					Practical work					Science and society					Assessment					Teacher well being				
Teacher	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**
Tay				x				x					x					x						x	
Mas		x				x					x						x					x			
Zim				x					x				x						x						X
Bob			x			x						x							x				x		

The table reflects the level at which the Biotechnology option of the A level curriculum is put into practice by the four teachers as is visible in table 7.1. I had to include a level 0 to Rogan and Grayson's model when there were no activities for certain constructs of the profile of implementation. I also included a column on teacher well-being based on the data generated (this is discussed in section 7.2.2.1).

The next table provides a summary of the capacity to support innovation. The summary shown in Table 7.2 was derived by completing the capacity to innovate for each of the four teachers enacting the PDI programme while they were teaching the biotechnology option at their schools. These four teachers lessons were observed, they were interviewed and their teaching files were subjected to document analysis. See Appendix P to S for the completed capacity to innovate for each of the four teachers.

Table 7.2 Summary of capacity to innovate

Teacher	Physical resources					Teacher factors					Learner factors					School ecology					Professional learning community				
Level	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Tay		x							x			x				x								x	
Mas		x					x						x					x				x			
Zim		x					x							x					x					x	
Bob		x						x						x			x							x	

I also needed to add level 0 for the constructs of the capacity to innovate when there the construct was absent in the school setting. Furthermore, I extended the constructs to include professional learning community as these 4 teachers repeatedly mentioned how the PLC provided different types of support to them (see section 7.2.2.). Table 7.3Table 7.3 shows data relating to the teaching strategies used in the observed lesson, and associated assessments methods.

Table 7.3 Summary from lesson observation on teaching strategy and assessment methods used

Teacher	**Section Lesson**	**Teaching strategy**	**Resources used**	**Assessment**
Tay	Food technology	Demonstration, practical work: group work	News paper articles Modified resources from PDI to suit learners	Practical report Concept map of news paper article
Mas	Agricultural biotechnology	Chalk and talk links content to local crops grown in Masvingo	Textbook -shared	Mind map
Zim	Environmental biotechnology	Contextualized problem based inquiry via field work –stream near school	Stream, worksheet	Report, Project Group presentation
Bob	Medical technology	Guided discussion Group work	News paper article Community doctor-talk	Poster presentation

The data from Table 7.3 shows that the four teachers had included innovative teaching and assessment strategies such as fieldwork, contextualised projects or problem based learning, concept maps and posters, according to their lesson plans and lesson observations. The teaching strategies that the teachers had selected demonstrated a distinct and critical awareness of the need for innovation in their teaching.

In addition to the four teachers whose lessons were observed and who allowed document analysis of their teaching files, data had been collected from the 16 A level biology teachers who enacted the PDI. Their reflections on the impact of the PDI on their teaching practice are summarized in Table 7.4. The individual teachers are referred to by number. The data from table 7.4 is discussed in section 7.2.1 and 7.2.2.

Table 7.4 How teachers' enactment of PDI benefited the biology A teaching

Participant	Classroom practice:		Practical work/use of equipment	Pacing lessons & syllabus coverage	Teacher confidence /motivation
	PCK	CK			
1	X	X	X		X
2	X	X	X	x	X
3	X	X			X
4	x	X	X	x	X
5	x	X	X	x	X
6	x	X	X	x	X
7	x	X	X	x	X
8	x	X			X
9	x	X		x	X
10	x	X	X	x	X
11	x	X	X	x	X
12	x	X	X	x	X
13	x	X	X	x	X
14	x	X	X	x	X
15	x	X	X	x	X
16	x	X	X	x	X

In the next section, I attempt to answer research question three, which entails three parts.

7.2.1. Engagement with PDI: did it alter the teaching of biotechnology?

The data from Table 7.4 is used to answer the first part of research question three, which is, *Has engaging in the biotechnology PDI altered their enactment of the biotechnology option in* *their classes?* From the table it is evident that all 16 A level biology teachers' enactment of the A level biology curriculum was altered due to their engagement with the PDI programme in terms of their pedagogical content knowledge, content knowledge, their motivation or confidence to teach and ability to use available resources and equipment during practical work. Because all 16 A level biology teachers' enactment of the A level curriculum was altered by their engagement in the PDI, it is thus not necessary for the third part of research question three, (*If not, why?*) to be answered. Thus it was necessary to address only the second part of research question three, for which I present data next.

7.2.2. The effects of PDI on classroom enactment of the biotechnology curriculum.

Data generated from the reflective diaries and interviews were used to answer the second part of research question three: *How has engaging in the biotechnology PDI altered their enactment of the curriculum in their classroom?* Content analysis of the reflective diary and interview transcripts reveal that teachers' enactment of curriculum was altered affectively, socially and cognitively. For each of the three themes, I present data from the reflective diary, and then corroborate it with data from the interviews, together with supporting findings from the literature.

7.2.2.1. Affective Transformations for teachers

All 16 'A 'level biology teachers described transformations in their emotions, confidence, interest, and attitudes about teaching and learning arising from their engagement in the PDI and in the learning community (BOTLC). This finding is reflected in data such as the excerpts below:

> "*I feel inspired to try new teaching methods, I'm rejuvenated after the PDI and the network of support is amazing, I reflect on my teaching to see how I can improve, I never did this before, I care about my learners' performance now, I feel the change daily and its good* " P6: reflective journal

> *"Just attending these meeting, touching base on a monthly basis after the PDI, sharing, rethinking my practice, trying out new ideas to teach the biotechnology option help me improve my confidence, I feel empowered, we need more of this type of development where we are not humiliated and our needs are catered for*" P16: reflective journal

> *"The most important resource I have is BOTLC, I have no support at school, I do not feel alone and isolated anymore, I am growing in confidence, knowledge and becoming a better teacher – my learners enjoy lessons now, they want to learn and are doing better in their tests, I have more compassion towards my learners and am excited about teaching again"* P1: reflective journal

The following excerpt from the interviews affirms the responses from the reflective journals.

> *"I enjoy teaching again, it was boring before the PDI and BOTLC I went through the motion without support but after the PDI I'm re-charged and maintaining contact with like-minded people is amazing, I'm eager to learn, try out new methods of teaching and assessing in my class, I'm also trying this innovation in the other subject I teach"* Tay: interview

All 16 teachers used words such as *recharged, empowered, inspired, rejuvenated, compassion, excited* and *confidence* to describe how learning from the PDI and connecting with BOTLC (*touching base on a monthly basis, most important resource I have is BOTLC)* rekindled their passion (*trying out new ideas to teach)* and excitement for teaching (*I enjoy teaching again).*

Furthermore, teachers also described a change in their attitude to teaching and learning because of the PDI and network forged through BOTLC. Teachers have rethought their work (*was boring before … went through the motion),* consequently, upon reflection, their paradigm shift is evident (*rethinking my practice, I reflect on my teaching to see how I can improve, becoming a better teacher).* In other words, they no longer see teaching as tedious (*boring)* but see it as a learning process both for themselves and their learners (*eager to learn, try out new methods of teaching and assessing).* Teachers testified to gaining confidence as professionals (*improved my confidence, I feel empowered*), thus they are now willing to try new ideas (*trying out new ideas, new teaching methods*) and even extend the new teaching methods into other subjects that they teach (*trying this innovation in the other subject I teach).* The preceding reflections indicate that teachers had experienced success in their 'new-found' method of teaching. Their success has inspired them to extend their innovative teaching methods to other classes or subjects that they taught. This finding reminds one of assertion by Mayer and Torracca's (2010) that innovation is flexible in nature and has the ability to be adapted to different contexts.

It is also clear in the excerpts above that teachers' participation in the PDI and their sustained ties with BOTLC (*attending these meeting, touching base on a monthly basis) had* inspired positive affective changes that contributed towards their professional growth (*I feel the change daily and it's good*). Furthermore, teachers' engagement in the PDI has initiated professional reflection of their work as teachers, which subsequently resulted in a change in attitude towards their learners (*I care out my learners' performance now).* The above findings are consistent with those of Scott and Sutton (2009) and Saunders (2013) who asserts that teaching has a strong emotional nature and that teachers' emotional experiences during curriculum reform are strongly linked to their thought processes, view of reality and their experiences of professional development. Similarly, Yoo and Cater (2017) conducted an ethnographic study on a professional development programme (PDP) for creative writing and writing practice where they found that participants experienced both positive (excitement, hope, inspiration) and negative (conflict, discouragement) emotions during the PDP. My findings are slightly different from, and perhaps more encouraging than, those of Yoo and Cater (2017) because the 16 A level biology teachers in this study indicated only positive responses to the impact of the PDI on their practice.

Furthermore, it can be inferred from the data above that the change in teachers' confidence, and attitudes, and their rejuvenated interest in teaching have a carryover effect on their learners' learning (*my learners enjoy lessons now, they want to learn and are doing better in their tests, I have more compassion).* These teachers had seen the effects of the PDI on their teaching through the positive reactions of their learners. This concurs with findings from a study conducted in Singapore by Tin *et al*. (1996) who found that most teachers are motivated by an increase in participation and performance of their learners. These authors add that it is important for teachers to find a place for innovation in their teaching.

The data above confirm that the classroom practices of teachers had been altered, as they displayed positive emotions, confidence, interest, new attitudes about teaching and learning, reflectivity, as well as having adopted new teaching strategies in their teaching. This finding corresponds 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.

7.2.2.2. Social Effects on teachers

Teachers reported that their engagement in the PDI had resulted in social benefits such as collaboration, networking, and connecting, which had in turn changed their practice and enactment of the biotechnology option in the A level biology curriculum, as is evident in the excerpts from reflective diaries given below.

> "*I don't feel isolated anymore, I have the support of BOTLC, I can call anyone of them when I need help or need to get a different perspective, or collaborate on assessments, this has motivated me and helped me reduce my workload as we share resources, I asked my learners to form small learning groups to help and support one another, there is an improvement in their class marks"* P2: reflective diary

> *"I also learn all the time by keeping in touch with BOTLC we have discussion on WHATSAPP, we share, debate this help me to learn"* P11: reflective diary

Excerpts from the interviews affirm the above view:

> *"I owe this change in me as a teacher to BOTLC, I sometimes meet a colleague for just to talk about my teaching and new ideas I have tried, it help* " Zim: interview

> "*I am the only biology teacher in my school, I'm all alone, because of BOTLC I can talk to any teachers ~~form~~ from the group to bounce ideas seek clarification, share resources, I changed my teaching strategy I'm getting my learners to work in groups to support each other – they are more responsive and are tackling higher order questions, slowly but surely I'm getting there* " Mas: interview

The above excerpts reveal the various ways in which teacher's network (*talk, WhatsApp, meet, call*) because of their engagement in the PDI. Further, these excerpts highlight the benefits the teachers experience by networking with teachers from other schools, such as overcoming isolation (*don't feel isolated anymore, I'm all alone)*, being exposed to different perspectives (*discussion*, *debate, bounce ideas, seek clarification*) and collaborating (*collaborate on assessments, share resources).* The isolation that the teachers overcome by networking is not restricted only to geographical isolation but extends to content area (*about my teaching*), differing perspectives (*debate, bounce ideas seek clarification*) that are not available to them in the absence of support from the CDU. Teachers have also extended the social benefits of their own networking practice to their learners (*my learners to form small learning groups to*

help and support one another) consequently the learners have *become more responsive and are tackling higher order questions* and there is an *improvement in their class marks.*
The above findings are in keeping with Fullan's (2001) call for teachers to engage in conversation, collaboration, observation and reflection which Van Driel and Berry,(2012) believe is necessary for effective change to their professional practice when implementing new initiatives. Furthermore the above findings correlate with the assertion by Rogan and Aldous (2005) that when teachers engage with effective professional development they are able to move from their current methods of teaching, through the ZFI and into 'ideal practices of teaching'. For the A level biology teachers the lack of resources (both physical and human) in their school context no longer hinders good practice as the teachers now have the capacity to innovate and finds ways to overcome challenges using the BOTLC support network.

7.2.2.3 Cognitive Changes for teachers

All 16 A biology teachers affirmed the various cognitive benefits associated with their engagement in the PDI activities and maintaining ties with BOTLC, such as content knowledge, pedagogical knowledge and becoming reflective practitioners. These affirmations are visible in the excerpts below.

> "*It feels good to try out new teaching method in class such as contextual project or problem based learning, inviting a specialist from the community, using smart phones to teach when resources are not available, field work in the community. I realised I need to keep on top of new content and developments in biology, we live in a knowledge explosion, I know now that I have to be a lifelong learner. I'm making an effort to improve my teaching and content, I ask myself how do I become a better teacher? The learners are interested and want to learn and are getting better marks, they can think critically and problem solve. I owe this change in me as a teacher to BOTLC, I sometimes meet a colleague for just to talk about my teaching and new ideas I have tried, it helps* " P8: reflective journal

> "*I changed my thinking about my teaching and started thinking about what good teaching is, I question my teaching and assessment and think about what I need to do to help my*

learners to succeed all the time now after engaging in the PDI, I call my BOTLC friends to share ideas, ask questions, seek clarity" P1: reflective journal

Excerpts from the interviews confirm the data above.

> "*I use creative ways to teach content after my engagement in the PDI, I have learnt how to use newspaper articles, smart phones to access visual images to reduce the abstractness of concepts and the surrounding context for problem/project based learning, the resources can be acquired easily with just a call , we share expertise and resources, in the PDI we practiced the teaching strategies during the PDI, learnt how to interpret results, do demonstrations, extract DNA it suited our needs and we were all eager to learn and grateful for Rurinda's effort to start this project*" Bob: interview
>
> "*I'm confident with the content after the PDI and BOTLC I have a deeper understanding and can link the sections together, now ask higher order question in class to promote learning in class*." Tay: interview

The above excerpts elucidate what teachers have learnt by engaging in the PDI; how they modify their practice in order to incorporate their improved content knowledge, pedagogical skills, intellectual skills and resources from the PDI into their classroom practice.

It is visible from participant P8's reflective journal and Tay's interview that teachers' content knowledge is not static (*keep on top of new content, live in a knowledge explosion).* They realise the need to be continually developing (*deep understanding …can link sections together, have to be a lifelong learner*) in order to be masterful teachers of biology (*ask higher order question in class to promote learning in class*).

The excerpts above and the lesson observation data summarised in Table 7.3 highlights the various new teaching strategies used by the teachers after their engagement in the PDI and through ties with BOTLC (*newspaper articles, smart phones, contextual project or problem based learning, inviting a specialist from the community, field work in the community, field work).* This means that teachers had at their disposal many new teaching strategies through which to engage their learners in multiple ways, in order to promote conceptual learning (*getting better marks)* and scientific literacy (*they can think critically and problem solve).* The teachers are using technologies (*smart phones*) to stimulate learners to learn the abstract concepts associated with biology and biotechnology. Akram and Mailk (2012) contend that the use of audio-visual material is effective because it enhances learner motivation, increases learners' interest levels, and makes lessons more memorable for learners. In a similar vein, Wood (2009) argues that any activity that increases learners' level of participation, curiosity and motivation is innovative. Nevertheless, what might be taken to be 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 16 teachers in my study revealed heightened levels of understanding about the types of resources that complement curriculum implementation and innovation. This concurs with Rogan's ZFI which places importance on the teacher using resources to move through the ZFI to reach more ideal practices of teaching (Rogan & Aldous, 2005).

It is noticeable in the excerpts that teachers experienced PDI in a completely different way to that during their previous exposure to professional development. Teachers were no longer passive recipients of information; they were actively involved. Teachers had the opportunity to practice what they were engaged with (*we practiced the teaching strategies during the PDI),* to develop special understandings (*deeper understanding)* and to become able to integrate (*can link*) their content knowledge, teaching strategies (*question my teaching and assessment),* student learning and assessment (*now ask higher order question).* This resonates with Gulamhussein's (2013) assertion that many programmes on professional development involving curriculum reform simply place the teacher as a passive listener and not as someone who is actively involved in the programme. Here, active involvement in the PDI allowed teachers to tailor the teaching and learning situation (*thinking about what good teaching is)* to the needs of their learners (*think about what I need to do to help my learners to succeed).* Effective professional development had altered the teachers' teaching practices, which had a positive effect on the learners' learning in their classroom, and teachers subsequently developed an increased sense of self-efficacy. This concurs with the views of Supovitz and Turner (2000), Kriek and Grayson (2009) as well as Sherron and Fletcher (2008) that there exists a direct link between effective professional development, improved teaching practices of science teachers, and resultant improved performance of learners in science.

The teachers in my study had taken ownership of their teaching and learning by forging sustainable ties with colleagues outside their schools through BOTLC. This type of networking (*meet a colleague for just to talk about my teaching, share ideas, ask questions, seek clarity*) served as a mirror for reflecting on their teaching practice (*changed my thinking about my teaching… question my teaching and assessment… how do I become a better teacher).* In this way teachers took responsibility for enriching their own repository of subject matter content knowledge and pedagogical content knowledge. Through this networking teachers were emboldened and had more courage and confidence to engage in new practices in their teaching. The above findings illuminate that teachers' PDI engagement had altered their practice in terms of their content knowledge, pedagogical knowledge and becoming reflective of their practice. The aforementioned findings concur with those from studies by Baumert and Kunter (2013) and Yang, Liu and Gardella Jr. (2018), where they noted improvements in teachers PCK after their engagement in professional development programmes that had been designed according to their needs. Rogan's (2007) ZFI theory postulates that when teachers receive 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 learner-centred methods. In the present study, the increased pedagogic content knowledge teachers gained from their engagement with the PDI informs these more ideal methods of teaching.

7.3. Conclusion

In this chapter I attempted to answer the last research question: *Has engaging in the biotechnology PDI altered their enactment of the biotechnology option in their classes? If so, how and If not, why.* Data from the teachers' reflective journals, interviews, lesson observation and document analysis were used to answer the third research question, which comprised three parts. Since all 16 A level biology teachers indicated that their engagement in the biotechnology PDI had altered their enactment of the curriculum in their class the third part of the research question became redundant. The participating teachers' enactment of the curriculum was altered, affectively, socially and cognitively. A common thread that traversed the affective, social and cognitive dimensions of teachers' growth through their engagement in the PDI was teacher identity. Through their engagement and enactment, teachers took on new identities, such as being a lifelong learner, while some changed their outlook on their role as teachers and teaching.

My findings on how teachers' engagement in the biotechnology PDI have, hhowever, altered their enactment of the curriculum in their classroom had highlighted some short-falls in Rogan and Grayson's (2005) theory of implementation. In the next chapter (which is the concluding chapter of the thesis) I present a summary of my finding, and critique the Rogan and

Graysons'(2005) theory of implementation; presenting an extended model and making recommendations.

CHAPTER 8

SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

8.1. Introduction

This qualitative study concerned a professional development intervention (PDI) for the A level biotechnology option that was initiated and established for biology teachers as part of a community based participatory action research (CBPAR) project. This chapter serves to bring together the key findings that emerged from the data. These findings contribute towards answering the three critical questions that guided the study. First, in the next section, a summary of significant research findings addressing each research question is presented. This is followed by a discussion of the Rogan and Grayson (2003) theory of curriculum implementation. Next, some recommendations are suggested and this concludes the chapter.

8.2. Summary of findings

This section captures the responses of participants to the following three research questions that framed this study, as shown in Table 8.1.

Table 8.1 Summary of findings

Research question	Overall finding	Themes
1. What is the A level biology teacher's professional development needs in terms of the biotechnology option?	The professional and contextual challenges identified via the data has a bearing on the ' profile of implementation' and teacher well being	Professional challenges: • Lack of Subject matter knowledge and Pedagogical content knowledge • Lack of professional support and need for a safe nurturing space • use equipment available • Teacher pacing and syllabus coverage Contextual challenges • Lack of support at school level Lack of resources
2. How do A level biology teachers experiences in the teaching and learning of biotechnology in the PDI platform created using CBPAR?	There is an affective domain attached to PDI, which is linked to teacher efficacy and confidence and their learning	Safe collaborative learning space and Teachers as learner • content knowledge

		• teaching strategies
3. Has engaging in the biotechnology PDI altered their enactment of the biotechnology option in their classes? If so, how If not , why	Via their engagement and enactment, teachers took on new identities such as lifelong learner, while some changed their outlook about their role as teachers and teaching	Affectively Socially and Cognitively

The findings for research question one illuminate the type of support teachers need from within the school and CDU for implementation of the biotechnology option to be effective. If teachers are to support learners in learning biotechnology in the A level biology classroom, teachers need to be actively engaged in activities that will help develop "deep content knowledge and pedagogical knowledge" for how to approach biotechnology as a knowledge-building activity (Moon, Michaels, & Reiser, 2012, page number 9). More so, my findings highlight that teachers need to be supported emotionally, administratively and professionally in order to improve teaching and learning, and so they can be effective and innovative during curriculum implementation.

The overall finding for research question two highlights the affective component attached to teachers' professional development. In this study, teachers emphasized the need for a safe collaborative learning space, which engenders trust, allows sharing of expertise, scrutiny of teaching practice, brings support from peers, encourages trying out new ideas and skills, thereby fostering the growth of the teacher (self-improvement) in terms of pedagogy and efficacy. The preceding idea is aligned to Vygotsky's perspective of constructivism, which illustrates that learners learn better when they work in groups than individually. It is through such collaborative endeavours with more skilled persons that teachers learn and internalize new concepts and tools needed to teach.

My findings reveal that teacher confidence and emotions influence their teaching practice. This highlights that the core features needed for a sustained informal professional learning community are collegiality, shared values and vision for teaching and learning, shared practice, supportive conditions, collective learning and distributed ownership and leadership. The findings show primarily that professional learning communities can be an effective form of professional development for teachers during curriculum reform. In a context where the CDU does not support teacher development appropriately during curriculum reform, sustainable teachers' professional development will rely on teachers themselves, their commitment to quality and to their learners.

The findings for research question three indicate that teachers benefitted affectively, socially and cognitively by engaging in biotechnology PDI.

8.3. Reflections on using Rogan and Grayson's theory of curriculum implementation

Rogan and Grayson's theory of curriculum implementation was an appropriate framework to use in this study as it highlights the continuous tension and interaction between the two constructs of profile of implementation and capacity to support innovation. That is, the two are always affecting, influencing or impacting on each other. Rogan and Grayson (2003) attempted to categorize practice, capacity to innovate, and support in stages called levels of operations, which progressed through from lower to higher levels of development (level 1-4). Levels of operation are identified by the level of development of practice going on in a particular situation. I found the notion of levels useful in identifying readiness for, and progress toward, reform. The level of operation clarifies that different schools and teachers have unique starting points in terms of physical resources, school ethos, learner factors and teacher factors. For instance, when classroom activities are not linked to the school context, according to this framework the level of curriculum implementation becomes trivial. Hence, it is important to know the effects of factors stemming from the capacity to support innovation on implementation. .

Rogan and Grayson's (2003) model for curriculum implementation vividly exposed the overall build-up that is needed after the design of a curriculum. Their first construct, profile of implementation, gives a concrete description of what is taking place inside the classroom, here specifically in terms of the enactment of the biotechnology option and, in general, for the A level biology curriculum,. The second part of the model, the construct capacity to support innovation, outlines a number of indicators (physical resources, teacher factors, and school ethos and ecology) that are internal to the school, but which may affect implementation. These are crucial structures in determining whether there will be effective implementation of the A level biology curriculum and the biotechnology option. Such factors can either promote or act as hindrances to implementation of the A level biology curriculum and the biotechnology option. Teachers' work and study conditions, school ethos including functionality of school and leadership patterns, both influence the extent of implementation of a new curriculum.

These broad areas depict the importance of well-developed capacity for effecting quality teaching and learning.

The findings of this study crystalise the relational interplay between the capacity to innovate and the profile of implementation, as well as the dislocation between the intended curriculum and implemented curriculum. Put simply, this means that effective curriculum implementation demands commitment to developing the necessary capacity to support changes. This includes amongst other factors, physical resources, teacher factors, learner factors and school ethos and ecology, as well as much needed continuous teachers' professional development. 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.

Due to the deficit in both physical and human resources in a developing country like Zimbabwe, as well as the lack of support for curriculum implementation from the CDU, my finding reveal that Rogan and Grayson's level of operation needs to be extended to include level zero as some schools have an ethos or ecology that cannot support any form of innovation and curriculum implementation. For example participant Tay (see table 7.2 and appendix P) teaches in an environment where the principal does not enforce rules that support teaching and learning (*it is difficult to get learner back in class after the break*) further where she is the only biology teacher and professional development within the school is almost non-existent (staff meeting occasionally).

After analysing the data from lesson observations, interviews and reflective journals of A level biology teachers I found that I needed to extend Rogan and Grayson's (2003) profile of implementation to include teacher well-being (added as another column). My finding in Section 7.2 concerning the effects of PDI on classroom enactment of the biotechnology curriculum (affective transformation of teachers, social effects on teachers and cognitive changes for teachers) elucidates the intrinsically intertwined link between teacher well-being and their ability to innovate and implement the curriculum. This led to two important adjustments that were required in the Rogan and Grayson (2003) framework. The first adjustment was the need for a column headed teacher well-being to be included (see Table 8.2 below). The well-being column reflects the feelings that teachers might encounter and the agency they may display during curriculum implementation Teachers' feelings and teacher agency have an influence on how teachers in this study reacted to the PDI programme and curriculum implementation. The teacher well-being column starts with level 0 and progresses to level 4. It is important to realise that a teacher could be on level 1 concerning classroom practice, but on level 3 regarding teacher well-being. The lack of support for teachers during curriculum implementation and the dilemmas teacher's encounter, which impacted their wellbeing, initiated a need to extend Rogan and Grayson's (2003) framework for curriculum implementation to include the personal well-being of the teacher. A low level of personal well-being among teachers could signal curriculum reform fatigue, which teachers encounter in the absence of supportive environment for curriculum implementation.

The second adjustment arose from the impact which the PDI programme had had on teachers' capacity to innovate. To accommodate the data generated I decided to add a column to the capacity to innovate called professional learning community. As with the well-being column, this professional learning community starts with level 0 and progresses to level 4. So a teacher can be on level 0 concerning school ethos or ecology, but on level 3 regarding professional learning community (see Table 8.3).The addition of teacher well-being, level zero and professional learning community to Rogan and Grayson's (2005) model for curriculum implementation is the contribution this study makes to the existing body of knowledge. The new model proposed in this study is better suited for curriculum implementation in developing countries.

Table 8.2 Personal well-being added to extend Rogan and Grayson's framework for curriculum implementation

level	Classroom practice	Science practical work	Science and society	Assessment	Personal well being
1	**Teacher:** -presents content in a well organized way -has a lesson plan -uses textbook effectively -engages learners with questions	**Teacher:** -uses demonstrations to develop concepts -uses specimens found in local environment for illustration	**Teacher** Use example and applications from everyday life	**Teacher:** -uses written tests mostly recall type questions some questions are higher order thinking -tests marked and returned promptly	Teacher experience feelings of : -Pressurized -Confused -Challenged -Frustrated
	Learners: -stays attentive and engaged -respond to and asks questions	**Learners** -observe -ask and answer questions	**Learners** -stay attentive and engaged ask and answer questions	**Learners** -mostly apply rote learning -sometimes apply higher order thinking	
2	**Teacher:** -Textbook used in conjunction with other resources	**Teacher:** -Uses demonstrations to promote a limited form of inquiry	**Teacher:** -Uses specific problem /issue faced by local community	**Teacher:** -Uses written test with 50% of questions	**Teacher:** -Reasonably confident -Good self esteem -capable

	-Engages learners with questions to encourage deep thinking			requiring higher order thinking -Some of the questions are based on practical work	
	Learners: -Uses additional resources to compile own notes -Engages in meaningful group work	**Learners:** -Assist in the planning and performing of demonstrations -participate in cook book practical work -communicate data using graphs/tables. Ask and answer questions	**Learners:** -Teachers assist the learner to explore the explanations of scientific phenomena by different cultures	**Learners** -Apply practical knowledge -Apply higher order thinking	
3	**Teacher:** -probes learners' prior knowledge -structures learning activities on relevant knowledge and problem solving techniques -introduces learners to the evolving nature of scientific knowledge	**Teacher:** Designs practical work to encourage learner discovery of information	**Teacher:** -Facilitates investigations	**Teacher:** -Uses written tests -Tests include seen and unseen guided discovery type activities -Uses other forms of assessment as well	**Teacher:** -Confident -Finding footing -Motivated organized
	Learners: -Engage in minds on activities -Makes own notes on the concepts learned from doing activities	**Learner:** -Perform guided discovery type practical work in small groups -Write a scientific report -Can justify conclusion in terms of data collected	**Learners:** -Actively investigate science application I own environment	**Learners:** -Apply practical knowledge -Apply higher order thinking	
4	**Teacher:** -Facilitates learners as they design and undertake long-term investigations/project -Assist learners to weigh theories that attempt to explain the same phenomena	**Teacher:** -Facilitates learners with design and data collection strategies -Facilitates learners on data interpretation and conclusions	**Teacher:** -Facilitates learners with the community project and identifying the needs	**Teacher:** -Create opportunity for different types of assessment -Facilitates in compilation of portfolio	**Teacher:** -Empowered -self-directed -respected
	Learner: -Takes major responsibility for own learning	**Learners:** -Design and do own open investigations -Reflect on designing and collected data -Interpret data	**Learners:** -Undertake long term community based investigation -Apply science to specific need in community	**Learner:** -Includes open investigation of community project in assessment -Create portfolio to present best work	

Table 8.3 Profile of the capacity to support innovation

Level	Physical resources	Teacher factors	Learner factors	School ecology and management	Professional learning community
1	-Basic building – but in poor condition -Toilets and running water available -Electricity in some rooms -Some textbooks but not enough for all -Some basic science apparatus -No science laboratory or laboratory is present it is not in working condition	-Teacher is under qualified for the position -Teacher does have a professional qualification -Teacher absenteeism is low -Teacher spends more than half the time teaching	-Learners have some proficiency in language of instruction -Some learners do not receive enough food at home -School has feeding scheme -Learners have socio-economic problems -Learners receive very little academic support at home	**Management**: -A timetable , class list and other routines are in evidence -The presence of the principal is felt in the school at least half the time -Staff and subject meetings are held at times -Attendance register for teachers exist **Ecology**: -Teaching and learning occurs most of the time -Teachers and learners return on time after the break -School governing body exists -School is secure	A single staff room exists – not well utilized Weekly meetings with staff Some social interaction between teachers Management organized some social function Some staff members feel marginalized Monthly subject meetings with discussions
2	-Adequate basic building- good condition -Suitable furniture -Electricity in most rooms -Textbooks for all learners -Reasonable amount of apparatus for science	-Teacher has minimum qualification for position -Teacher is motivated and diligent -Teacher participates in professional development activities -Teacher has good rapport with learners	-Learners attend school on a regular basis -Learners are nourished well -Learners are given activities -Teacher has good relationship with learners-respect	**Management**: -Teacher attends school regularly -principal is present in school most of the time and there is regular contact with staff -Timetable properly implemented -Extramural activities are organized in such a way they do not interfere with scheduled lessons -teachers and learners who shirk their duties are held accountable Ecology: -Responsibility of making the school functional is shared by teachers , management and learners -SGB operates well -School functions all the time	-Daily meeting in staff room -Regular interaction between teachers -Management involved in community building -Staff used fully -Science teachers have regular discussions on subject matter
3	-Good building- enough classrooms and science laboratories	-Teacher is qualified for position- has sound	-Learners have access to a safe place to study	**Management:** Principal takes strong leadership role, is visible	-Teachers meet socially before school, during breaks and after school

	-Running water and electricity in all rooms -Textbook for all learners and teachers -Sufficient science apparatus -Additional subject reference books for teachers -reasonably equipped library -Secure premises -Well-kept grounds	understanding of subject -Teacher is an active participant in professional development activities -Conscientious attendance of class by teacher -Teacher makes extra effort to improve teaching	-Learners come from supportive home environments -Learners can afford extra books and tuitions -Parents show an interest in their child's progress -Learners have access to IT	during school hours Teachers and learner play an active role in school management **Ecology**: Everyone in the school is committed to making it work -Parents play an active role in the School development	-Management and staff interact and communicate socially and professionally on a regular basis -Science teachers help each other out and reflect together
4	-Excellent buildings -More than one well equipped lab -Library is well resourced -Adequate curriculum materials and other textbooks readily available. -Good teaching and learning resources -Active grounds -Good copying facilities	-Teacher is over qualified for post, has excellent knowledge of content - Teacher is very committed to teaching -Teacher shows willingness to change, improvise and collaborate -Teacher shows local and international leadership in professional development activities	-Learners take responsibility for their learning -Learners are willing to try new kinds of learning	Ecology: -There is shared vision -School plans for, supports and monitors change -Collaboration of all stakeholders **Management**: There is a visionary but participatory leadership at school	-Sustained social and professional interaction between staff members -Management nurtures and partakes fully in community -A caring professional learning community exists between science teacher -All professional development needs are catered for within the PLC

The findings of the study confirm that for practicing teachers to be able to implement the curriculum two key factors are essential. These are continuous teachers' professional development (CPTD) and the capacity to innovate. Figure 8.1 captures this intricate triad relationship between CTPD, capacity to innovate and profile of implementation. The funnel in figure 8.1 (re)presents the school ecology which has to support and contain curriculum implementation, provide CTPD and allow for innovation during curriculum implementation

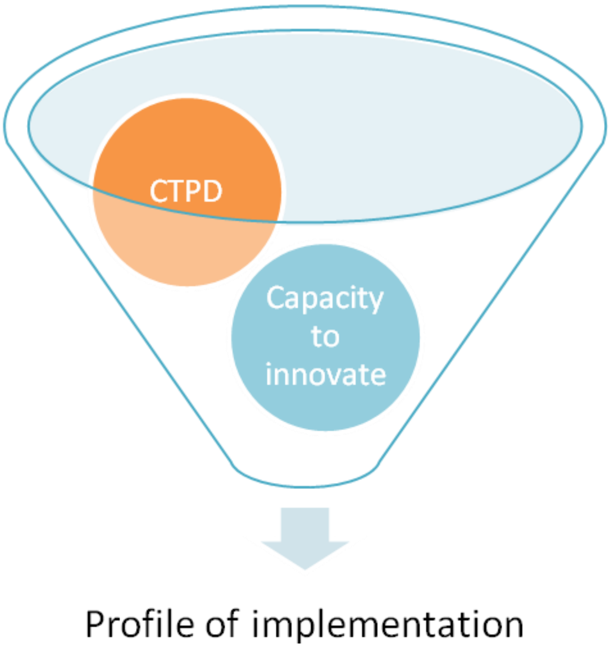


Figure 8.1 The inter-relation between capacity to innovate, continuous teachers' professional development and the profile of implementation.

8.4 Recommendations

Recommendations arising from this study apply to tertiary institutions and education administration in Zimbabwe.

8.4.1 Recommendations for tertiary intuitions

As biotechnology play an increasing role in our society, biology teachers have a crucial role in informing learners about these new technologies. Therefore universities and other institutions of higher learning are charged with developing biotechnology education curriculum materials that would enable in-service and pre-service teachers to acquire relevant and current information on these aspects.

- The contribution and shortfalls of biotechnology to our personal and societal lives.
- The ethical, social and cultural issues related to biotechnology.

8.4.2. Recommendations for policy makers in Zimbabwe

The Ministry of Primary and Secondary Education has embarked on a five plan for radical changes to the education system, with the introduction of the new curriculum to be implemented between 2017 and 2022. Lessons learnt from educational reform initiatives worldwide indicate that implementing a new curriculum, such as with the biotechnology option in the A level biology curriculum (9190), presents many challenges, especially when teachers do not have sufficient opportunity and support to internalize the required teaching repertoire. Recommendations relevant for policy consideration include the following:

- The PDI platform should be considered as a framework for development and implementation of any curriculum.
- A change like this should be implemented simultaneously across the different elements of the education system. That is the professional development intervention efforts should also focus on the school principals and improving the working environment for the teachers, so that a coherent meaningful change may be brought about in classroom practice and improvement of student learning outcomes.

Recommendations for teachers' professional development programs, based on findings from this study are:

- That future professional development endeavors should be based on the pressing needs and actual classroom practices of practicing teachers.
- Professional development scenarios should enhance teachers' subject matter and pedagogical content knowledge, encouraging teacher learning and reflection in daily practices through participatory action research.
- Considering the costs of sustained professional development for of biology teachers in Zimbabwe, cost-effective efforts should focus on building up the capacity of district in-service teams; that is using a cascade model and improving school conditions for out-of-classroom peer-to-peer collaborations. The Science Education In-service Teacher Training (SEITT) model in Zimbabwe could be very effective if it were established at district level and further.
- As part of the PDI platform for teachers, a selected group of biology teachers and in-service providers such as Education Officers (EO) in science could be trained in biotechnology coaching, and so, in turn, provide coaching within their respective

districts, facilitating the creation and the activities of district teams with the assistance of the Education Officers for science in the province.

- Research on the PDI for other but equally challenging biology options, such as genetics, should also be included.
- The Ministry of Primary and Secondary Education should build a strong working relationship with other educational partners interested in developing teachers; not limited to biology but including all science educators.
- Identify biotechnology teachers within each province who are good in biotechnology content knowledge and afford them an opportunity to empower their colleagues.
- A needs questionnaire should be administered to biology teacher to identify gaps in the biotechnology curriculum.
- The study also recommends that research projects should be encouraged and funded by the government through the Ministry of Primary and Secondary Education. This applies not only to the knowledge and ethical issues related to biotechnology but on Science Education in general.

8.5 Conclusion

The findings presented in Chapters 5, 6 and 7 indicated that the PDI platform created through CBPAR was very much appreciated by all the biology teachers involved. It brought teachers together, thereby mutually enhancing their biotechnology teaching and learning as well as engagement in biotechnology. The impact of the established PDI platform was felt by all the teachers who created it, and their views were expressed that it made the teaching and learning of biotechnology considerably more engaging and simpler. Teacher isolation was considerably reduced as teaching collegiality and collaboration was enhanced. Biotechnology instructional and learning materials were now available in the schools. Overall, the level of biotechnology awareness had been enhanced in the Masvingo teaching community; undoubtedly this had a wider influence on the community at large.

REFERENCES

Afework, T.H. & Asfaw, M.B. (2014). The availability of school facilities and their effects on the quality of education in government primary schools of Harari Regional State and East Hararghe Zone, Ethiopia. *Middle Eastern & African Journal of Educational Research*, 1(11), 59-71.

Akram, S., & Mailk, S.K. (2012). Use of audio visual aids for effective teaching of biology at secondary schools level. *Elixir Leadership Management*, 50, 10597-10605.

Alexander, P. A. (2008). Charting the course for the teaching profession: The energizing and sustaining role of motivational forces. *Learning & Instruction*, 18(5), 483-491.

Alshehry, A. (2018). Case study of science teachers' professional development in Saudi Arabia: Challenges and improvements. *International Education Studies*, 11(3), 70-76.

Alsubaie, M (2016). Curriculum Development: Teacher Involvement in Curriculum Development. *Journal of Education and Practice*, 7(9), 106-107.

Anderson, J. R. (2000). *Learning and memory: An integrated approach*. Hoboken, NJ: John Wiley & Sons Inc.

Anderson, S. E. (Ed.). (2002). *Improving schools through teacher development: Case studies of the Aga Khan Foundation Projects in East Africa*. Lisse, Netherlands: Swets & Zeitlinger.

Appleton, J. J., Christenson, S. L. & Furlong, M. J. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology in the Schools*, 45, 369–386.

Armstrong, P. (2015). Teacher characteristics and student performance: An analysis using hierarchical linear modelling. *South African Journal of Childhood Education*, *5*(2), 123-145.

Asan, O. & Montague, E. (2014). Using video-based observation research methods in primary care health encounters to evaluate complex encounters, *Informatics in Primary Care*, 21(4), 161-70.

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

Barab, S. & Squire, K. (2004). Design-based research: Putting a stake in the ground. *Journal of the Learning Sciences, 13*(1), 1-14.

Barnes, R. (2005). Moving towards technology education: factors that facilitated teachers' implementation of a technology curriculum. *Journal of Technology Education*, 17(1), 6-14.

Baum F., MacDougall C. & Smith D. (2006). Participatory action research. *Journal of Epidemiology and Community Health*, 60(10), 854-857.

Baumert, J. & Kunter, M. (2013) The COACTIV model of teachers' professional competence. In M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss & M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 25–48). Boston, MA: Springer.

Beatty, B.(2000). Teachers Leading their Own Professional Growth: self-directed reflection and collaboration and changes in perception of self and work in secondary school teachers. *Journal of In-Service Education*, 26, (1),73-97.

Behar R. and Gordon, D.A. (Eds) (1995), *Women writing culture*. Berkeley: University of California Press.

Bell, B. & Gilbert, J. (1994). Teacher development as personal, professional, and social development. *Teaching and Teacher Education*, 10, 483-497.

Bell, B. & Gilbert, J. (1996). Teacher development: A model from science education. London: Falmer Press.

Bergold, J. and Thomas, S (2012). Participatory Research Methods: A Methodological Approach in Motion. *Forum: Qualitative Social Research*,13(1) Article 30. http://nbn-resolving.de/urn:nbn:de:0114-fqs1201302

Berman, P. & McLaughlin, M.W. (1976) Implementation of Educational Innovation, *The Educational Forum*, 40(3), 345-370, DOI: 10.1080/00131727609336469

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

Birman, B., Desimone, L., Porter, A.C. & Garet, M.F., (2000). Designing professional development that works. *Educational Leadership,* 57(8), 28-33.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3–15.

Borko, H., Jacobs, J. & Koellner, K. (2010). Contemporary Approaches to Teacher Professional Development. In P. Peterson, E. Baker & B. McGaw (Eds.), International Encyclopaedia of Education (pp. 548-556). Oxford: Elsevier.

Botha, E. M. (2012). Turning the tide: Creating Professional Learning Communities (PLC) to improve teaching practice and learning in South African public schools. *Africa Education Review*, 9(2), 395 - 411.

Bowen, G. A. (2008). Naturalistic inquiry and the saturation concept: A research note. *Qualitative Research*, 8(1), 137-152. doi:10.1177/1468794107085301

Brouwer, P., Brekelmans, M., Nieuwenhuis, L. & Simons, R. J. (2012). Communities of practice in the school workplace. *Journal of Educational Administration*, *50*(3), 346-364.

Bulelwa, K.(2014). Understanding life sciences teachers' engagement with ongoing learning through continuous professional development programmes. Unpublished PhD thesis. University of Kwa Zulu Natal.

Butts, R.F. (2010) *A History of Education in American Culture*. New York: Rinehart and Winston.

Buykgungor, H. & Gruel, L. (2009). The role of biotechnology on the treatment of wastes. *African Journal of Biotechnology*, 8(25), 7253-7262.

Camar, O. (2015). Community-Based Participatory Action Research in Mental Health: A Special Focus on Photovoice: Ozge Carta, *European Journal of Public Health*, 25, (supplement3), https://doi.org/10.1093/eurpub/ckv169.056.

Campbell D. J. (2008). The Learning Theory Podcast. Episode 4. Retrieved January 15, 2016, from http://www.dancampbell.us/podcast/LTP-4_Vygotsky_ZPD.pdf

Chambers, M. (1999). Thoughts on the efficacy and ethics of using digital multimedia for educational purposes. In Tait, A. & Mills, R. (eds.). *The convergence of distance and conventional education*. (pp,159-200) London: Routledge.

Chingos, M. M. & West, M. R. (2010) *Do more effective teachers earn more outside of the classroom?* Programme on Education Policy and Governance: Working Paper Series PE-PG 10-02.

Clarke, D. & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947-967.

Cochran-Smith, M. (2005). Studying teacher education: What we know and need to know. *Journal of Teacher Education*, 56(4), 301-306.

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* (5th ed.). New York: Routledge.

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

Cornwall, A. and Jewkes, R. (1995) What is participatory research? *Social Science and Medicine*, 41(12): 1667-1676.

Creswell, J. (2010).. *Qualitative inquiry and research design: Choosing among five approaches*. London: Pearson.

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

Creswell. J.W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Los Angeles: SAGE Publications

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

Dawson, V. (2007). An exploration of high school (12–17 year old) students' understandings of, and attitudes towards biotechnology processes. *Research in Science Education, 37*(1), 59-73.

Day, C. (Ed.). (1999). *Developing Teachers: the challenges of lifelong learning*. London: Falmer Press.

Day, C. & Sachs, J. (Eds.). (2004). *International handbook on the continuing professional development of teachers.* Berkshire: McGraw-Hill Education.

De Jong, O., Veal, W. R. & Van Driel, J. H. (2002). Exploring chemistry teachers' knowledge base. In J.K. Gilbert, O. De Jong, R. Justi, D.F. Treagust & J.H. Van Driel (Eds.), *Chemical education: towards research-based practice* (pp. 369–390). Dordrecht, Netherlands: Kluwer Academic.

Delport, A., &Dhlomo, D.(2010). Music education in Zimbabwean schools: What teacher narratives reveal. *South African Education Journal,* 7(1)*,* 1-15.

De Vos, A.S. (2004). 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), (pp. 339-355). Pretoria: Van Schaik.

De Vos, A.S., Strydom, H., Fouché, C.B. & Delport, C.S.L. (Eds) (2005). *Research at grass roots for the Social Sciences and Human Service Professions.* Pretoria: Van Schaik.

Denzin, N.K. & Lincoln, Y.S. (1994). *Handbook of qualitative research*. Town: Sage publications, Inc.

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.

Desimone, L. M. (2011). A primer on effective professional development. *Phi Delta Kappan,* 92, 68-71.

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

DuFour, R. (2004). Schools as learning communities. *Educational Leadership*, 61(8), 6-11.

DuFour, R. & Eaker, R. (2008). *Revisiting professional learning communities at work: New insights for improving schools*, Bloomington, IN: National Educational Services.

Durrheim, K. (2004). Research design. In M. Terre Blanche & K. Durrheim (Eds.), *Research in practice: Applied methods for the social sciences* (pp. 29-53). Cape Town: University of Cape Town.

Durrheim, K. & Wassenaar, D. (2002). Putting design into practice: writing and evaluating research proposals. In M. Terre Blanche & K. Durrheim (Eds.), *Research in practice: applied methods for the social sciences* (pp. 54-71).University of Cape Town Press, Cape Town,

Eckert, P. (2006) Communities of Practice. In: Brown, K., Ed., *Encyclopaedia of Language and Linguistics* (2nd ed), pp. 683-685. Amsterdam: Elsevier. Retrieved from http://dx.doi.org/10.1016/B0-08-044854-2/01276-1

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

Evans, A., Ali, S., Singleton, C., Nolan, P. & Bahrami, J. (2002). The effectiveness of personal education plans in continuing professional development: an evaluation. *Medical Teacher*, *24*(1), 79-84.

Evers, A., Van der Heijden, B. & Kreijns, K. (2016). Organizational and task factors influencing teachers' professional development at work. *European Journal of Training and Development*, 40, 36-55.

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

Fals-Borda, O. (2001). Participatory action research in social theory: Origins and challenges. In P. Reason & H. Bradbury (Eds). *Handbook of action research: Participatory inquiry and practice* (pp. 27-37). Thousand Oaks, CA: Sage.

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.) (pp. 1-54). Luxembourg: Institute for Prospective Technological Studies.

Ferraro, J. (2000). Reflective practice and professional development. ERIC document number ED449120. retrieievd from <<GIVE specific link url, not simply ERIC >>

Fleisch, B., Taylor, N., Herholdt, R. & Sapire, I. (2011). Evaluation of Back to Basics mathematics workbooks: A randomised control trial of the primary mathematics research project. *South African Journal of Education*, *31*(4), 488-504. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0256-01002011000400003&lng=en&tlng=en

Fraser C, Kennedy A, Reid L & McKinney S. (2007). Teachers' continuing professional development: Contested concepts, understanding and models. *Professional Development in Education*, 33(2):153-169. doi: 10.1080/13674580701292913

Friedman, A & Philips, M (2004) Continuing Professional Development: Developing a Vision. *Journal of Education and Work*, 17(3), 361 – 376.

Fuhrman, J.A, Jacob C. & Needham, D. (2015). Marine microbial dynamics and their ecological interpretation. *Nature Reviews Microbiology*, 13, 133-146. doi:10.1038/nrmicro3417.

Fullan, M. (1991). *The New Meaning of Educational Change* (2th ed.). New York: Teachers College Press.

Fullan, M. (2001). *The New Meaning of Educational Change* (3th ed.). New York: Teachers College Press.

Fullan, M. (2006). Leading professional learning. *School Administrator*, 63(10), 10-15. Retrieved February 18, 2017, from http://aasa.rd.net/publications/saarticledetail.cfm?mnitemnumber=&tnitemnumber=&ite number=7565&unitemnumber=&pf=1&snitemnumber

Fullan, M. (2007). The New Meaning of Educational Change (4th ed). London: Teachers College Press.

Fullan, M. & Miles, M.B. (1992). Getting reform right: What works and what doesn't. *Phi Delta Kappan*, 73(10), 745-752.

Gastrow M., Roberts B., Reddy V. & Ismail S. (2016) Public perceptions of biotechnology in South Africa. *South African Journal of Science*. 114(1/2), Article number 2017-0276, 9 pages. http://dx.doi.org/10.17159/ sajs.2018/20170276 .

Gaventa, J. (1988). Participatory research in North America. *Convergence*, 24, 19-28.

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

Goldschmidt, P. & Phelps, G. (2009). Does teacher professional development affect content and pedagogical knowledge: How much and for how long? *Economics of Education Review*, 29(3), 432-439. doi:10.1016/j.econedurev.2009.10.002 .

Gore, J., Lloyd, A., Smith, M., Bowe, J., Ellis, J. & Lubans, D. (2017). Effects of professional development on the quality of teaching: Results from a randomised controlled trial of Quality Teaching Rounds. *Teachings and Teacher Education*. 68, 99-113.

Grundy, S. & Robinson, J. (2004). Teacher professional development: themes and trends in the recent Australian experience. In C. Day & J. Sachs, *International Handbook on the Continuing Professional Development of Teachers*,, pp 146-166. Glasgow, UK: McGraw-Hill, .

Gulamhussein, A. (2013). Teaching the teachers: effective professional development in an era of high stakes accountability. Center for Public Education, Retrieved from http://www.centerforpubliceducation.org/Main-Menu/Staffingstudents/Teachingthe-Teachers-Effective-Professional-Development-in-an-Era-of-High-StakesAccountability/Teaching-the-Teachers-Full-Report.pdf

Guskey, T. R. (2000). *Evaluating Professional Development*. London, CA: Sage Publications.

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

Hall, G. & Hord, S. (1987). *Change in schools: Facilitating the process*. New York, NY: State University of New York Press.

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.

Hargreaves, A. (1998). The emotional politics of teaching and teacher development: With implications for educational leadership. *International Journal of Leadership in Education Theory and Practice*, 1(4), 315-336.

Hargreaves, A. & Fullan, M.G. (1992). Introduction. In A. Hargreaves, A. & M.G. Fullan (Eds) *Understanding Teacher Development*, pp. 1–19. London: Cassell.

Harvey, D. (2005). *A Brief History of Neoliberalism.* Oxford, England: Oxford University Press.

Henning, E., Van Rensburg, W. & Smit, B. (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.

Hord, S. M. (1987). *Evaluating educational innovation*. NY. Routledge.

Hord, S.M. (2004) Professional Learning Communities: An overview, in Hord, S.M. (Ed.) Learning Together, Leading Together: Changing schools through professional learning communities, pp. 5–14. New York: Teachers College Press.Hoy & Miskel (2013)

Hoy, W.K., Miskel, C.G. & Tarter, C.J. (2013) *Educational administration: Theory, research, and practice* (9th ed.). New York, NY: McGraw-Hill.

Huberman, M. (2001). Networks that alter teaching: Conceptualisation, exchanges and experiments. In J. Sole, A. Craft & H. Bugerss (Eds). *Development: exploring our own practice,* pp141-159. London: Paul Chapman.

Ismail, R. (2017). *Exploring how Science Teachers Engage in Curriculum Innovating in Environment and Sustainability Education.* Unpublished Ph.D. thesis. University of KwaZulu-Natal.

Jull, J., Giles, A. & Graham, I. (2017). Community-based participatory research and integrated knowledge translation: advancing the co-creation of knowledge. *Implementation Science*, 12(1), 1- 9.

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.

Keke, B. (2008). *Science Foundation Students' Experiences at a Tertiary Institution.* Unpublished M.Ed. dissertation, University of KwaZulu-Natal, Durban.

Kemmis, S. (2010). Research for praxis: Knowing doing. *Pedagogy, Culture & Society,* 18(1), 9–27.

Kennedy, M. (2016). How Does Professional Development Improve Teaching? *Review of Educational Research,* 86(4), 945-980.

Kinginger, C. (2002). Defining the Zone of Proximal Development in US foreign language education. *Applied Linguistics,* 23, 240-261.

Komba, W..L. & Nkumbi, E. (2008). Teacher professional development in Tanzania: Perceptions and practices. *Journal of International Cooperation in Education*, 11(3), 67-83.

Korkko, M.,O. Kyro-Ammala. & T. Turunen. (2016). Professional Development through Reflection in Teacher Education.. *Teaching and Teacher Education,* 55, 198-206.

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.

Lapan, S., Quartaroli, M. and Riemer, F. (2012). *Qualitative Research: An Introduction to Methods and Designs*. San Francisco: Jossey-Bass.

Lemons, L., Todd B.M., Burris, S., Meyers, C. & Price, M.A. (2015). Factors Contributing to Attrition as Reported by Leavers of Secondary Agriculture Programs. *Journal of Agricultural Education*, 56(4), 17-30. doi: 10.5032/jae.2015.04017.

Liakopoulou, M. (2011). The Professional Competence of Teachers: Which qualities, attitudes, skills and knowledge contribute to a teacher's effectiveness? I*nternational Journal of Humanities and Social Science*, 1(21), 66-78.

Lieberman & L. Miller (Eds.), *Teachers caught in the action: Professional development that matters* (pp. 174–187). New York: Teachers College Press.

Lieberman, A. & Pointer Mace, D.H. (2010). Making practice public: Teacher learning in the 21st century. *Journal of Teacher Education*, *61*(1-2), 77-88.

Lieberman, A. & Wood, D. (2001). When teachers write: Of networks and learning. In A. Lieberman & L. Miller (Eds.) *Teachers caught in the action: Professional development that matters*, pp. 174–187. New York: Teachers College Press. .

Little, J.W. (2003). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis*. 15(2), 129-151.

Little, M.E. & Houston, D. (2003). Research into practice through professional development. *Remedial and Special Education*, *24*(2), 75-87.

Long T. & Johnson M. (2000). Rigour, reliability and validity research. *Clinical Effectiveness in Nursing*, 4(1), 30–37.

Loucks-Horsley, S. & Matsumoto, C. (1999). Research on Professional Development for Teachers of Mathematics and Science: The State of the Scene. *School Science and Mathematics*, 99(5), 258-71

Loughran, J., Berry, A., & Mulhall, P. (2012). *Understanding and developing science teachers' pedagogical content knowledge* (2nd ed.). Rotterdam, The Netherlands: Sense Publishers, Louis, K. S. & Marks, H. M. (1998). Does professional community affect the classroom? Teachers' work and student experiences in restructuring schools. *American Journal of Education*, 106(4), 532- 75.

Mackenzie, N. & Knipe, S. (2006). Research Dilemmas: Paradigms, Methods and Methodology. *Issues in Educational Research*, 16(2), 193-205.

Mangwaya, E; Blignaut, S. & Pillay, S. (2016). The readiness of schools in Zimbabwe for the implementation of early childhood education. *South African Journal of Education*, 36(1), 1-8.

Maree, J. G. (2009). Career counselling in the 21st century: South African institutions of higher education at the crossroads. *South African Journal of Higher Education, 23*(3), 436-458.

Maree, K. (2007). *First steps in Research*. TOWN: Van Schaik Publishers.

Maree, K. (2009). *First Steps in Research* (???ed.). Pretoria: Van Schaik.

Marshall, C. J., & Rossman, B. G. (2006). *Designing Qualitative Research*. Thousand Oaks: Sage.

Martinez, K. (2004). Mentoring new teachers: Promise and problems in times of teacher shortage. *Australian Journal of Education*, 48(1), 95-108.

Mayan, M. & Daum, C. (2016). Worth the Risk? Muddled Relationships in Community-Based Participatory Research. *Quality Health Research*, 26(1), 69-76.

Mayer, M. & Torracca, E. (2010). (eds.) *Innovative methods in learning of science and technology. National findings and international comparison.* 230 pp. Austrian Institute of Ecology 244265_kidsINNscience_Deliverable_D3-1_100730.pdf retrieved from http://www.kidsinnscience.eu/download.htm

McDonald, J. & Dominguez, L.A. (2015). Developing university and community partnerships: A critical piece of successful service learning. *Journal of College Science Teaching*, 44(3), 52-56. https://doi.org/10.2505/4/jcst15_044_03_52.

McLaughlin, M.W. & Talbert, J.E. (2006). *Building school based teacher learning communities: Professional strategies to improve student achievement.* New York: Teachers College Press.

McMillan, J.H. & Schumacher, S. (2010). *Research in Education: Evidence-Based Inquiry* (7th ed.). New Jersey: Pearson.

McTaggart, R. (1989). Bureaucratic rationality and the self-educating profession: The problem of teacher privatism. *Journal of Curriculum Studies, 21*(4), 345-361.

Merriam, S.B. (1998). *Case Study Research in Education: A Qualitative Approach*. San Francisco: Jossey-Bass.

Mestry, R. (2017). Empowering principals to lead and manage public schools effectively in the 21st century. *South African Journal of Education*, 37(1), 1-11.

Micheal,D.,Magodi,M.,S, Hakim,J.G, Talib, Z, Mipando, H., Chidzonga, M., Matsika, A & Simuyemba, M. (2017). A peer evaluation of the community-based education programme for medical students at the University of Zimbabwe College of Health Sciences: A southern African Medical Education Partnership Initiative (MEPI) collaboration. *African Journal of Health Professions Education*,. 9(3), 138-143.

Ministry of Primary and Secondary Education (MoPSE) A level Biology Examination results : Masvingo Province records of 2015. MoE

Minkler, M., Blackwell, A.G., Thompson, M. & Tamir, H. (2003). Community Based Participatory Research: Implications for Public Health Funding. *American Journal of Public Health,* 93(8), 1210-1213.

Mitchell, C. & Sackney, L. (2000). *Profound improvement: Building capacity for a learning community.* Lisse, The Netherlands: Swets & Zeitlinger.

Molapo, R. (2015). How educators implement curriculum change. Unpublished M.Ed. dissertation. University of Pretoria, Petoria.

Moon, J., Michaels, S. & Reiser, B. J. (2012). Science standards require a teacher-learning rethink. *Education Week*, *32*(13), 9-22.

Mpofu, N. & de Jager, L. (2018). Exploring Beginner Teachers' Sources of Knowledge for Teaching Literature in ESL Classrooms. *Journal for Language Teaching,* 51(1), 201-217.

Mupa, P., & Chinooneka, T., I.(2015). Factors contributing to ineffective teaching and learning in primary schools: Why are schools in decadence? *Journal of education and practice*, 6 (19), 125-133.

Muwanga-Zake, J.W.F. (2008). Is Science Education in a Crisis? Some of the Problems in South Africa. *Science in Africa.* 1(1), 17-30.

Najumba, J. (2013). *The effectiveness of teaching and learning in primary schools*. Boston: Sage Publications.

Ndawi, O. & Maravanyika, O. (2011). C*urriculum and its building blocks: Concepts and processes.* Gweru, Zimbabawe: Mambo Press.

Neuman, W. L. (1997). *Social Research Methods Qualitative and Quantitative Approache*s (3rd ed.). TOWN: PUBLISHER

Nieuwenhuis, J. (2007). Introducing Qualitative Research. In K. Maree (Ed.), *First Steps in Research*, pp. 46-68. Pretoria: Van Schaik.

Nyamubi, G. J. (2016). Students' Attitudes and English Language Performance in Secondary Schools in Tanzania. *International Journal of Learning, Teaching and Educational Research*, 15(2), 117-133.

Ostovar-Nameghi, S.A. & Sheikhahmadi, M. (2016). From teacher isolation to teacher collaboration: Theoretical perspectives and empirical findings. *English Language Teaching*, 9(5), 197-205.

Parawira, W. (2008). The status and trends in food, industrial and environmental biotechnology research in Zimbabwe. *African Journal of Biotechnology*, 7(10), 1377-1384.

Parawira, W. & Khosa, E. (2009). Biotechnology research, development, applications and management in Zimbabwe: Review. *Scientific Research and Essay,* 4(9), 825-841.

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. *Complicity: An International Journal of Complexity and Education*, *2*(10), 37.

Pintò, 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.

Putnam, R.T. & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, 29(1), 4-15.

Reason, P. & Bradbury, H. (2006). Introduction: Inquiry and participation in a world worthy of human aspiration. *Handbook of Action Research.* London: SAGE,.

Reddy, C. (2011). Inaugural Address Environmental Education and Teacher Development: Engaging a Dual Curriculum Challenge. *Southern African Journal of Environmental Education, 28,* 9-28.

Robson, C. (2011) *Real world research: a resource for users of social research methods in applied settings*. Chichester: Wiley.

Rogan, J. & Aldous, C. (2005). Relationships between the constructs of a theory of curriculum implementation. *Journal of Research in Science Teaching:* 42(3), 313-336

Rogan, J.M. (2007). How Much Curriculum Change is Appropriate? Defining a Zone of Feasible Innovation. *Science Education, 91*, 439-460.

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.

Rollnick, M., Bennett, J., Rhemtula, M., Dharsey, N. & Ndlovu, T. (2008). The place of subject matter knowledge and pedagogical content knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education*, 30(10), 1365-1387. doi:10.1080/09500690802187025

Rousseau, P. (2015). *The role of reflection in integrating theory and practice in foundation phase teacher education.* Unpublished Ph.D. thesis. University of Stellenbosch, Stellenbosch.

Samuel, M. (2014). South African teacher voices: recurring resistances and reconstructions for teacher education and development**,** *Journal of Education for Teaching: International research and pedagogy***,** 40(5), 610-621**.**

Saunders, R. (2013). The role of teacher emotions in change: Experiences, patterns and implications for professional development. *Journal of Educational Change,* 14, 303–333. doi:10.1007/s10833-012-9195-0

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.

Scott, C. & Sutton, R.E. (2009). Emotions and change during professional development for teachers: A mixed methods study. *Journal of Mixed Methods Research*, 3(2), 151–171.

Selinger, M. (1997). Open learning, electric communications and beginning teachers. European *Journal of Teacher Education*, 20(1), 71–84

Shea, J.M., Poudrier, J., Thomas, R., Jeffery, B. & Kiskotagan, L. (2013). Reflections from a creative community-based participatory research project exploring health and body image with First Nations girls. *International Journal of Qualitative Methods*, 12, 272–293.

Sherron, T. & Fletcher, C. (2008). Exploring the Effects of Professional Development on Science Teaching Practices. Paper presented at the *Association for Science Teacher Education.* Science education conference. Paris, 2008.

Shulman L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15, 4-14.

Shulman, L.S. (1987). Knowledge and Teaching Foundations of the New Reform. *Harvard Educational Review*, 57, 1-22.

Shulman, L.S. (2004). The wisdom of practice: Essays on learning, teaching, and learning to teach. NY. Sage.

Singer, J., Marx, R.W., Krajcik, J. & Chambers, J.C. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, 35(3), 165 – 178.

Singh-Pillay, A. (2010). *An exploration of the interface between schools and industry in respect of the development of skills, knowledge, attitude and values.* Unpublished PhD thesis. University of KwaZulu-Natal, Durban.

Singh-Pillay, A. & Alant, B. (2015). Tracing the Policy Mediation Process in the Implementation of a Change in the Life Sciences Curriculum. *African Journal of Research in Mathematics, Science and Technology Education.* http://dx.doi.org/10.1080/10288457.2014.1002297Singh-Pillay, A. & Samuel, M.A. (2017). Life Sciences Teachers Negotiating Professional Development Agency in Changing Curriculum Times. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(6), 1749-1763.

Smith, C. & Gillespie, M. (2007). Research on professional development and teacher change: Implications for adult basic education. In J. Comings, B. Garner & C. Smith (Eds.), *Review of adult learning and literacy: Connecting research, policy, and practice*, pp. 205-244. Mahwah, NJ: Lawrence Erlbaum Associates.

Smith, C., Hofer, J., Gillespie, M., Solomon, M. & Rowe, K. (2003). *How teachers change: A study of professional development in adult education* Cambridge, MA: NCSALL Reports. Retrieved from http://www.ncsall.net/fileadmin/resources/research/report25a.pdf .

Spillane, J.P. (1999). External reform initiatives and teachers' efforts to reconstruct their practice: the mediating role of teachers' zones of enactment. *Journal of Curriculum Studies* 31(2), 143-175.

Sprinkle, J.E. (2009). Student perceptions of educator effectiveness: A follow-up study. *College Student Journal*, 43, 1341-1358.

Stein, S., McRobbie, C. & Ginns, I. (1999). Introducing Technology Education: Using teachers' questions as a platform for professional development. *Research in Science Education*, 29(4), 501-514.

Steyn, G.M. (2008). *Continuing professional development for teachers in South Africa and social learning systems: conflicting conceptual framework of learning.* University of Pretoria. BOOK ? (needs publisher) Thesis/dissertation? (needs details) Report ? (needs url)

Stoll, L., Bolam, R., McMahon, A., Wallace, M. & Thomas, S. (2006). Professional Learning Communities: A Review of the Literature. *Journal of Educational Change*, 7, 221-258.

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, Y.-S.M. & Caleon, I.S. (2016). Problem finding in Professional Learning Communities: A learning study approach. *Scandinavian Journal of Educational Research*, 60(2), 127-146. doi:10.1080/00313831.2014.996596.

Tashakkori, A. & C. Teddlie (2010) *Sage Handbook of Mixed Methods in Social & Behavioral Research.* Thousand Oaks, CA: Sage Publications.

Taylor, N. & Vinjevold, P. (1999). *Getting learning right: Report of the President's. Education Initiative Research Project.* Johannesburg: Jet.

Tichapondwa, M. (2013). *Preparing your dissertation at a distance: A research guide.* Vancouver: Virtual Unit for the Small States of the Commonwealth.url?

Tin, L.G., Hean, L.L. & Leng, Y.L. (1996). What motivates teachers? *New Horizons in Education*, 37, 19-27.

Toole, J. & Louis, K.S. (2002). The role of professional learning communities in international education. In K. Leithwood & P. Hallinger (Eds.), *The Second International Handbook of Educational Leadership*, pp. 245-279. Dordrecht, Netherlands: Kluwer.

Tytler, R., Symington, D. & Smith, C. (2011). A Curriculum Innovation Framework for Science, Technology and Mathematics Education. *Research in Science Education, 41*, 19-38.

Vacirca, E. (2008). How do teachers develop their technological pedagogical content knowledge in the context of system-wide pedagogical and curriculum reform? *Conference of Australian Association for Research in Education*, Brisbane, Nov 30–Dec (Vol. 4). Retrieved from http://publications.aare.edu.au.

van Driel, J. and Berry, A. (2012). Teacher professional development focusing on pedagogical content knowledge, *Educational Researcher*, 41(1), 26-28.

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 Laren, L., Mitchell, C., Mudaly, R., Pithouse-Morgan, K. & Singh, S. (2012). Exploring University Educators' Lived Experiences of Curriculum Innovating Through Integrating HIV and AIDS. *Alternation*, 19(2), 138-161.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Process*. Cambridge: Harvard University Press.

Weaver, K. & Olson, J.K. (2006). Understanding paradigms used for nursing research. *Journal of Advanced Nursing,* 53(4), 459-469. doi: 10.1111/j.1365-2648.2006.03740.x

Wenger, E. (2000). Communities of practice and social learning systems. *Organization,* 7(2), 225-246.

Wenger, E. (2011). *Communities of Practice: A brief introduction*. Watertown, MA: Harvard Business Press.

Wilson, S. M. & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education,* 24, 173–209.

Witte, T. & Jansen, E. (2016). Students' voice on literature teacher excellence. Towards a teacher organized model of continuing professional development. *Teaching and Teacher Education*, 56, 162-172.

Wood W. B. (2009) Innovations in teaching undergraduate biology and why we need them. Annual . Reviewof Cell and Devlopmental Biology. . 25: 93–112.

Yang, Y, Liu, X & Gardella Jr., J.A. (2018). Effects of professional development on teacher pedagogical content knowledge, inquiry teaching practices, and student understanding of interdisciplinary science. *Journal of Science Teacher Education,* 29(4), 263-282, DOI: 10.1080/1046560X.2018.1439262.

Yap, R.A. (2015). Building professional learning communities with the aid of activity theory. *7th ICMI-East Asia Regional Conference on Mathematics Education*, (pp. 535-542). Cebu City, Philippines.

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.). London: Sage.

Yoo, J. & Carter, D. (2017). Teacher Emotion and Learning as Praxis: Professional Development that Matters. *Australian Journal of Teacher Education,* 42(3) PAGES. http://dx.doi.org/10.14221/ajte.2017v42n3.3.

Zembere, M. (2018). *Democratic citizenship education in Zimbabwe's higher education system and its implications for teaching and learning.* Unpublished Ph.D. thesis. University of Stellenbosch, Stellenbosch.

Zimbabwe Biotechnology unit. (2006) Zimbabwe Policy Framework for Biotechnology, Government printers, Harare.

Zimbabwe Curriculum Blueprint (2015-2022). Harare. Government Printers

Zimbabwe School Examinations Council (2013-2015 (Advanced Level Syllabus Biology 9190. Harare. Government Printers

APPENDICES

APPENDIX A ETHICAL CLEARANCE APPROVAL

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

08 July 2015

Mr Elias Rurinda 213574317
School of Education
Edgewood Campus

Dear Mr Rurinda

Protocol reference number: HSS/0773/015D
Project title: An exploration of the CBPAR to create and innovative platform for engaging "A" levela Biology teachers' in Biotechnology within the Biology curriculum in Zimbabwe

Expedited Approval

In response to your application dated 23 June 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

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

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

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

Yours faithfully

....

Dr Shenuka Singh (Chair)

/px

cc Supervisor: Dr A Singh-Pillay
cc Academic Leader Research: Professor P Morojele
cc School Administrators: Ms B Bhengu, Ms T Khumalo, Ms P Ndimande & Mr NS Mthembu

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 B INVITATION LETTER TO STAKEHOLDERS

UNIVERSITY OF
KWAZULU-NATAL

INYUVESI
YAKWAZULU-NATALI

Edgewood Campus
Private Bag X03
Ashwood
3605

Dear: Esteemed Stakeholder

My name is Elias Rurinda, I am a PhD student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, **An exploration of the use of CBPAR to create an innovative platform for engaging "A" level Biology teachers in Biotechnology within the Biology curriculum in Zimbabwe**

The purpose of this project is to create a platform for teacher engagement in Biotechnology via a professional development intervention programme.

You are kindly invited to attend a meeting to jointly plan on how to create a platform aimed at creating awareness of and engagement in biotechnology, in Masvingo Province.

Venue: Victoria High School, Great Hall
Date: 20 June 2015
Time: 10 am

I look forward to seeing you and listening to your valued inputs at this meeting. More information about my study will be provided at the meeting.

Ps. Light refreshment will be served after the meeting

Thank you.

Yours faithfully
Elias Rurinda

Should you have any queries you can contact my supervisors
Dr. A. Singh –Pillay Telephone no: 031- 260 3672

Email: pillaya5@ukzn.ac.za
Ms. Mariette Synmann from the Research Office may also be contacted. Her details are:
University of KwaZulu-Natal
Humanities and Social Sciences Research Ethics
Govan
Mbeki Centre
Tel: +27 31 260 8350 Fax: + 27 31 260 3093 Email: snymanm@ukzn.ac.za

Acknowledgement –Stakeholders

I _______________________________________ (full name) 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 lesson to be observed
- Given/not given (delete that which is not applicable) for my photo narratives, and reflective journal 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 stakeholder

____

Date

APPENDIX C CONSENT FORMS FOR TEACHERS

UNIVERSITY OF KWAZULU-NATAL

INYUVESI YAKWAZULU-NATALI

Edgewood Campus
Private Bag X03
Ashwood
3605

Dear: Biology teacher

My name is Elias Rurinda, I am a PhD student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, **An exploration of the use of CBPAR to create an innovative platform for engaging "A" level Biology teachers in Biotechnology within the Biology curriculum in Zimbabwe**

The purpose of this project is to create a platform for teacher engagement in Biotechnology via a professional development intervention programme. In addition the study will focus on how biology teachers who have engaged in professional development learning activities enact the curriculum through innovating in biotechnology education. I would like to collect data from you by multiple methods. These include two interviews, each of approximately 30 minutes duration which will be audio recorded, observations, 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. It is expected that through this study biology teachers would propagate awareness of and engagement in biotechnology amongst learners. The findings of the research will not be used for any 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
Elias Rurinda

Should you have any queries you can contact my supervisors
Dr. A. Singh –Pillay
Telephone no: 031- 260 3672
Email: pillaya5@ukzn.ac.za

Ms. Mariette Synmann from the Research Office may also be contacted. Her details are:
University of KwaZulu-Natal

Humanities and Social Sciences Research Ethics
Govan Mbeki Centre
Tel: +27 31 260 8350   Fax: + 27 31 260 3093   Email: snymanm@ukzn.ac.za

----

Acknowledgement –Biology teacher

I ______________________________________ (full name) 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 lesson to be observed
- Given/not given (delete that which is not applicable) for my photo narratives, and reflective journal 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 D CONSENT FORM FOR HEADMASTER

Edgewood Campus
Private Bag X03
Ashwood
3605

Dear: Principal

RE: Request for permission to conduct research at your school.

My name is Elias Rurinda, I am a PhD student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, **An exploration of the use of CBPAR to create an innovative platform for engaging "A" level Biology teachers in Biotechnology within the Biology curriculum in Zimbabwe**

The purpose of this project is to create a platform for teacher engagement in Biotechnology via a professional development intervention programme. In addition the study will focus on how biology teachers who have engaged in professional development learning activities enact the curriculum through innovating in biotechnology education.

I hereby request permission to conduct my research with biology teachers at your school. I would like to collect data from biology teachers at your school using multiple methods. These include two interviews, each of 30 minutes duration which will be audio recorded, observation of lessons, analysis of photo narratives and reflective journals 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 biology teachers would obtain insight into curriculum innovation. You are assured that the findings of the research will not be used for any 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
Elias Rurinda

Should you have any queries you can contact my supervisors
Dr. A. Singh –Pillay Telephone no: 031- 260 3672

Email: pillaya5@ukzn.ac.za
Ms. Mariette Synmann from the Research Office may also be contacted. Her details are:
University of KwaZulu-Natal
Humanities and Social Sciences Research Ethics
Govan Mbeki Centre
Tel: +27 31 260 8350   Fax: + 27 31 260 3093

Email: snymanm@ukzn.ac.za

Acknowledgement by the principal

I ________________________, the Principal of____________________________ grant permission to Elias Rurinda to conduct her research in the above mentioned school.

____________________   ____________________

Signature of Principal   Date

APPENDIX E BIOLOGY SUBJECT HEAD

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Edgewood Campus
Private Bag X03
Ashwood
3605

Dear: Biology Subject head –Masvingo province

<u>RE: Request for permission to conduct research</u>

My name is Elias Rurinda, I am a PhD student at the University of KwaZulu-Natal Edgewood campus. I am currently engaged in a research project entitled, **An exploration of the use of CBPAR to create an innovative platform for engaging "A" level Biology teachers in Biotechnology within the Biology curriculum in Zimbabwe**

The purpose of this project is to create a platform for teacher engagement in Biotechnology via a professional development intervention programme. In addition the study will focus on how biology teachers who have engaged in professional development learning activities enact the curriculum through innovating in biotechnology education.

I hereby request permission to conduct this Study in Masvingo province. 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 biology teachers would obtain insight into curriculum innovation. You are assured that the findings of the research will not be used for any purpose other than the doctoral dissertation. In this regard, no harm will be caused to you, the CDU and the educator/s participating in this study. Furthermore, your anonymity is assured. Pseudonyms will be used to protect your identity. 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
Elias Rurinda

Should you have any queries you can contact my supervisors
Dr. A. Singh –Pillay Telephone no: 031- 260 3672
Email: pillaya5@ukzn.ac.za

Ms. Mariette Synmann from the Research Office may also be contacted. Her details are:
University of KwaZulu-Natal
Humanities and Social Sciences Research Ethics

Govan Mbeki Centre
Tel: +27 31 260 8350 Fax: + 27 31 260 3093

Email: snymanm@ukzn.ac.za

Acknowledgement –Biology Subject head Masvingo province

I ____ (full name) 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.

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 Subject head

____
Date

_________________________ __________________________________
Phone number Email address

APPENDIX F CONSENT TO CONDUCT RESEARCH

ALL communications should be addressed to "The Provincial Education Director for Primary and Secondary Education

Telephone: 263585/264331
Fax: 039-263261

ZIMBABWE

Ministry of Primary and Secondary Education
P.O Box 89
MASVINGO

TO WHOM IT MAY CONCERN

Re:Teaching and learning of Biotechnology Option (9190) in high schools

Mr Elias Rurinda is helping our 'A' level teachers in the teaching of Biotechnology in the high schools. He is also spearheading SEITT (**Science Education In-Service Teacher Training)** workshops in Masvingo Province basically in this area. We have granted him permission to assist in the following high schools

- Pamushana High School
- Victoria High School
- Chibi High School
- Lundi High School

through participatory action research methods in 'A' level Biology teaching and learning.

Mugarisi Fanuel
Education inspector science
For :Provincial Education director
MASVINGO PROVINCE

MINISTRY OF PRIMARY & SECONDARY EDUCATION
PROVINCIAL EDUCATION DIRECTOR
MASVINGO
21 APR 2015
P.O. BOX 89, MASVINGO
ZIMBABWE
TEL: 039 - 264331

Appendix G PERMISSION FROM HIGH SCHOOL HEADS TO CARRY OUT RESEARCH ON BIOTECHNOLOGY OPTION

CHURCHES OF CHRIST IN ZIMBABWE

MASVINGO CHRISTIAN COLLEGE

Stand No 1446
Chasura Road, MASVINGO

Tel: 039-264772/253118
Box 436, MASVINGO

22 April 2015

To Whom It May Concern

Mr. Rurinda Elias, a lecturer at Great Zimbabwe University in the faculty of Education (Environmental Science) has been granted permission to undertake his participatory research in the teaching of 'A' Level Biology Biotechnology option 9190/3.

This will go a long way in improving the teaching and learning of this option.

Yours faithfully,

MURESHERWA. E
(SCHOOL HEAD)

THE DEPUTY HEAD
MASVINGO CHRISTIAN COLLEGE
24 APR 2015
P. O. BOX 436
MASVINGO
PHONE : 039 - 264772

QUALIFICATIONS

(i) MBA (ii) M Ed (iii) B Ed (Geo) (iv) B Com (H R M) (v) H N D (H R M) (vi) Dip Training Mgt (vii) C E (S) (viii) N.Y.S Training of Trainers Cert

APPENDIX H LESSON PLAN DOCUMENT ANALYSIS QUESTIONS

Questions guiding the analysis of biology teachers' lesson plans

- Does the lesson plan incorporate curriculum innovating in Biotechnology
- What innovative teaching methods are incorporated in the lesson plan?
- What innovative assessment strategies 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? (Rogan & Aldous, 2005)

APPENDIX I INTERVIEW SCHEDULE

1. Did you feel the professional development intervention related to biotechnology education has impacted on your teaching of biology?
2. Were you able to identify the need for innovation in biotechnology education?
3. Did the professional development intervention enhance your knowledge of biotechnology education? Which events made you feel this way?
4. What aspects of the professional development intervention impacted negatively or positively on your knowledge of biotechnology education?
5. In your opinion, would more professional development of this nature be beneficial to your teaching? Please elaborate.
6. What innovating strategies for the implementation of curriculum on biotechnology education did you gain from the intervention offered?
7. What innovating strategies of assessment in biotechnology education did you gain from this professional development?
8. In your teaching, what factors enable or enhance innovating when teaching biotechnology education? Please elaborate.
9. In your teaching, what factors constrained innovating when teaching biotechnology education? Please elaborate.
10. Did the curriculum development intervention bring about any change/transformation in your teaching of biotechnology education? If so, describe the change/transformation.
11. Did your current teaching practice of biotechnology education change after the curriculum development intervention? Explain.

APPENDIX J EXEMPLAR REFLECTIVE JOURNAL TEMPLATE

1. What innovating strategies for the implementation of curriculum on biotechnology education did you gain from being part of the professional development intervention programme? Which events come to mind in this regard?
2. What innovating strategies of assessment in biotechnology education did you gain from being part of this professional development? Describe events related to this.
3. In your teaching, what factors enable or enhance innovating when teaching biotechnology education? Describe events related to this.
4. In your teaching, what factors constrained innovating when teaching biotechnology education? Describe events related to this.
5. Did the professional development bring about any change/transformation in your teaching of biotechnology education? If so, describe the change/transformation.

APPENDIX K FOCUS GROUP DISCUSSION- STAKEHOLDER MEETING

Focus group discussion: transcripts- first meeting with stakeholders

Question: what are your experiences of the biotechnology option

I'm uncertain about teaching this option, all 5 sections in the syllabus my knowledge is limited I wasn't trained in biotechnology, it a challenge, I don't know the content how can I design activities? (P4)

I don't feel I can handle teaching the content in the 5 sections of this option , I cannot respond to learners questions, I just teach and tell them go home and learn the notes- I cannot explain it (P6)

I will have to read about each topic, learn it before I can try to teach, to read on all sections is very demanding physically and intellectually I still don't know how to teach the learners abstract concepts…(P5)

I'm not confident to teach this option as I don't know the content .. I don't want to look like a fool in front of my learners.. so how can I know how to teach it, if what I'm doing is correct (P30)

We were not consulted about the option, there is no training , how can we teach if we are not trained to teach… (P20)

I have a few learners in my school who want to do the option but the teacher discourages learner from taking the option as he is ill equipped to teach it (P40)

This option was introduced, we were not trained or workshopped to teacher it, we are battling, no one care about how we cope with no resources, support or content. We need a group to be formed to support us in teaching this option,, it must be a place where I can share my lack of knowledge without being judged (P6)

Many of us are the only biology teachers at our schools, it is difficult to get support from the school management team, they do not understand the nature of the subject that you need equipment for practicals, that it cannot occur in the classroom only. I do what I can, what I cannot do in the curriculum I leave out, I cannot change practice without support. Having support is necessary during curriculum reform. I find it difficult to know the depth required, I feel isolated, ignored at my school. No one cares that biology is also extinct at schools- something needs to be done urgently (P15)

We don't know how to handle this curriculum, we don't know what is expected off us, and had no training for implementation.(P5).

Question: What forms of help is needed

I don't know how to use some of the equipment available at my school, I'm afraid to ask for help, my headmaster will be angry (P15)

What if I damage it, or its doesn't work in the lesson, how embarrassing it will be, I rather not use it so I avoid practicals (P11)

It's so difficult to try and follow the instruction when I want to use the apparatus to demonstrate something to leaners, I become so nervous, I want to die (P24)

I tend to spend more time on topic or aspect I know , then I run out of time and skip the topic I don't know well (P21)

I don't know how to manage my classroom time, I lose a lot of time as learners take long to grasp, so I have to leave out many topics in the syllabus(P32)

Not having enough information to teach… (P14)

There are no option booklet available… like for the other options(P13)

Schools do not have laboratories… there is no instructional assistance (P10)

Classes are large, discipline is poor textbooks are too few- 5 learners to a text (P6)

Relevant resources for practical and textbooks are not easy to get(P11)

Biotechnology is a new phenomenon, we need developed materials to assist us, I'm not qualified for biotechnology (P4)

Need to interact with universities so we can gain the knowledge and skill needed to teach it, TPD does not exist, so hope can we cope (P2)

to sell the idea to the people or to the Eos or Ministry of education because if it is started by the Ministry we will not face many hassles, we will have support in terms of resources and will be able to teach the option (P5)

should work on something where teachers would occasionally meet … production of low cost materials… I get no support at school(P3)

we need a team approach to teach these aspects of biotechnology option (P12)

Question: what support do you enjoy at school for curriculum implementation?

It is so difficult I'm the only teacher of biology in my school, you cannot talk to the principle and ask for help in terms of teaching.(P13)

Principals do not assist or support, they do nothing to improve the lack of professional development by the MoE, we are stuck in the classroom all day, with no resources, in our free period we serve relief, there is no time factored for professional development.(P3)

I am all alone, I'm the only biology teacher at my school, when I seek help from the school management; they always say they don't know the subject and cannot assist, who do I turn too? This PDI is a blessing to us. (P5)

APPENDIX L REFLECTIVE DIARY ENTRIES ON EXPERIENCES OF PDI ENGAGEMENT

*This was a good safe opportunity to learn how to teach differently, to work with colleagues, working together is productive and enjoyable I never did this before, I always work in isolation as schools are so far apart. But now I know differently, the meeting organised by Science Education In-service Teacher Training (SEITT) programme is one sided – just information handout it is not about our needs (*P12)

We now have a safe space to monitor and support ourselves and each other- this is something I never experienced previously. At school there is no time allocated for us to meet, share ideas on our teaching to improve both our teaching and our learners results. Now this PDI has created aa learning space (P7)

Before the establishment of the PDI platform on, I avoided the biotechnology content as I did not know it. I did not study biotechnology , I never encouraged learners to take this option because I couldn't teach it, now I'm confident as I was given the chance to learn the content in a step by step process, in a safe space with other teachers who supported my learning. I now know how to use newspaper articles as resource to support my teaching for example in the teaching of environmental biotechnology, I can develop my own resources to improve my teaching and help my learners (P11)

There is no one to collaborate with at school – I'm just by myself – so I struggled and struggled with the biotechnology content. During this PDI I learnt the content from those 5 sections and now if I'm stuck I call on can call on our team to bounce off ideas and other experts to assist like the food and medical technologist from my community. (P5)

I was so set in chalk and talk I refused to use any innovative ways of teaching now that I have tried out how to use field trips, demonstration, practs, during the PDI I'm confident- this was a safe way of learning with and from colleagues. Rurinda's research is really making a difference to my attitude towards teaching the biotechnology option, if it was not for this PDI I would have used the same boring method to teach all my classes. When there is no official professional development for practicing teachers you get stuck in your ways and change is not something you can do alone. This PDI is an excellent learning platform; it is safe to show you do not know (P1)

APPENDIX M TRANSCRIPTS FROM VIDEO OBSERVATION OF FOCUS GROUP DISCUSSION- EXPERIENCES OF ENROLMENT DURING PDI

I didn't feel humiliated to ask question, the atmosphere is relaxed, you don't feel stupid to ask when you don't know (P8)

I could try out new methods of teaching the sections I have problems with, to colleagues without fear or embarrassment, what we are doing in this PDI is connected to our real practices of teaching, it about our needs (P 19)

The sad thing is there was no support for teachers of biology before this PDI from the SEITT program, now we have formed our own network and we can all grow , I confident about the content, I am now getting learners to develop an interest in biotechnology and its offered at my school. (P17)

What I like is that this intervention is made to suit us- it pays attention to what we need help with, I can teach all 5 area now without feeling uncertain, my confidence to teach biotechnology has increased, I can walk into a class and not feel the tension and anxiety I used to experience before the PDI. (P15)

I can now confidently try the following teaching strategies in my class: demonstrations, group work, role playing, field trips that I learnt and tried during the PDI (P2)

The PDI platform had an impact on my teaching of biotechnology; yes I have certainly changed the way I taught after I was involved in the PDI platform and after having got a bit more feedback during the CBPAR. It was a case of doing a whole rethink of how best to get the lessons on biotechnology across to the learners. I don't think I put in any effort previously, now I design my own assessments to suit my context and learner. I constantly try new ways of teaching, its exciting, I feel inspired as my learners performance is improving (P6)

APPENDIX N REFLECTIVE JOURNAL OF TEACHERS WHOSE LESSONS WERE OBSERVED

"*I feel inspired to try new teaching methods, I'm rejuvenated after the PDI and the network of support is amazing, I reflect on my teaching to see how I can improve, I never did this before, I care out my learners performance now, I feel the change daily and its good* " P6

"Just attending these meeting, touching base on a monthly basis after the PDI, sharing, rethinking my practice, trying out new ideas to teach the biotechnology option help me improve my confidence, I feel empowered, we need more of this type of development were we are not humiliated and our needs are catered for" P16

"The most important resource I have is BOTLC, I have no support at school, I do not feel alone and isolated anymore, I am growing in confidence, knowledge and becoming a better teacher- my learners enjoy lessons now, they want to learn and are doing better in their tests, I have more compassion towards my learner and am excited about teaching again"- P13

"*I don't feel isolated anymore, I have the support of BOTLC, I can call anyone of them when I need help or need to get a different perspective, or collaborate on assessments, this has motivated me and helped me reduce my workload as we share resources, I asked my learners to form small learning groups to help and support one another, there is an improvement in their class marks "* P2

"I also learn all the time by keeping in touch with BOTLC we have discussion on WHATS APP, we share, debate this help me to learn" P11

"*It feels good to try out new teaching method in class such as contextual project or problem based learning, inviting a specialist from the community, using smart phones to teach when resources are not available, field work in the community. I realised I need to keep on top of new content and developments in biology, we live in a knowledge explosion , I know now that I have to be a lifelong learner. I'm making an effort to improve my teaching and content, I ask myself how do I become a better teacher? The learners are interested and want to learn and are getting better marks, they can think critically and problem solve. I owe this change in me as a teacher to BOTLC, I sometimes meet a colleague for just to talk about my teaching and new ideas I have tried, it helps* " P8

"*I changed my thinking about my teaching and started thinking about what good teaching is, I question my teaching and assessment and think about what I need to do to help my learners to succeed all the time now after engaging in the PDI, I call my BOTLC friends to share ideas, ask questions, seek clarity*" P1

APPENDIX O POST OBSERVATION INTERVIEW TRANSCRIPT

" I enjoy teaching again , it was boring before the PDI and BOTLC I went through the motion without support but after the PDI I'm re-charged and maintaining contact with like-minded people is amazing, I'm eager to learn, try out new methods of teaching and assessing in my class, I'm also trying this innovation in the other subject I teach " Tay

"*I'm confident with the content after the PDI and BOTLC I have a deeper understanding and can link the sections together, now ask higher order question in class to promote learning in class*." Tay

"I owe this change in me as a teacher to BOTLC, I sometimes meet a colleague for just to talk about my teaching and new ideas I have tried, it help " Zim

"*I am the only biology teacher in my school, I'm all alone, because of BOTLC I can talk to any teachers form the group to bounce ideas seek clarification, share resources, I, changed my teaching strategy I'm getting my learners to work in groups to support each other- they are more responsive and are tackling higher order questions, slowly but surly I'm getting there* " Mas

"*I use creative ways to teach content after my engagement in the PDI, I have learnt how to use new papers article, smart phones to access visual images to reduce the abstractness of concepts and the surrounding context for problem/project based learning, the resources can be acquired easily with just a cal , we share expertise and resources, in the PDI we practiced the teaching strategies during the PDI, learnt how to interpret results, do demonstrations, extract DNA it suited our needs and we were all eager to learn and grateful for Rurinda's effort to start this project* " Bob

APPENDIX P LESSON OBSERVATION: TAY

Lesson observation: Tay- section food technology

Teacher: Tay			
Dimension	Descriptors	Remarks	Level
Classroom practice	Teaching method	Learner centered - hand on activities Facilitates inquiry based learning: appropriate teaching strategy used Teachers familiar with content	3
	Lesson plan	Planned in detailed objective clearly stated introduction: used teacher lead demonstrations, learners worked in groups 4 to 5 per group	
	Use of textbook	No textbook available Used support material developed during PDI and modified it to suit the context	
	Use of media	News paper articles, old magazines used	
	Learner engagement	Learners eager to learn- fully occupied	
Practical work	Practical work	yes	2
	Method used	Group work	
	Teacher role	demonstration	
	Learner involvement	Some learner partially erngaged	
	Local environment	Resources from local environment used to innovate	
	Equipment availability	poor	
	Improvisation	Yes- can innovate using local resources	
Science in society	Everyday examples	Links theory to local context/challenges	1
	Involves local community	No	
	Learner involvement	All not fully involved in lesson actively	
Assessment	Type of assessment	Practical investigation	2
	Type of questions	Based on practical investigation	
	Portfolios	Yes, contains tests, assignments, word search activities, practicals, remedial activities	
	Amount of work done	Almost all topics covered and assessed	
Personal well being	Feeling experienced	Confident, joy,	3
	Teacher agency	Positive attitude, reaches out to learners, innovates	

Table on profile of implementation Tay

Teacher	Classroom practice					Practical work					Science and society					Assessment					Teacher well being				
level	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Tay				x				x					x					x						x	

Table on capacity to innovate: Tay

Physical resources	Teacher factors	Learner factors	School ecology and management	Professional learning community
-Basic building –has electricity, running water -few textbooks : learners share- Dilapidated lab with few apparatus Most apparatus are non functional apparatus	-Teacher is qualified in biology not biotechnology	-Learners poor -Some learners do not receive enough food at home -Learners have socio-economic problems -learners do not receive support at home	**Management**: Principal not strict **Ecology**: -Teaching and learning occurs most of the time Sometimes its difficult to get learner back in class after the break	A single staff room exists Staff meeting occasionally Only biology teacher Forged ties with teachers of natural sciences and biology at the school- have regular discussion
Level 1	Level3	Level 1	Level 0	Level3

APPENDIX Q LESSON OBSERVATION MAS

Lesson observation: Mas –section Agricultural biotechnology

Teacher: Mas			
Dimension	Descriptors	Remarks	Level
Classroom practice	Teaching method	Teacher centered- chalk and talk Teachers familiar with content	1
	Lesson plan	Not planned in detail , objectives stated but learner activities not stated	
	Use of textbook	Learners frequently asked to consult the textbook during the lesson	
	Use of media	n/a	
	Learner engagement	Learners well manners and responded to questions posed to them, classroom discipline strict	
Practical work	Practical work	n/a	0
	Method used	n/a	
	Teacher role	n/a	
	Learner involvement	n/a	
	Local environment	n/a	
	Equipment availability	n/a	
	Improvisation	n/a	
Science in society	Everyday examples	Apply content to local crops grown in Masvingo	1
	Involves local community	n/a	
	Learner involvement	Partial – only to answer questions posed	
Assessment	Type of assessment	Mind map	1
	Type of questions	Recall and forming links	
	Portfolios	has a variety of tasks	
	Amount of work done	Adequate- will complete syllabus on time	
Personal well being	Feeling experienced	Overwhelmed, exhausted, overworked	1
	Teacher agency	Building confidence and not feeling isolated	

Table on profile of implementation Mas

Teacher	Classroom practice					Practical work					Science and society					Assessment					Teacher well being				
Level	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Mas		x				x							x				x					x			

Table capacity to innovate: Mas

Physical resources	Teacher factors	Learner factors	School ecology and management	Professional learning community
-Basic building –- Electricity, Toilets and running water available - textbooks available- Some basic science apparatus -No science laboratory present	-Teacher qualified -teacher strict- prefers chalk and talk -Teacher spends more time talking- only poses questions to learner and learners asked to consult textbooks	-Learners proficiency in English Learners neatly dress and well mannered	**Management**: -A timetable , class list and other routines are in evidence -The presence of the principal is felt in the school – school almost military -Attendance register for every period **Ecology**: -Teaching and learning occurs all the time -Teachers and learners return on time after the break	A single staff room exists – not well utilized Weekly meetings with staff No time to meet and plan with colleagues Only biology teacher – communicates with BOTLC
Level 1	Level 1	Level2	Level 2	Level 2

APPENDIX R LESSON OBSERVATION: ZIM

Lesson observation: Zim –section environmental biotechnology

Teacher: Zim			
Dimension	Descriptors	Remarks	Level
Classroom practice	Teaching method	Learner centered- facilitation – Problem based learning via group work field work	3
	Lesson plan	In detailed	
	Use of textbook	n/a	
	Use of media	News paper articles	
	Learner engagement	Learners involved in fieldwork along the steam	
Practical work	Practical work	Yes- contextual problem based inquiry	3
	Method used	Investigation-in groups	
	Teacher role	facilitator	
	Learner involvement	Each learner fully engaged	
	Local environment	Is used as a resource	
	Equipment availability	Some-	
	Improvisation	Yes	
Science in society	Everyday examples	yes	2
	Involves local community	no	
	Learner involvement	yes	
Assessment	Type of assessment	Test, assignment, project, practicals	3
	Type of questions	Higher order and some recall	
	Portfolios	yes	
	Amount of work done	On par with PDI work schedule	
teacher well being	Feeling experienced	Empowered, enthusiastic, happy motivated, inspired	4
	Teacher agency	Confident, eager to try new strategies, care for learners and their performance	

Table on profile of implementation Zim

Teacher	Classroom practice					Practical work					Science and society					Assessment					Teacher well being				
level	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
				x					x				x							x					x

Table: capacity to innovate :Zim

Physical resources	Teacher factors	Learner factors	School ecology and management	Professional learning community
-Good building- Electricity, running water, toilets present science laboratories well equipped – equipment old -teacher has addition resource materials	-Teacher is qualified - has sound understanding of subject -Teacher is an active participant in professional development activities -Conscientious attendance of class by teacher -Teacher makes extra effort to improve teaching	-Learners have access to a extra lessons at school	**Management:** Principal takes strong leadership role, is visible during school hours Teachers and learner play an active role in school management **Ecology**: Everyone in the school is committed to making it work	-Teachers meet before school, during breaks and after school to interact and discuss challenges and support each other -Management and staff interact and communicate socially and professionally on a regular basis -Science teachers help each other out and reflect together
Level 3	Level 4	Level 3	Level 3	Level 4

APPENDIX S LESSON OBSERVATION: BOB

Lesson observation: Bob-section medical technology

Teacher: Bob			
Dimension	Descriptors	Remarks	Level
Classroom practice	Teaching method	Learner centered- learner poster presentation in groups Teachers familiar with content and using appropriate teaching strategy	2
	Lesson plan	In detailed – objectives, activities listed	
	Use of textbook	No textbook, Used support material developed during PDI	
	Use of media	News paper articles	
	Learner engagement	Learners eager to learn all engaged in poster presentation	
Practical work	Practical work	n/a	0
	Method used	n/a	
	Teacher role	n/a	
	Learner involvement	n/a	
	Local environment	n/a	
	Equipment availability	n/a	
	Improvisation	n/a	
Science in society	Everyday examples	yes	2
	Involves local community	Yes- doctor invited to address learner before poster presentation could begin	
	Learner involvement	Fully engaged	
Assessment	Type of assessment	Investigation, test, assignments, projects	2
	Type of questions	Varied includes all levels of blooms taxonomy	
	Portfolios	Well maintained	
	Amount of work done	More than adequate	
Teacher well being	Feeling experienced	Encouraged, happy, motivated	2
	Teacher agency	Eager to learn more	

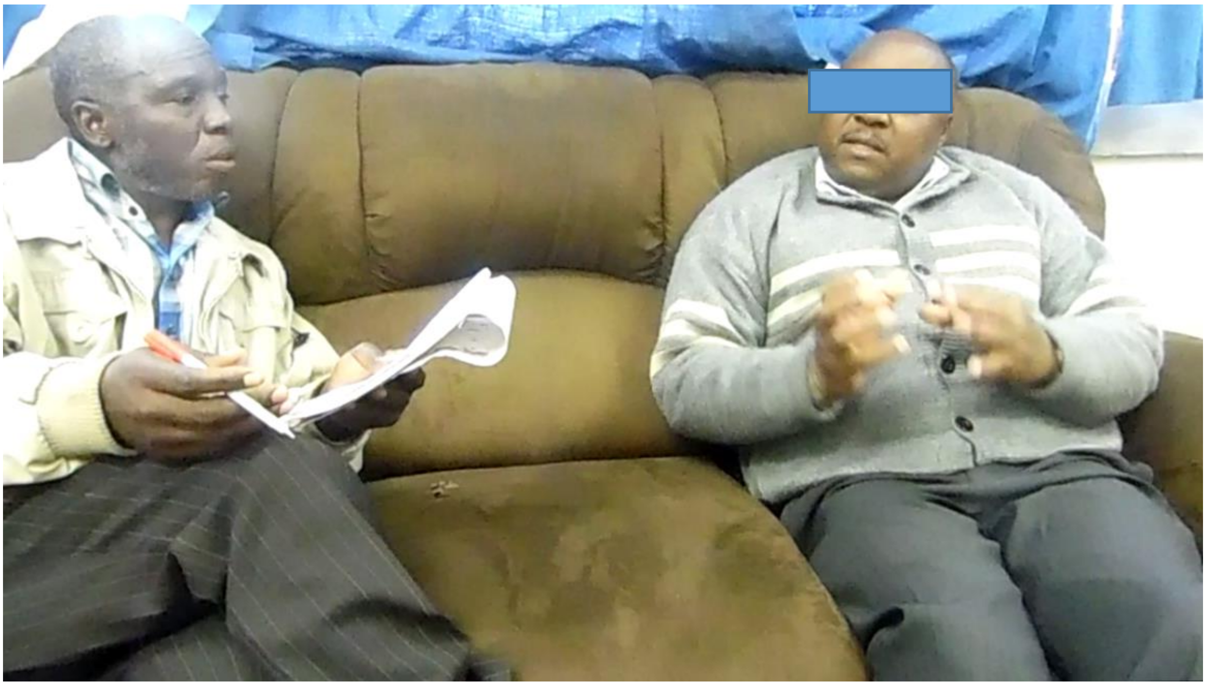
Table on profile of implementation Bob

Teacher	Classroom practice					Practical work					Science and society					Assessment					Teacher well being				
Level	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
			x			x							x					x					x		

Table showing capacity to innovate: Bob

Physical resources	Teacher factors	Learner factors	School ecology and management	Professional learning community
-Basic building – but in poor condition -Toilets and running water available -Electricity in some rooms -few textbooks but not enough for all -No science laboratory or laboratory is present it is not in working condition	-Teacher qualified for the position -uses variety of teaching strategies	-learners eager to learn	**Management**: - Principal walks around to ensure teaching and learning occurs. - -Attendance register for teachers sand learners exist **Ecology**: -Teaching and learning occurs at all times -Teachers and learners return on time after the break	Weekly meetings with staff Some social interaction between teachers Management organized some social function Some staff members feel marginalized Monthly subject meetings with discussions
Level 1	Level 2	Level 3	**Level 3**	Level 3

APPENDIX T: INTERVIEW WITH ZIMSEC A LEVEL BIOLOGY SUBJECT MANAGER

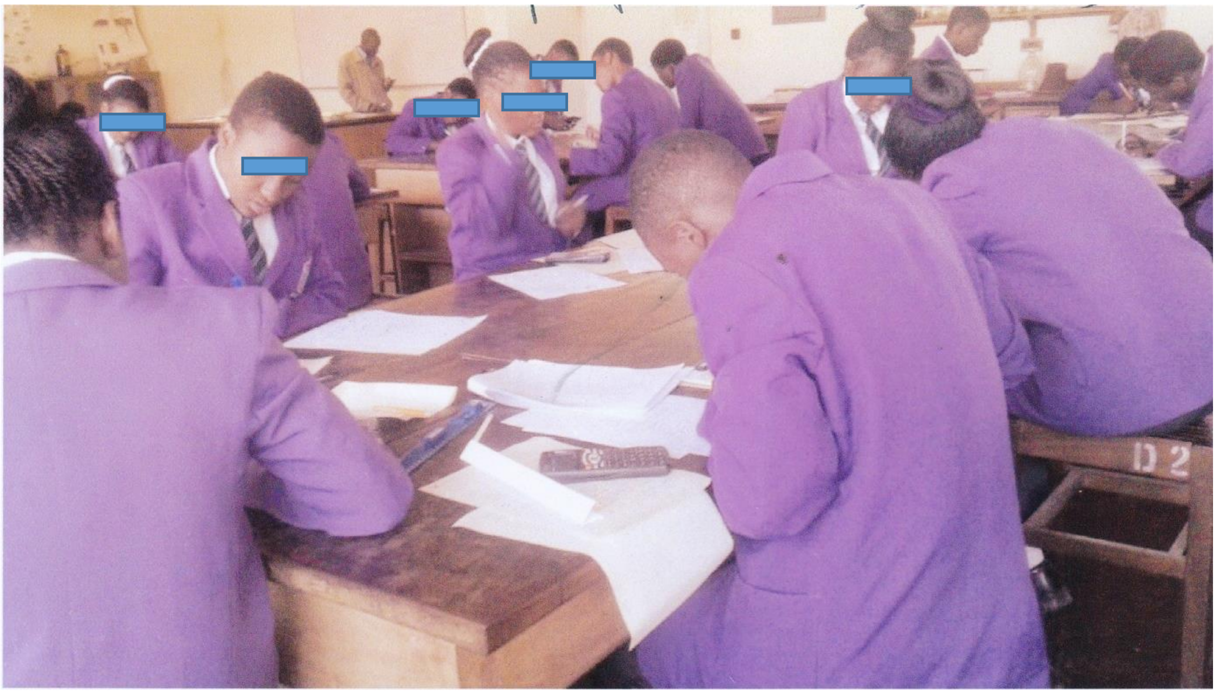


APPENDIX U: INTERVIEW WITH AN A LEVEL BIOLOGY TEACHER AFTER LESSON OBSERVATION ON AGRICULTURAL BIOTECHNOLOGY IN THE PDI PLATFORM

APPENDIX V: INTERVIEW WITH AN A LEVEL BIOLOGY TEACHER AFTER LESSON OBSERVATION ON MEDICAL BIOTECHNOLOGY IN THE PDI PLATFORM

APPENDIX W: BIOTECHNOLOGY INSTRUCTIONAL MATERIAL PRODUCTION TEAM IN THE PDI PLATFORM

APPENDIX X: LEARNERS WORKING ON CONTEXT BASED BIOTECHNOLOGY MATERIAL PRODUCED DURING THE PDI BY THEIR TEACHERS



APPENDIX Y: ZIMSEC FINAL RESULTS ON BIOTECHNOLOGY OPTION FROM ONE OF THE SCHOOLS INVOLVED IN THE PDI PLATFORM

Syllabus Results and Component Grades

Centre No. | Centre Name

Qualification	Syllabus/Option	Syllabus Title	Session
GCE A LEVEL	9190	BIOLOGY	NOV 2016

Candidate Results by Syllabus Option and Component

— Component Number and Grade —

Cand. No.	Candidate Name	Result	01	02	03	04
5042		B(b)	A	B	C	C
5043		A(a)	A	A	C	D
5044		B(b)	A	A	D	D
5054		B(b)	A	B	D	C
5058		B(b)	A	B	C	D
5059		B(b)	A	C	C	B
5060		D(d)	C	B	F	C
5061		D(d)	A	C	D	0
5063		B(b)	A	B	D	D
5064		E(e)	C	D	O	E

Page 144

12/01/2017

Zimbabwe School Examinations Council