Table of Contents

Chapter 1. An Investigation into Clusters or Networks as Opportunities for Learning about Science Content and Pedagogical Science Knowledge

Chapter 2 Literature review

Chapter 3 Research Methods

List of Appendices

List of table

List of figures

Glossary of Terms and Definitions

Term **Definition**

C2005 Curriculum 2005 is the new curriculum that was introduced in South Africa by the National Education department
CASS Continuous Assessment is the assessment procedures policy adapted by South Africa to take into consideration all the performance of tasks by the learners
CES Chief Education Specialist is the person who is in charge of the specific subject at the provincial level
CI Curriculum Implementer is the subject advisor whose responsibility is to support teachers on specific content knowledge
CK Content Knowledge is the knowledge of the subject matter
CL Cluster Leader is a teacher who is selected to be a facilitator of a cluster
CM Circuit Manager is the person that is in charge of a number of schools and activities in the circuit
DCES Deputy Chief Education Specialist is the person that is assisting the person that is in charge of the specific subject
EHL Ehlanzeni region is one of the three regions in Mpumalanga which means the low veld
FET Further Education and Training is the level of education that is made up of three grades 9 to 12 which are the final last years of schooling
GET General Education and Training is the senior primary and the junior secondary school grades (4-9)
GS Gert Sibande is one of the three regions in Mpumalanga
HOD Head of Department of the specific subject /s at the school level
INSET In-Service Training is the training and the development of teachers who are already teaching
JICA Japan International Cooperation Agency
JP Japan
M&S Mathematics and Science
MDE Mpumalanga Department of Education
MSSI Mpumalanga Secondary Science Initiative
NCS National Curriculum Statement is policy document issued by National department of education in S.A. that is a guide on the implementation of the new cuuiculum
NKA Nkangala is one of the three regions in Mpumalanga . Nkangala means Highveld.
NUE Naruto University of Education in Japan
OBE Outcome-Based Education is an approach adopted by South Africa for its New Curriculum.
PCK Pedagogical Content Knowledge is the knowledge that is imparted in the classroom

PD Professional Development means the process of engaging teachers with the aim of improving their teaching profession.
RNCS Revised National Curriculum Statement is the modified policy on the implementation of the new curriculum
SEP Science Education Project is the Non Governmental Organization that helped teachers to improve their science teaching
Sibonelo The name given to the external cluster which means Exemplary
SIM Simulated cluster is the created cluster that modeled how the cluster could operate in helping teachers to learn from each other
UP University of Pretoria

Chapter One

AN INVESTIGATION INTO TEACHER CLUSTERS OR NETWORKS AS OPPORTUNITIES FOR LEARNING ABOUT SCIENCE CONTENT AND PEDAGOGICAL CONTENT KNOWLEDGE

1.1 Study Overview

As the sun set on my life and on my years of teaching, I started to look back and reflected on my past teaching experiences, especially those that left marks of growth and development in my whole teaching career. One of the most exciting experiences of my life and career was to be a member of a group of science teachers who met periodically to share and discuss ways to improve science teaching in our schools. That group of teachers, which we called a cluster, consisted of teachers who came from neighboring schools that were geographically situated about two kilometers or less from each other. Discussions and sharing of ideas and materials on specific science topics made up the key activities of our cluster. A lecturer from the then University of Natal, now called the University of KwaZulu-Natal, had initiated this idea of forming a cluster of science teachers that would meet fairly regularly. Consequently, when this cluster was formed, the university lecturer concerned became our group mentor. He was always willing to assist when the teachers in our group invited him to the cluster, which we did quite a few times while the cluster was being set up.

The idea behind our science cluster was to engage ourselves as teachers in discussions on real classroom issues that challenged the way science was taught at schools. Like many of my colleagues in our cluster, I was familiar with, and had used the excuses of not having enough science equipment, not enough time for practical work; and no running water at our schools to explain the poor teaching practices in my science classes. Fortunately for us, our collaborations and the supportive guidance from the university lecturer helped us to challenge and rethink our excuses and thereby our teaching practices in general. Upon reflection, I can still see how, many of the teachers in this cluster became active participants because of this guidance and support from Mr. Knowles, the university lecturer. Over time, we also came much closer together in our thinking and in our beliefs about teaching science. As time went on, and discussions continued, we began to see the importance and value of practical work in the teaching of science. The teachers from schools that had science equipment, among the cluster members, also became more and more willing to share their resources with the rest of their colleagues in the cluster.

The teachers in our cluster met twice a month, with different teachers taking turns to present on a science topic to the group. Each member of the cluster was given an opportunity to teach a session and also to conduct experiments at each session. Each presenting teacher was given feedback on his or her topic, and that was often followed by a discussion on how each of the focus experiments should be conducted in a real classroom situation under conditions of large classes. In those days, the Education Department prescribed the work program to be followed by teachers on specific science topics to be taught. With the help of Mr. Knowles, our mentor, the members of the cluster were able to make changes to the prescribed work programme in order to suit the needs of the learners and teachers in our schools.

The major goal of the cluster was to encourage us to challenge and re-examine our knowledge and practices of science teaching. We were then expected to use the knowledge gained in these sessions to improve our teaching in our own schools and classrooms and then to come back and share the classroom experiences in the subsequent cluster workshops. As I reflect back on my teaching career, I can still argue with myself that this is where my teaching of science changed significantly, from a focus on teaching only the topics that I understood with no use of practical work or experiments to progressively incorporating practical work and investigations in almost every science lesson I taught. I moved from a practice of just reading the experiments from the book with the expected results as written out by the authors, to a practice of using the investigations to explore and facilitate conceptual understanding of science concepts for the learners. I know that this was the case for most, if not all of the teachers in our cluster, because two years after the cluster had been initiated, four teachers were awarded a British Council Scholarship to further their studies in science education in England. Three out of the five schools from where the cluster teachers came, became best performing science schools in KwaZulu-Natal. Indeed, I am still convinced that something interesting and worth investigating happened in that cluster to result in the kinds of outcomes and professional growth that I have just described.

For me, participation in the cluster was very different from the In-Service Education and Training (INSET) that was offered by the then Education Department in the KwaZulu-Natal Province. The Education Department's policy used to take teachers away from their schools to a residential teaching center, where they were required to spend a week on professional development. During this week of professional development, the teachers would be expected to carry out experiments and watch the teacher trainers demonstrating the use of such practical work in science teaching. While the week-long activities were often exciting, unfortunately when the teachers went back to their schools, they were never provided the time to practice what had been taught at the centre and in most cases just continued to teach as before. This scenario, on professional development, still occurs in many regions of South Africa. Accordingly, the providers of teacher training and development continue to search for meaningful ways of making INSET transferable into the classroom. That is, the provision of such meaningful INSET still remains a challenge in South Africa.

It is the differences between the INSET that was provided by the Department of Education, compared to the cluster workshops that we had initiated as a group of teachers that continues to challenge my thinking about the opportunities provided for teachers' professional growth and development. What seems to be best approach for providing opportunities for teacher professional growth and development? How can teachers be encouraged to use the knowledge and experiences gained in such professional development opportunities to challenge and change their classroom teaching of science? These are the questions that have prompted the present investigation and research study.

The phrase, “teacher development" is used often in this study. In the context of this document it is taken to mean the development of

- teaching or pedagogical skills;
- subject content knowledge (CK); and
- beliefs and affects.

This notion of teacher development brings into focus the question of what it will take for teachers to challenge and change their classroom practices – an important question in my research investigation.

Against the background of my checkered experiences with teacher development programs of different types, I have been motivated to pursue the research question on how opportunities for teacher development in science education are conceptualized and practiced. Furthermore, my investigation sought to examine the role of teacher development programs in challenging and reshaping the teachers' content knowledge (CK) and pedagogical content knowledge (PCK) in the context of science teaching. The two major drivers leading up to this study were personal and theoretical.

1.1.1 Personal Drivers

I had my first opportunity to participate in a cluster as a teacher leader, when the school I was teaching at got involved with the Science Education Project (SEP), which was a Non-Governmental Organization (NGO) involved in Teacher Development. Later on, I had matured within the cluster and became involved in teacher development myself, both as a mentor and Head of Department (HOD). As a mentor, I became interested in working with younger, and less experienced teachers informally, and primarily on a voluntary basis and this where my scholarly interest on teacher change and development was nurtured.

The cluster, as described earlier, was made up of a community of five schools in the Durban area of the Kwa-Zulu Natal province. I participated as a leader in that cluster for a number of years and then moved on as my career took its turns and twists. The cluster was able to sustain itself long after I left the province and has since grown bigger and now even has a fundraising committee with an operational budget for scientific activities for the learners in the focal schools where the teachers come from. Learners are given opportunities to visit areas of scientific interest and participate in regional and provincial students' science seminars.

Clustering as an approach to teacher professional development appeals to me because I personally benefited greatly from working within such a structure. Unfortunately, up to this point, I had been unable to reflect systematically and explore intelligently the activities or events that led to my own growth and development as a teacher and a leader within the cluster. It is this dire need for reflection on my own life and experiences as a teacher leader that provides the initial drive for this study on teacher development through cluster activities.

As I will discuss later, in the literature review, the concept of clusters is a promising one for teacher development although there is still a lot to learn about the complexities and benefits of such clustering. We know very little about how teacher clusters help teachers to (re)construct and use new knowledge to challenge and change their own classroom practices, especially in science. Part of the complexity arises from the fact that an individual's knowledge is often invisible to others, and so it is difficult to categorize any changes in that knowledge or what might have led to those changes. This study attempts to understand this complexity of knowledge and the changes in classroom practice motivated by such changes in conceptions and knowledge, by studying carefully teacher clusters as opportunities for teachers to (re)examine their content knowledge (CK) and pedagogical content knowledge (PCK).

1.1.1a Teacher Development

Teacher development practitioners in South Africa view clusters differently, in their conceptualization and characterization of the way they operate. In some cases clusters are viewed as a group of teachers working together to improve the quality of teaching in the classroom (Guskey, 1996). In others, clusters are viewed as a better way of implementing policies of the Education Department in a group of schools where teacher development may not be a priority (Ovens, 2000; Prosser 2000). Nevertheless, in the context of this study a cluster is viewed as a group of teachers that;

- voluntarily plan activities;
- meet on a regular basis ; and
- address classroom subject content issues with the aim of improving classroom practice.

Teacher clusters following these principles, in my view, address more centrally the issues of teacher development. Other researchers and scholars refer to this cluster approach as "teacher communities of learning" or "teacher networks" (Lieberman and Grolnick, 1996; Fullan, 2001; Adams, 2000).

My personal experiences as a cluster leader resonate with those documented by scholars of “teacher networks” and “teacher communities of learning”, who for example, reported on people who participated in networks/clusters, but cannot identify what it is that made them change or develop within the clusters. Lieberman and Grolnick (1996), for example, argue that “although many educators have observed and participated in educational networks for some time, little is known about how such networks are formed, what they focus on and how they develop teachers”. This statement reads like a summary of my own experiences as a cluster leader.

In this study, I have explored and tried to understand how clusters in the Mpumalanga province of South Africa assisted teachers in changing their knowledge and practices in the science education. Furthermore, I examined how the learning opportunities and approaches that were created, all functioned to enhance learning and change in the cluster sessions. On the basis of my own experiences as a science teacher and a teacher developer, I postulate that clustering of schools based on teachers' voluntary participation, interaction and collaboration based on real classroom activities, has the potential to challenge and change the classroom practices of science teachers. This study is a contribution to the literature on teacher development and should be an aid to policymakers and providers of INSET generally.

1.1.2 Theoretical Drivers

Theoretically, the study of teacher clusters, as a form of professional development is important in its potential contributions to our understanding of:

- the nature of knowledge and conceptions required for changing classroom practice; and
- the processes by which this knowledge and conceptions get translated into classroom actions in practice.

Overall, the major question that bothered me as a researcher was how the cluster approach could create the opportunities that would help teachers begin to challenge and change their classroom practices. I will explore these theoretical drivers further in my literature review in chapter two.

1.2. Clusters as aid to teacher development

Over the past few years, South Africa has been engaged in various approaches to teacher development with the hope of changing the teachers' science content knowledge, as well as their teaching practices in the classroom. Despite all the efforts and enthusiasm that the National Department of Education and other groups, such as the NGO sector engaged in teacher development, very little appears to have changed in teachers' classroom practices (Kahn, 1995, Lubisi, 2000).

Recently, however, there have been several experiments using various models of teacher development that promise better and lasting changes to teacher practices in the classrooms. Teacher networks or the cluster model is one such experiment in teacher development. This cluster/network model often involves teachers from various schools working together voluntarily on professional issues. Although the model has gained popularity in countries such as the United States of America (USA) and Britain, research on its efficacy in changing teachers' knowledge, beliefs and practices is not conclusive. The history of teacher networks goes as far back as the seventies in the United States of America (USA), but was not linked to the name, 'networks' at that time (Lieberman and Grolnick, 1998). It was seen and described as an environment created by peers collaborating with strong professional relationships that enabled teachers to feel comfortable in sharing ideas, acknowledging difficulties, and solving problems that they encountered in the classroom (Fraser-Abder, 2002: 5). As this activity involved the process of teachers and schools networking, it was later called "teacher networks".

The history of clusters in South Africa resulted more from a need experienced by NGOs in working with isolated as well as rural, disadvantaged schools of this country (Gray, 1999). The names given to teacher networks in South Africa varied between teacher groups and clusters depending on the teachers and organizations that were involved. The principle of sharing and learning from each other, however, remained the key words in what was called the zones, clusters, and/or teacher groups. This system of teachers working together has a potential to break teacher isolation and encourage conversations about classroom practice and change.

Rosenholtz (1989) identified teacher isolation, "as a major obstacle to school improvement. Isolation tends to keep teachers at an unchanged level of competence and leads to consequences, such as not seeking advice from other teachers because it may be seen as an admission of incompetence." Isolation further evokes feelings in teachers that they are not measuring up to their colleagues (Lieberman and Millar, 1984:136). Networks/clusters are believed to have the potential to break down these barriers of isolation amongst teachers by allowing them to work together as peers. In South Africa, the most commonly used word is clusters rather than networks and for the purposes of this study I will adopt the word clusters to describe such networks.

As South Africa began to practice this model of teacher development, clustering questions around its relevance and efficacy in addressing the problem of teacher change became critical. Although there are many differences in the nature of clusters from province to province, some of the challenges are generic. These generic challenges revolve around cluster formation, leadership and the competence of teachers in sharing ideas.

An important question for education policymakers in South Africa is whether the teacher networks or cluster model leads to changes in the classroom practices of the teachers. Furthermore, research is needed to uncover how, if at all, the cluster approach better supports teachers in changing their science content knowledge and classroom practices. In addressing these questions around teacher development and change, it is important to understand something about the learning and teaching science particularly and therefore the rationale for teacher development through the clusters.

Learning and teaching science is not only about acquisition of knowledge; it is about challenging misconceptions and about knowledge construction. Consequently, constructivistic thinking may provide a useful framework for developing professional learning experiences for teachers as well. The expectations would be that such experiences would in turn be transferred into the teachers' own classrooms (Driver, 1988). Using this rationale, knowledge would be constructed in a social context of a cluster of classroom practitioners. These practitioners would then have an opportunity to explore and challenge their own content knowledge as individuals and through interactions as a group. This process of knowledge sharing and co-construction would enrich each individual's knowledge and allow for the creation of new knowledge and ideas. This hopefully, would enhance their teaching of science in the classroom.

From a pedagogical perspective, the shift to clusters in professional teacher development would seem to make sense, because it involves curriculum and teaching strategies that are based on a participatory model of learning. Various scholars have made claims about the effectiveness of networks or clusters in changing teachers' knowledge and practices in the classroom. There is still very little empirical evidence, however, as to what makes this approach to teacher development effective and how this effectiveness is actually achieved in practice (i.e. the processes behind the changes) (Gottesman, 2002; Adams, 2000; Lieberman and Grolnick, 1996; Fullan, 2001). This study is an attempt to unravel the issues around the processes and effectiveness of the teacher cluster model of professional development.

1.2 Mpumalanga Secondary Science Initiative

The context for this research investigation is the Mpumalanga Secondary Science Initiative (MSSI) project. The MSSI is a teacher-development project funded by the Japanese International Co-operation Agency (JICA) that uses a cluster model as its major intervention strategy. The cluster model that is used by MSSI believes in teachers meeting in groups from different schools in order to explore content knowledge with the aim of changing classroom practices. The focus of the MSSI project is on the teaching and learning of science and mathematics in the secondary schools of one province, the Mpumalanga province of South Africa.[1] The two subject areas; mathematics and science were chosen because of the known problems in the lack of teachers' content knowledge and ineffective teaching of these subjects in the classroom (Brodie; 2003; Jita; 2004; Lieberman and Grolnick, 1999). Japanese learners are known to be performing well in these two subjects as shown by the results of the Third International Mathematics and Science Study in 1999, thus the partnership. The intervention focused on the teachers' content knowledge and the way this content knowledge is imparted in the classroom. The major targets of intervention are classroom teachers as they are at the forefront of

[1] The Mpumalanga province is one of the nine provinces of South Africa. It is located on the Eastern side of the country, bordering both Swaziland and Mozambique on either side. It is a fairly rural province with pockets of heavy mining and agricultural industries that service its economy. Educationally, the province

teaching and learning of these subjects in the classroom. The University of Pretoria, as well as two universities in Japan (Hiroshima and Naruto Universities) worked as partners with the Mpumalanga Department of Education (MDE) on this MSSI project. The major objectives of the project were:

- to ensure that the secondary school students acquire enhanced skills in mathematics and science;
- to improve the quality of teaching in mathematics and science in the province through the enhancement of the capacity and experience of the teachers; and
- to promote the development of a province-wide system of continuous in-service training for mathematics and science teachers so that this capacity enhancement effort may evolve into sustained practice (JICA Policy document, 1999 to 2001).

In its first phase, the MSSI project attempted to include all schools (grades 7 to 9) over the three- year period of implementation (1999 to 2001). In order to cover all the schools, using limited resources, the MSSI opted for a cascade approach to teacher development. In this approach, information is carried to various parties through a series of cascading levels in which information is transmitted. In the phase 1 model, the information was to be transmitted from the university experts, to curriculum implementers (subject advisors) and then to HOD's and finally to the classroom teachers. Teachers were at the bottom of this cascade structure. An empirical observation was that some information was "lost" in moving between the layers and never reached the classroom, (JICA- MSSI Evaluation Report, 2003). When the project was evaluated after the initial three year period, it was discovered that this approach to teacher development had produced little or no impact in the science and mathematics classrooms of Mpumalanga. That is, there was no evidence of change in the classrooms of many of the teachers, who participated in the project, (JICA- MSSI Evaluation report, 2003).

---

has been struggling significantly in terms of its matriculation (end of high school) national results for the past five years.

To improve this situation, for its second phase of implementation (2003-2006), the MSSI partners opted for a cluster approach to teacher development. This was assumed to have the potential of:

- developing a co-operative and collaborative approach to professional development of educators;
- developing effective approaches in teaching of mathematics and natural sciences;
- fostering ties between teachers within a cluster and encouraging the sharing of expertise and resources;
- facilitating dialogue and reflection amongst educators;
- fostering innovation and resourcefulness in educators pursuit of solutions to local problems;
- enhancing the status of teaching profession in the Mpumalanga community; and
- promoting peer teacher learning. (Cluster Leaders' Report 2002).

The second phase of implementation also included the General Education and Training (GET) schools (grade 7 -12) that are committed and willing to follow the cluster model. The major objective of the second phase (cluster approach) was to improve directly, the classroom practices of the science and mathematics teachers in the secondary schools of Mpumalanga. Much of the training is focused on the teachers' content knowledge in science and in mathematics and how it could be transferred into the classroom to reshape their practices. This approach assumes that the individuals are capable of self-direction and self-initiated learning and that they are best placed to judge their own learning needs.

This study uses the experiences of the Mpumalanga teachers as an aid in attempting to understand the concept of clustering and the influence of clustering on teachers' classroom practices. The cluster leaders, who are selected for each cluster, are the major players in the organization and leading of the clusters of peers. They are teachers themselves, who have been given this extra responsibility. Their role is to support other teachers by facilitating all the cluster activities in their locality. The Curriculum Implementers, previously known as subject advisers, have been included in Phase 2 of MSSI project, mainly to play a support and monitoring role in activities of the various clusters. While the MSSI project focuses on both science and mathematics, this study focused only on the sciences because of my personal interest and experience in the teaching of the sciences. In undertaking this study I was keen to understand the processes behind the changes in the knowledge and practices of the cluster members and, furthermore, how this change gets transferred, if at all, into the classroom.

1.4 Statement of the problem

The issue of teacher development and change is based, first and foremost, on the exploration of the kinds of knowledge, and conceptions that are required to change classroom practice. Secondly, how do teachers acquire this knowledge and conceptions and how do they transfer these new skills into changed classroom practices?

This study tries to address these questions by examining the cluster approach to teacher development. The cluster approach is intended to provide opportunities for teachers to explore and share their CK and PCK with the aim of influencing their classroom practices. The processes that are fundamental to clusters are hopefully, intended to close the gap that exists between the science knowledge that is experienced and constructed at the workshops as well as the pedagogical content knowledge that drives or guides the actual practice in the classroom of the teachers. This gap is often very obvious in science because of the poor preparation of teachers in South Africa.

Many of the short-term strategies that the South African government has engaged in to deal with this problem, such as importing teachers from Cuba and Japan as volunteers to help in the classrooms, are not likely to create a sustainable solution. When the imported "experts" leave, they leave with their knowledge and skills, having transferred little to their peers.

In this piece of work I suggest that there is a need for a shift in status and in focus. This shift expands a view of research as the basis for improved practice to a view of collaborative improvement of practice as research. This status of research, in this view is methodological; its focus is the practices of others in sharing and uncovering CK and PCK through clusters. This strategy is intended to help the teachers to improve their particular CK and PCK.

To explore the efficacy of networks or clusters in providing the relevant kinds of knowledge and conceptions to change practice, I asked the following critical questions to guide the research:

1. What kinds of clusters operate in the Mpumalanga Province and how are these clusters formed?
2. How do these clusters challenge and support teachers of science in re-shaping and changing their knowledge and practices?
3. What is the nature of the resulting knowledge and classroom practices?

(i.e. *the empirical determination of knowledge and conceptions that are required by the science teachers to change practice)*

1.5 The organisation of the study

This work consists of five chapters, which will draw together the several threads of this research. My discussion in the thesis will touch on several issues concerning the nature of clusters, their formation and their potentiality in providing opportunities for teachers to uncover and improve their CK and PCK. I will also sketch out the evidence of teachers participating in cluster workshops and the nature of CK and PCK that was explored in such networks/clusters to illustrate how these clusters became opportunities for teachers to challenge, re-xamine, and change their CK and PCK. The threads discussed in each chapter are outlined briefly below.

As a point of departure, chapter one has described the concept of teacher clusters as a case of teacher development and the implications it may have on changing teachers' classroom practices. I also reflected on my own experiences as a teacher and as a leader of a cluster in order to contextualize and locate my present research and scholarly interests on teacher clusters and teacher development generally. It has also aided in explaining and exploring the visions and intentions relating to teacher development, innovation and change in science education.

The second chapter explores the literature on teacher development and the way in which CK and PCK are understood and discussed in the literature. This chapter also explores features such as teacher knowledge, the construction of meaning in science and the nature of environments constructed for learning; for example, the idea of clustering and its potential to change classroom practice. The literature reviewed demonstrates that clusters vary widely in the way they are formed and in the activities they engage in to change teachers' knowledge.

The third chapter discusses the research methodologies used in this study. In the light of the methods, approaches and procedures employed in this study, detailed discussions on these issues are explained clearly in this chapter. It explains the techniques and strategies used in data collection and how the data was analyzed in order to understand the opportunities and processes provided for teachers to explore and share their CK and PCK.

The fourth chapter reviews the general findings of the study on the clusters that exist in Mpumalanga and begins to make sense of these findings. Detailed observations and discussions on two case studies are documented in order to explore in greater depth the opportunities provided for teacher growth and learning resulted in their re-examination of both their CK and PCK.

The fifth chapter gives further detailed descriptions and analysis of the two case studies and explores how teachers in these clusters used the opportunities created for their own development in changing classroom practices. These two cases highlight the stories and experiences of the teachers who participated in the selected clusters. The discussion focuses on the cross-case analysis and highlights the similarities and the differences in the formation, operation and the potentialities of the different cluster approaches to changing and challenging CK and PCK. This chapter further gives a brief summary of the entire study and gives pointers and the important themes and new knowledge coming out of the study. It also highlights the importance of this research and opportunities for further research in this field.

Chapter two

LITERATURE REVIEW

2.1 Introduction

In this chapter, I discuss the relevant literature for understanding and exploring the research questions on clusters as discussed in chapter one. To recap, my study seeks to provide insights into the following research questions:

- What are the kinds of teacher clusters that operate in Mpumalanga and what is the nature of their formation?
- How do the clusters help science teachers to challenge and change their content knowledge (CK) in science?
- What is the nature of the resulting content knowledge (CK) and PCK and how is it used by teachers to shift their classroom practices in science?

In carrying out this literature review, I wanted first and foremost to find out what research has been done in the field of networking/clustering of teachers. This is primarily because, clusters have in the last few years, been regarded as one promising approach to teacher development (Lampert, 1988; Lieberman and Grolnick, 1996, Adams, 2000, Southwood, 2002). I was also interested to find out especially what research has been done in Africa and other developing countries on clusters.

In the second instance, my literature review was informed by the fact that this research study is situated in a broader context of an exploration of issues of teacher development, knowledge and what it takes for teachers to change their practices. Changing the teachers' classroom practices in science and mathematics involves, among others, changing the teachers' expertise in content knowledge and pedagogical content knowledge to allow for changes in the classroom practice (Spillane, 2000). This is a very difficult and challenging task in which many programs that are geared to teacher development have come short. In this chapter, I will then review the traditional and innovative approaches to teacher development that have been used to try and foster teacher change in science education. The focus on teacher clusters

/networks is also informed by the reality that such networks have been posited as an alternative approach to teacher development.

Furthermore, this, chapter focuses on a discussion of the literature that explores the nature of teachers' knowledge that is needed to change classroom practice. The first section of this chapter seeks to unpack in detail the concept of teacher knowledge as it forms the backbone of teaching and learning; and later issues of teacher development that are centred on this concept. The choice of this literature on teachers' knowledge for this study provided a useful conceptual framework that helped to frame the data collection and analysis of the various themes that emerged from this study.

In order to make sense of all this information, the chapter is divided into three sections that are directly related to my research questions:

- teachers' knowledge;
- teacher development approaches; and
- teacher clusters .

2.2 The meaning of knowledge as viewed by various researchers

Knowledge is a very complex concept that means different things to different people. Rathborne (1971) and Barth (1972) (as cited in Candy, 1991) argued that knowledge is idiosyncratically formed, individually conceived, fundamentally individualistic and that theoretically, no two people's knowledge can be the same, unless their experience is identical. For Candy (1991), while individually conceived knowledge is important, it becomes useful and effective if it socially shared and constructed in a community of people.

Teachers' knowledge of practice is often socially constructed. The social construction of teachers' knowledge of practice is usually influenced by the environment, ethos and the culture of the school. As teachers we do not learn isolated facts and theories independently of the practices in which they arise. These practices may be work processes, experiments, arguments about theories or principles and the like. Teaching and learning is contextual. While the teachers are engaged in the same processes of teaching and learning, their experiences that form part of their knowledge base are therefore different. And while as individuals their different life experiences in the teaching profession are valuable, but they become more valuable when they are shared, critically examined and used to construct general knowledge of and about practice. This constitutes what Shulman (1987) talks about as pedagogical content knowledge (PCK). "Pedagogical content knowledge is a special amalgam of content and pedagogy that is uniquely the province of teachers" (Shulman, 1987:8). Effective science teaching combines many elements to engage students in learning. In order to achieve this expertise of effective teaching, teachers must therefore know more than science content and more than just some teaching strategies.

2.2.1 Content Knowledge (CK) and Pedagogical Content Knowledge (PCK)

To teach science effectively, teachers require relevant insights into science as explored by the experts and scholars (Guskey, 1986; Fullan, 2001), and this is where the gap of teacher development has been identified**.** These knowledge insights are based on content knowledge (CK) and the Pedagogical Content Knowledge (PCK). It is my view that, traditional approaches to teacher development that separate the teachers' classroom experience and the content knowledge have discouraged teachers from active participation in enhancing their CK and PCK.

A number of researchers on teacher knowledge have also explored the notion of different types of teacher knowledge. In his search for the expert pedagogue, Berliner (1988) made it clear that teaching in the classroom is based on a genuine scholarship practice. This genuine scholarship practice is based on knowledge. The word, "knowledge" has been defined differently by different researchers in education (Cochran-Smith and Lytle, 1999; Connelly and Clandinin, 2000). Their definitions of knowledge and distinctions between the definitions have impacted on what researchers have looked for and valued in attempts to articulate links between practice and knowledge. However many of these attempts to articulate links between practice and knowledge have proved to be extremely difficult.

Shulman's (1986, 1987) approach to teachers' knowledge has led to a shift in our understanding of the knowledge for teaching and learning science in the classroom. In his conceptual scheme, Shulman identified components of what constitute a teachers' professional knowledge. This conceptual shift has enabled researchers to focus much research on, among others, the specific topics and how they are taught in the classroom. This is the notion of pedagogical content knowledge (PCK). According to Shulman (1987) pedagogical content knowledge is understood as the knowledge that links the particular science content and the teaching practice. Using Shulman's approach, this study also sought to capture the pedagogical content knowledge of (teacher) cluster leaders who are the main drivers of the MSSI clusters in Mpumalanga. The main aim was to understand and respond to the questions on:

- how teacher clusters help teachers to challenge and re shape both their CK and PCK; and
- how this knowledge is translated into practice in their respective classrooms.

2.2.2 Conceptual Framework

If constructivism takes seriously the knowledge construction by learners, then in the same vein, there must also be recognition of the knowledge construction by the teachers who are the learners during the teacher development programmes.

This study adopted a conceptual framework based on the views of Cochran Smith and Lytle's (1999) and Shulman, (1986; 1987). Cochran Smith and Lytle (1999) provided an analytic framework for theorising teacher learning on the basis of fundamental ideas about how knowledge and practice are related and how teachers learn within communities and other contexts. Their views are based on a scheme that explores firstly the knowledge that teachers have acquired through formal training before they qualify to be teachers; secondly, the knowledge they acquire during teaching experiences and lastly the combination of both which is the knowledge for professional practice. These three concepts of teacher knowledge are identified as:

- knowledge of practice
- knowledge in practice and
- knowledge for practice.

While these concepts that explore teacher learning on the basis of the relationship between knowledge and practice are important, they still fell short on articulating the issue of pedagogical content knowledge. This is what Shulman (1986; 1987) considers the missing paradigm that accounts for that strong relationship between what teachers know, and how they teach what they know. Linking the two conceptual frameworks on knowledge, as dicussed above makes sense for examining the teachers CK, PCK and the resulting changes in classroom practice. This combination of perspectives of teachers' knowledge in my conceptual framework avoids the limitations of the past research that has only sought to understand what teachers need to know, and how they learn to teach instead of what they know and how they teach what they know (Lieberman and Miller, 1991).

Shulman (1987) originally identified seven categories of teacher knowledge required for effective practice. These are:

- general content knowledge ;
- general pedagogical knowledge;
- curriculum knowledge;
- pedagogical content knowledge;
- knowledge of the learners and their characteristics;
- knowledge of the educational contexts;
- knowledge of educational ends, purposes and values, and their philosophical and historical backgrounds.

The importance of the seven categories of teacher knowledge is the link and the relationships of these knowledge categories in teaching and learning. It becomes difficult to show and display teaching knowledge into segments.

Of critical importance to the present study, are concepts of CK and PCK. Grossman, et al (1989), using Shulman's scheme on knowledge further conceptualised the idea of PCK as identifying four types of sub-themes of knowledge, namely

- content knowledge;
- substantive knowledge;
- syntactic knowledge; and
- beliefs about the subject matter.

Their identification of the PCK lies on the premise that the teacher is an expert in the subject that he/she teaches and is able to disseminate this knowledge to the learners.

The notion of different types of knowledge needed for teaching was further explored by researchers such as, Lieberman and Miller (1991); Lampert (1988); Senge (2000), and Sawyer (2001). They all supported mostly the category of teacher knowledge in the general pedagogical knowledge as defined by Shulman, (1987). Their views relate to what teachers know about topics such as the curriculum, lesson assessment and preparations. Much of this knowledge is been acquired during the years spent in the classroom by teachers as subject teachers (Sawyer, 2001)

The theoretical constructs of knowledge of practice, knowledge in practice and knowledge for practice as discussed by Cochran Smith and Lytle (1999) also provided a very critical component of my conceptual framework for this study.

Fig.1 Schematic presentation of my Conceptual Framework

Knowledge (Science)

Knowledge of Practice (Pre-service) + Knowledge in practice (In-service)
Professional Development
= knowledge for practice

Content knowledge (CK) + Pedagogical Knowledge (PCK)
Professional Development
= improved teaching practice

{ Cochran Smith-Lytle ,(1999} and Shulman, (1987) }

2.2.3 Knowledge of practice

This knowledge is acquired by the teacher during the teacher training program, for initial teacher training (Cochran Smith and Lytle, 1999). During pre-service training, learning subject content knowledge is always accompanied by learning of teaching methods. The teachers' competence in using both the content and the teaching methods is challenged once the teacher is engaged in a real classroom situation. At this stage, the teachers' knowledge is usually cluttered with theories and assumptions of what should happen in the classroom, however, these are the only tools that the teacher has to use in the classroom.

There has been always a concern as to the relevance and effectiveness of the content knowledge that is offered to subject teachers in pre-service programmes (Ovens, 2000).When students graduate as teachers, they use this knowledge as knowledge in practice as they practise and encounter new challenges in the classrooms (Little, 1993). Gess-Newsome et.al. (1999) claims that most science majors leave college with poor understanding of science subject matter, methods of teaching and the contextual elements of schools. They have been exposed to and ingested a great deal of science content, but not digested and assimilated it in a manner useful to teaching. This content knowledge is usually exposed and challenged by the real classroom encounters. As they meet these challenges, they are often required to reflect on them with other teachers. The knowledge that teachers share and reflect on during in-service training is viewed as, knowledge in practice (Cochran smith and Lytle, 1999).

2.2.4 Knowledge in Practice

When the process of teacher development continuous as an on job- training, teachers bring with them a vast number of experiences that influences their previous knowledge which was acquired during pre-service training. This knowledge relates to what teachers know about topics and the context of the curriculum which they have used as practitioners in their own classrooms. Many factors will influence this content knowledge and the pedagogical content knowledge. Some of these factors might be related to the number of learners in the classroom. For example, in the presentation of science lesson in a class of 60 learners, experiences will be different from the class with 20 learners. Teachers teaching in these classrooms will definitely use different teaching strategies to reach these learners. The availability of teaching and learning resources and the teaching experiences of teachers influence the presentation of science lessons in the classroom (Rogan, 2000; Jansen, 2000).

The skills and challenges that the teacher faces in the classroom would build and enrich his or her knowledge in practice. Johnson, Monk and Swain, (2001) offer examples of how school factors shape classroom practice. In their opinion, teachers' classroom behaviour is best understood by observing from the selection of pedagogical content knowledge that is successful in the classroom environment in which the teacher works.

2.2.5 Knowledge for Practice

When training workshops are organised for practicing teachers (INSET), teachers are exposed to "new knowledge" and skills of teaching in the classroom. This "new knowledge" is often assumed to have no link with the knowledge that teachers already have. In my view, this is one of the big mistakes that teacher developers make in running their workshops and programmes. This view is supported by McNiff (1993), as she argues that working with case studies of actual practice and modifying practice in the light of evaluation, can aid the professional development of classroom practitioners rather than working with theory as if the teachers bring no experiences of their own. This sharing allows all participants to build on their *knowledge of practice* (Lampert and Ball, 1995*).* During training teachers acquire more of and become adept at the use of this knowledge. Some researchers call this "new knowledge" (Fullan, 2001) because it brings in new dynamics, shifts and changes in teacher's life. It might also bring in new encounters in the teaching and learning of science in the classroom. Bell and Gilbert (1996) in their studies on teacher development confirm the value of sharing the experiences as a way of filling in the gap of knowledge in practice. Whilst their study on teacher development confirms the value of sharing experiences by the teachers, it was thin on the discussion of the ways and strategies in which this can be done effectively. This is the gap that this study identified and it is trying to close it by exploring the functioning and operation of teacher clusters as a basic structure for sharing by the teachers at their own communities.

Most researchers of professional development and teacher change have discussed the gap that is usually created by teacher development programmes in failing to link CK and PCK when working with teachers (Hargreaves and Fullan, 1992; Schlerechty, 2000; Rogan and Grayson, 2002). Some of these researchers talk of, "inside knowledge" and "outside knowledge". Inside knowledge being the knowledge that one possesses before it is challenged and reshaped by new ideas while outside knowledge refers to the new knowledge that is brought about by reshaped ideas (Fullan, 2000; Sawyer, 2001).

In summary, it is important to note that as science teachers are developing scientists of the future, they themselves should be exposed to the construction of *scientific knowledge* as individuals and as peers in a community of teachers (Gottesman, 2002). This is still a gap as little or no opportunities are provided for teachers to explore their scientific content knowledge.

2.2.6 Knowledge Construction

Central to the concept of constructivism is the idea that people are "self-constructing and that they can reconstrue their circumstances through the application of their personal worldview" (Candy, 1991:279). Learning is an active process in which the learner interprets and uses sensory input and constructs meaning out of it. The crucial action of constructing meaning is mental and it happens in the mind. Teachers have created and constructed their own meaning of specific concepts and the theories which can only be seen and observed through actions and hands on experiences. These interpretations might be misleading as expressed through actions and experiences in the classroom. Professional development programmes that provide opportunities for teachers to tap on these concepts have a better chance to allow the teacher to formulate a better meaning and understanding of the new knowledge that will fit into a recognisable pattern. We all learn by making mistakes. We can learn from getting things right and reflecting on but more often than not, we learn from mistakes we make as teachers. All experiences are potentially educative (Dewey, 1939).

Teachers are adults and their learning occurs in a social context. Most learning needs derive from membership of social group, e.g. members of a working environment (Lampert and Ball, 1995, Southwood, 2002). A great deal of learning takes place in group settings rather than in isolation; even those who begin their learning alone often seek out other learners against whom to measure their progress and with whom to share their experiences. Teachers who sometimes struggle to perform tasks often succeed when they are helped by mentors or HOD's. This is usually not very practical in a South African context because of the duty loads that CI's and HOD's have and the availability of such opportunities in schools. This concept of mentoring borrows from socio- cultural theories by emphasizing the social nature of learning through joint activity as viewed by Vygotsky (1978) cited in Gluck and Draisma (1997). Vygotsky's main contribution to learning theory is the concept termed the '*zone of proximal development'*. He referred to this term as *a gap* that exists for an individual between what he or she can do alone and what he or she can achieve with help from someone who knows. Some teachers have larger zones of proximal development than others especially in subjects like science and mathematics which are abstract in nature. An experienced or competent teacher provides assistance to the struggling or less competent so that the latter develops greater potential of teaching. The perspective presented here, whereby individuals through their own mental activity, experience with the environment and social interactions progressively build up and restructure their schemes of the world around them.

This process of knowledge construction by teachers is still problematic in South Africa as schools are isolated from each other. Also, the nature of teacher development programmes have not yet provided learning environment for teachers to construct knew knowledge by sharing their classroom experiences (Kahn, 1995). This study seeks to examine examples of how these opportunities can be provided for teachers to construct CK and PCK, in teacher development programs, by making use of their daily experiences in the classrooms. Everyday teaching provides the new learning experience that enhances the development of PCK which might be explored and be used collaboratively for the improvement of science teaching in schools.

2.2.6.1 Knowledge construction through reflection

The notion of a teacher as a reflective practitioner was popularised through the work of Schon (1983; 1987). Schon (1987) argues that, guided reflection assists the process of conceptual change, and the intuitive knowledge upon which teaching practice rests. There is however, little record of how such reflections can be achieved and made more accessible (McMahon, 2000).

Teachers need to reflect both individually and collectively on the learning and its consequences in the classroom (Southwood, 2002). Reflecting collectively will have an advantage of allowing teachers to put their experiences and associated feelings into words with peers with the aim of confirming or strengthening their beliefs about teaching and learning of science in the classrooms (ibid). Reflecting on their own life histories also provide an important resource for teacher knowledge. Jita and Vandeyar, (2003), clearly indicate that the identity that the teachers have with respect to their subject reflects the way in which they were taught as early as in elementary schools. Furthermore, these scholars argue that changing classroom practice eventually depends on the teachers' ability to construct a counter identity around their subject area e.g. mathematics, and to incorporate new (reform) vocabulary within their own systems of thought and practice.

Denis (2000) gives a warning that, without a change in how teachers perceive themselves, they will go through the motions of learning but they will not retain the material in the long term. This argument is important, in my view, to take into consideration the CK and the PCK that individual teacher bring to developmental sessions and construct the new meaning by making use of it. If the teachers' contributions are not discussed and clarified on how they differ or are similar with what is being done, the teachers will continue to hang on to their original ideas and practices.

Boyd and Fales (1983) view reflective learning as a process of internally examining and exploring an issue of concern. This issue of concern is usually triggered by an experience. The experience usually creates and clarifies meaning, which results in a changed conceptual perspective. In most cases, the person that reflects on an experience (reflector) usually thinks of a familiar experience, compares it to the new experience and makes a decision on the relevance of that new experience. Reflection on one's knowledge should be based on learning experiences which take place, as far as possible, in everyday situations and be embedded in familiar activities as eluded by researchers such as Brown, (1989). As Popper, cited in Fensham (1988:79) observed that, "we make progress by reflecting about our errors rather than basking in our strengths." This statement simply confirms that we all learn from our mistakes through reflections.

2.2.6.2 Knowledge construction through sharing

The science curriculum reflects the theories and models, which have been constructed, and the ways in which these are checked and evaluated as coherent and useful (Driver, 1988). This process does not happen in a vacuum. Theory making and testing is a dynamic human enterprise that takes place within the socially defined community and institutions through sharing *(ibid).* Louckes-Horsley, et.al. (1987) argue that construction of knowledge is a process and the change that includes addition, creation, modification, refinement, restructuring and rejection. Knowledge can be collectively constructed at a teachers' course (*ibid*). This new knowledge must be built onto existing knowledge. Fullan (2001) argues the issue of knowledge building by saying that, change in instructional practice involves working through problems of practice with peers and experts, observation of practice and steady accumulation over time of new practices anchored in one's own classroom setting." Knowledge building and accumulation takes time and it need to be built into teaching practice of the individual as a way of monitoring the link between the knowledge of practice and the knowledge in practice (Shulman, et al.2004).

When teachers are in situations where they can construct, share and reflect on their knowledge and skills with the aim of improving their teaching in the classroom, the process is known as teacher development (Adams, 2000; Ovens, 2000). Teacher development approaches and strategies take place in various forms and in a variety of teaching and learning contexts (Joyce and Showers, 1988). These strategies on teacher learning and the construction of knowledge impact on the way teachers are developed (Lieberman and Miller, 1991; Ball and Gilbert, 1996).

2.3 Teacher development

Having discussed my conceptual framework based on the literature on knowledge for teaching and the various conceptions on knowledge change and its potential impact on classroom practice, I now wish to examine the various kinds of teacher development approaches that have been tried in an effort to reshape science teachers' classroom practices that will ultimately lead to the present practices especially in South Africa. I want to explore the idea of teacher development as a process of growth of the individual whereby the individual's life is formed and informed by the values that she/he holds and the knowledge that she/ he develops and practice. This discussion focuses on the approaches that have been and are still being used world-wide and specifically in South Africa for teacher development.

2.3.1 Traditional approaches to teacher development

Numerous studies have already established that many of the approaches used to develop teachers have shown minimal results in influencing and changing the teachers' classroom practice (Cuban, 1993; Jansen, 1999; Fullan, 2001; Gottesman, 2002). Most of these approaches to teacher development relied mostly on the top-down approach. The top down approach to teacher development is based on the assumption that the development of teachers should be closely linked to the overall planning processes of the school management. In most cases it is driven by an expert who claims to know the needs of the individuals and could provide training (Ovens, 2000). In some cases there would be uniform details and requirements applied to all teachers in a province or in an area to be serviced by the workshop. Decisions and plans are often centred on an 'expert' that offered the training. Such traditional approaches to teacher development continue to be used in many countries, including South Africa (Jansen, 2000; Rogan, 2000).

Many such professional development sessions are characterized by a gap between the content knowledge that the experts offer with the knowledge and experiences that the teachers bring along to the workshops. In order to understand and to begin to see possibilities beyond such traditional approaches to teacher development, it is important to identify and investigate those situations where teachers and academics come together to form communities of learners in South Africa (Southwood, 2002).

The challenge that concerns teacher developers is to find an approach that helps teachers change their beliefs, knowledge and practices in the classroom. According to Louckes-Horsley et.al. (1987), such approaches should engage teachers in those processes that improve job-related knowledge, skills or attitudes. De Feiter (2002) makes a similar point in arguing that teacher education and development programmes should be linked to what happens in the classroom. Unfortunately, a great deal of evaluation of staff development programs begins and ends with the assessment of the individual's reactions to workshops and courses (Little, 1993). In such cases there is little to learn about the acquisition of new knowledge and skills and how that learning affects teacher's daily practice (Guskey, 2001). Evaluation of staff development usually assesses the knowledge acquired by the teachers at the workshop, but in most cases, fails to asses it in the classroom (Louckes-Hoserley, et.al 1987). The transfer of skills and knowledge that goes back into the classroom remains unexamined and will form an important component of this study.

Kelly, et.al (2002), summarises the challenges facing professional teacher development decisions and dilemmas of in-service education as the failure to define professional development beyond the cataloguing of school clock hours. Their concern is that the provision of teacher development fails to differentiate between the classroom, school and district activities. This means that teacher development programs concentrate more on management issues and new policies and neglect the content knowledge that is needed in the classroom. Without denying the importance of in-service education for all teachers in all districts, the challenge of understanding the problems associated with the processes of effecting change in the classroom continues to elude us (Joyce and Showers, 1988). This is not withstanding Fullan's caution that you sometimes need a little of both of departmental INSET and community based INSET support in order to influence implementation of changes in practice (Fullan 2001).

A very recent example of such an approach to teacher development was used in South Africa during the introduction and implementation of the new curriculum known as Curriculum 2005. This approach was based on a cascade model conducted by the "experts" moving from one province to another. They first trained a group of selected Department of Education officials from the various provinces who were expected to train the local Subject Advisers. The Subject Advisors, in turn, selected and trained one teacher from each school with the mandate to go back to schools and train others. This "chain" was too long to reach the classroom and the context of this training further neglected content knowledge and focused on the skills (Rogan, 1999; Jansen, 2000; Kahn, 1999). A similar approach was still being used when the Revised National Curriculum Statements (RNCS) was introduced to teachers more recently South Africa therefore still needs to come up with approaches that provide opportunities to understand the personal and professional development needs of teachers, investigate those situations where teachers come together to form communities of learners (Southwood, 2002).

In this study I have classified the approaches on teacher development into two broad categories, namely, traditional approaches and new innovative approaches to teacher development. I now turn to a discussion of the new, innovative approaches. Such approaches are those that as Ovens (2000) observes: promote close observation of the teacher's own classroom; harness teacher's ability to deepen their awareness of their own professional needs; promote individual and collaborative reflection about shared learning from their experiences; and promote the critical use of others' published ideas.

2.3.2 New and Innovative Approaches to teacher development

Innovative approaches to teacher development are regarded so far as the better ways of improving classroom practices, where content knowledge and pedagogical content knowledge takes the form of reflection on action (Wilson Berne, 1999; Southwood, 2002). As a consequence of lack of effective classroom practices, problems and related theoretical debates, especially in South Africa, many new approaches to professional development, have begun to emerge (Southwood, 2002). These innovative approaches are mostly targeting science and maths teachers (Grayson, 2001; Kahn, 1988) South African literature reviews that the majority of teachers are ill or under qualified to teach science, especially at the senior high schools (Kahn, 1995; Taylor and Vinjevold, 1999, Jansen, 2000; Lubisi, 2000). The majority of these teachers are heavily dependent on textbooks for content and use rote learning as a teaching methodology in most cases (Kahn, M. & Rollnick, M. 1991). The baseline survey conducted by JICA (JICA1999) showed that Mpumalanga teachers lack content knowledge in science and mathematics subjects to teach effectively in the classroom. Grayson et al. (2001) also mentions the negative attitudes that South African teachers have towards the teaching of science and how this impacts on the teaching and learning of science in the classroom. Reflecting on the South African context where teachers lack content and pedagogical content knowledge, because of ill training and ineffective INSET programs that address classroom issues (Lubisi, 2000; Jita, 2004), innovative and effective teacher development approaches are needed to fill the gap. The type of intervention that is ideal would be different from the Western countries where teachers are well qualified to teach the subject, but meet in teacher networks for sake of improving, expanding or 'polishing' their knowledge and skills of teaching (Lieberman& Wood (2002).

Taking the context in which the teachers operate and their characteristics as outlined above, it makes sense to implement teacher development approaches that are innovative. At the heart of the new approaches is the move towards teacher clusters as a form of teacher development (Southwood 2002). Teacher clusters are a "form of professional community that provides a context within which members can come together and understand their practices"(Secada and Adajian, 1997; 193). Lieberman and Grolnick (1988) have highlighted the fact that, although there is no single definition of clusters or networks, the 17 clusters that they studied, engaged in similar activities. Amongst the activities that they examined the following were rated as the most common characteristics of network/ clusters: Sharing content knowledge, reflecting on their teaching experiences, giving feedback, collaboration and negotiation among others.

While, I reviewed the descriptions of the networks provided by Western researchers, I assume that teacher networks in South Africa will not provide an adequate substitute for Western examples, since the context is different and the focus might be different. For example, teachers in the Western countries might be focussing on teaching the subject better while the teacher in South Africa might be focussing on understanding concepts and terminology that were never taught during his or her training but faced with the task of teaching them. In a way, the teacher cluster provides an opportunity for this teacher to learn new concepts and new terminology that helps to bridge the gap in content knowledge. This is the knowledge that the teacher would have learnt during Pre- Service Training.

Collaboration and sharing of knowledge among peers help teachers to reflect on their practices as equals through meaningful social interaction. Prawat (1992) uses the term 'negotiation' to describe this social interaction because it involves learning and unlearning new information. When teachers share their classroom experiences they learn from each other and unlearn their old experiences by accepting new knowledge so that it becomes meaningful. Further to the acquisition and exchange of knowledge, Gottesman (2002) observes that when teachers work together as a community, they develop skills of mentoring each other as peers and learn to plan collaboratively as peers. Wineberg and Grossman (2000) confirm the value of collaboration by observing that peer-coaching, combined with the acquisition of new teaching skills, is an expedient, positive and supportive way for teachers to implement new strategies in the classroom.

The new innovative cluster approach to teacher development therefore seems to enhance the kind of learning that has a potential of providing opportunities for teachers to engage in learning which promotes the collaboration, construction and sharing of CK and PCK in a meaningful way (Guskey, 1986).

The cluster approach is currently being used in most provinces in South Africa in one form or another. In some cases it is embedded in the community structures of teachers, in others it is part of the Department of Education structures (Gray, 1999; Southwood, 2002; De Feiter, 2002). The approach is still fairly new in South Africa, although it has been in used in the United Kingdom and in the United States of America since the seventies (Parker, 1971). It has recently become popular in other countries as well: Swaziland (through the SMART project); Botswana through a Netherlands funded project (UB INSET, 1976) and in Namibia (De Feiter, 2002). Views from researchers on the successes and the failures of such teacher clusters are at this stage few and far between, a gap which this study seeks to fill by documenting examples on the structure and functioning of teacher clusters for science teachers in the Mpumalanga province of South Africa.

2.3.3. Cluster Approach

My review of the literature suggests that clusters differ from one another, especially with respect to their formation, mode of operation and their consequences or effects on teachers' knowledge and classroom practices. A review of Guskey (1986), for example, identified four types of clusters, on the basis of their formation and operation. Guskey (1986) named the three clusters as follows:

- Formal hierarchical top-down cluster;
- Formal expert/funder driven cluster; and

- Informal community driven cluster.

The differences between the hierarchical top down cluster is that in most cases the cluster is led by a senior person within the departmental structures and in most cases it fails to engage teachers to issues that are addressing CK and PCK. In most cases it focuses on policy and administrative issues. The expert or funder driven cluster is often driven by an expert who is an outsider. The experts usually impose to the teachers and fail to consider the CK and PCK that teachers bring to the teacher development programs. In some cases, if the teacher development program is funded by an outsider with his/her own objectives, it imposes its strategies and practices on the teachers.

The informal community driven cluster on the other hand, is mainly a bottom up structure that is initiated by teachers in order to improve their CK and PCK. In most cases, this cluster is driven by teachers themselves, and the context of meeting is collaborative and reflecting on their classroom practices.

Similarly, Lieberman and Grolnick (1996) identified 6 different types of clusters. The latter scheme, developed 10 years after the Guskey's scheme was more comprehensive due to the fact that it further identified three types of clusters.

- Informal subject based cluster
- Informal radical issue driven cluster; and
- Informal collaborative subject based cluster.

The subject-based cluster focused on the specific subject within the schools that are close to each other. This cluster is usually linked to school improvement policies. It differs completely from the collaborative subject based cluster in that it is school based and it is guided by the school policies and subject policies. The collaborative is very informal and the participation is very informal and voluntary. The radical clusters are more concerned with all the issues of education that affect teachers. They concentrate on issues that are generic and that are not specifically focussing on the complexities of content knowledge and how it is taught in the classroom.

Table 1 Cluster definitions and characteristics

Type	Characteristics	Status	Participation
Community	Embedded in the community Structures	Informal	Voluntary
Collaborative	Concern interest group	Informal	Voluntary
Reform radicals	Radical and open-ended issues e.g. teachers 'rights, teachers' salaries, challenging new policies and structures in education	Informal	Voluntary
Hierarchical	Top-down inside expert	Formal	Compulsory
Expert-driven	Out-side expert	Both formal and informal	Voluntary

2.4 Summary

Continuous learning on the job has great potential to influence teacher's practices in the classroom. The word change dominates this study and as a result it became important to review briefly the literature on change of teachers' classroom practices. According to Roget's Thesaurus (Kirkpatrick, 1987), one meaning of the word "change" is, the difference at different times". Others associated with change, are alteration, reformation, improvement and transformation. All these words attempt to explain the acts or processes that lead to change. This study endeavours to understand this change process in teachers by examining what they do to improve and transform their teaching practices in clusters. The issues of CK and PCK become the key tools of transforming and changing classroom practices. Fullan (2001) noted that the future of educational change lies in the learning process of the individuals or in change processes in organisations where both see the active construction of meaning, as participants. The process of change involves developing a mindset and action set that is constantly cultivated and refined. Here the role of in-service education and training (INSET) becomes vital. Change in instructional practice involves working through problems with peers or experts, observation of teaching practice, and steady accumulation of new practices overtime anchored in one's own classroom setting (Fullan, 2001). The emphasis here is placed on learning in the setting where you work e.g. learning while teaching in a classroom. This type of learning has the greatest reward because it is more specific, customised to the situation, and social involves a group (Fullan, 2001:126).

This study examines the opportunities that innovative teacher development programmes provided for teachers to engage in the analytic process of uncovering and challenging their CK and PCK through as peers. In order to understand these teacher changes and teacher development, this chapter focused on a literature review and how it influenced the design of this study. The areas covered in it are views on teacher development, teacher knowledge, theories and models of initiating and implementing innovation and change. The literature helped to focus the research design in respect of teacher change in science education by providing theories on the process of teacher change and the context that enhanced learning. These theories took into consideration the nature of science and its philosophy as it impact on teaching and learning.

The next chapter describes the research design used for exploring my research questions in detail. It further discusses the experiences and challenges of data collection in this study. The research design took the form of qualitative approaches in order to collect in-depth descriptions on the formation and functioning of teacher clusters. This approach was used with an attempt to understand the nature of opportunities provided for teachers' development and personal growth.

Chapter three

RESEARCH METHODS

3.1 Introduction

In this study, I used qualitative research methods to investigate and explain the content and context of a professional development programme using teacher clusters or networks in the province of Mpumalanga in South Africa. The purpose was to develop an understanding of how teacher clusters create the opportunities for science teachers to challenge and change their Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) and thereby their classroom practices. I chose to use qualitative methods because their techniques provided the verbal descriptive analysis and the interpretation of the phenomenon of clustering. Strauss and Corbin (1994), define qualitative research as any kind of research that produces findings not arrived at by statistical procedures or other means of quantification. The reason for choosing qualitative research methods is because this study intends to gain in-depth information on teacher development in clusters and to review events and occurrences as they avail themselves as part of investigation. Denzin and Lincoln (1994:1) argue that qualitative research "is a field of inquiry in its own right surrounded by a complex, interconnected family of terms, concepts and assumptions and methods".

Perspectives and methods associated with this intellectual tradition include interpretative status of culture, content analysis, discourse analysis and context sensitivity (Guba and Lincoln 1994). In the light of the research paradigm adopted for this study, I assumed that clusters existed in multiple, intangible realities that should be studied holistically. This assumption is based on the literature reviewed on the existence of different types of clusters/teacher networks as expressed by other researchers, such as Lieberman and Grolnick (1996); Fullan, (2001); Senge, (2001) and Fraser-Abder, (2002). I, therefore, employed various strategies and methods in order to deal with qualitative data that emerged from the fieldwork. In accordance with the adopted paradigm, realities about teacher clusters could not be described and understood in terms of separate independent and dependent variables.

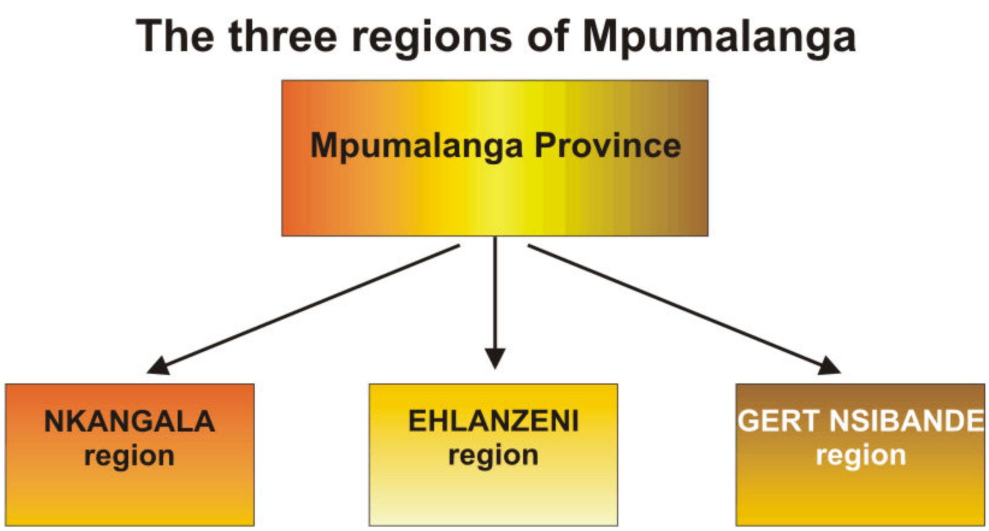
Qualitative techniques provided this study with descriptions that portrayed the richness and the complexity of events that occurred in natural settings of clusters from the participants' perspective. By triangulating the data collected from the various sources and through the various instruments, I was able to examine a range of issues within the clusters on the way teachers participate in clusters and the nature of content knowledge they bring into the cluster for sharing (Yin 1994). These various sources of information enabled me to understand the complexity in teacher clusters from individuals, groups, regional and provincial officials' perspectives. Furthermore, a multiple source technique helped to establish agreements and disagreements during the analysis of data. The data sources used in this study are discussed later in this chapter.. In order to get in-depth knowledge and information about the clusters, the form of qualitative method used in this study was of an interactive nature, namely case studies. The interactive nature which was mainly formal, but sometimes informal, enriched the data on cases that I selected.

According to Hammersley (1994), case study research provides the setting of research which is natural and holistic on what goes on in the event(s) being investigated. Case studies were chosen as they explore single events and processes that are unique in the way in which one can understand the operation and functioning of the clusters. I chose to use the case study approach in this study in order to examine and investigate the way and the approaches that teachers used in sharing their classroom experiences and how these changes impacted on their classroom practices. Two completely different clusters were selected as case studies in this research. For the sake of convenience these two clusters were given special operational names: SIM and Sibonelo clusters. These were examples of clusters that existed in Mpumalanga as they were an indication of how teachers helped and supported each other in constructing new knowledge that impacts on the teaching in the classroom. The issue under study is the nature of opportunities that are created for teachers by clusters to learn from each other as peers. Furthermore, the two cases were targeted for displaying in depth the processes and the interaction values of the classroom practitioners' experiences that aimed at influencing each other's science teaching and learning in the classroom.

3.1 .1 Description of the Field

This study was conducted in the Republic of South Africa in a province called Mpumalanga. The word Mpumalanga means, a place where the sun rises. This province is close to two other African countries, Mozambique and Swaziland (see appendix 1). This province exemplifies all the key features of South Africa i.e. from rural to urban and poor to rich. It was chosen for this study because of these key characteristic features and also because the province had just started the practice of clustering schools with the aim of improving the quality of science teaching. Also, the MSSI project, funded by the Japanese, used the University of Pretoria as its partner in working with the teachers and the schools in this province on teacher clusters for science and mathematics.

Fig. 2. Illustrates the three regions of Mpumalanga



Mpumalanga Province is divided into three regions, Nkangala which is semi rural and closer to Pretoria, Ehlanzeni which is rural and far from Pretoria and Gert Nsibande which is also rural and far from Pretoria. As one of UP's facilitators in science and mathematics workshops, I worked in the whole province (see fig. 2 on dominant MSSI clusters on this chapter). I had a fairly good understanding of the geographical areas of this province. For this study I chose to target all regions but sampled on specific areas and schools that would give me the best understanding of clusters' operation at their contexts.. Ehlanzeni was chosen for the Isibonelo cluster as a case study because it has unique features that compared well with the other cluster - SIM. at Nkangala. The choice of these two different cluster structures was for a specific purpose for this study. Firstly, both clusters engaged teachers in constructing and reshaping their scientific content knowledge. Secondly, they are both under the leadership of cluster leaders but their leadership and operation differs. The one operates in a hierarchical fashion while the other operates in a voluntary way as discussed and defined in table one. Thirdly, the provincial policies and the implementation of MSSI activities affected both of them in a similar manner. By studying in detail their operation and functioning in reshaping science teachers CK and PCK would enable me to understand the concept of clustering better. I intended to bring the contrasts and similarities in the way in which the clusters operate in helping the teachers to learn from each other as peers. For example; if we take the case of Sibonelo cluster, it is the only cluster that engaged teachers in different types of cluster activities which it called, *cluster teaching* and yet was the most rural. Cluster teaching means teachers after attending a cluster meeting of collaborative planning of lessons, they will invite learners from all the cluster schools and teach them while the other teachers are observing. This is a unique feature that I had intended to explore and examine in detail by selecting and working with the schools that were participating in these clusters. The findings of my investigations are shared in chapter four of this study.

The context for this study was teacher clusters and the opportunities created for teachers to explore their scientific content knowledge. My entire study was located within the MSSI project that operates in all secondary schools in Mpumalanga with the objectives of improving the teaching of science and mathematics in schools. This project was started in 1999. The first three years of the project focussed more on capacity building of the curriculum implementers and the HODs at schools and this became the phase one of the project implementation. My research took place within the period of MSSI phase two (2002 - 2005) which focussed on the implementation of the project through clusters. (See appendix 2)

3.1.1. (a) Schematic data collection points for the study

Fig. 3 Illustration of data collection points at Dominant Clusters

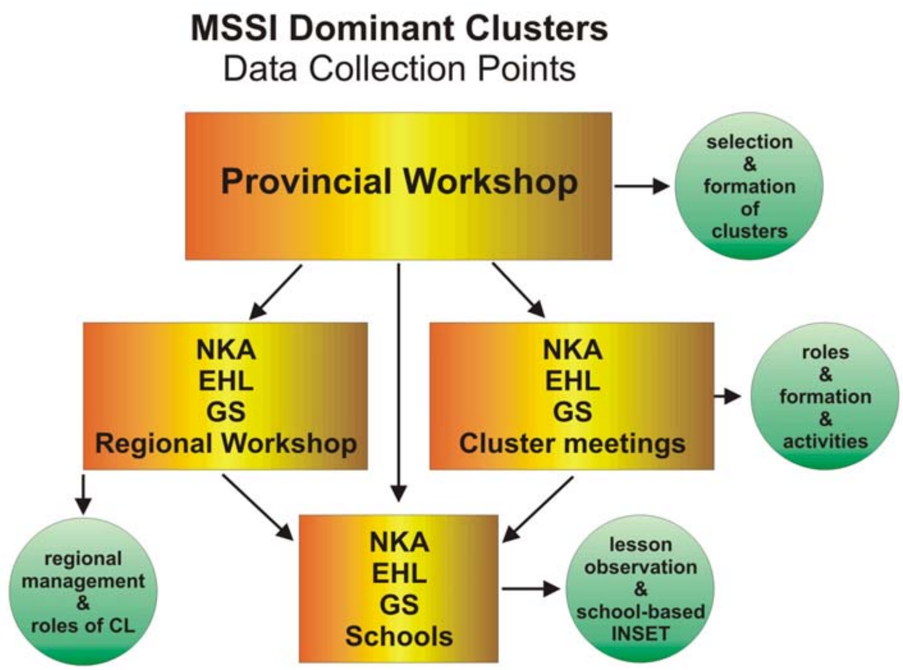


Fig. 4 Illustration of data collection points at SIM Cluster

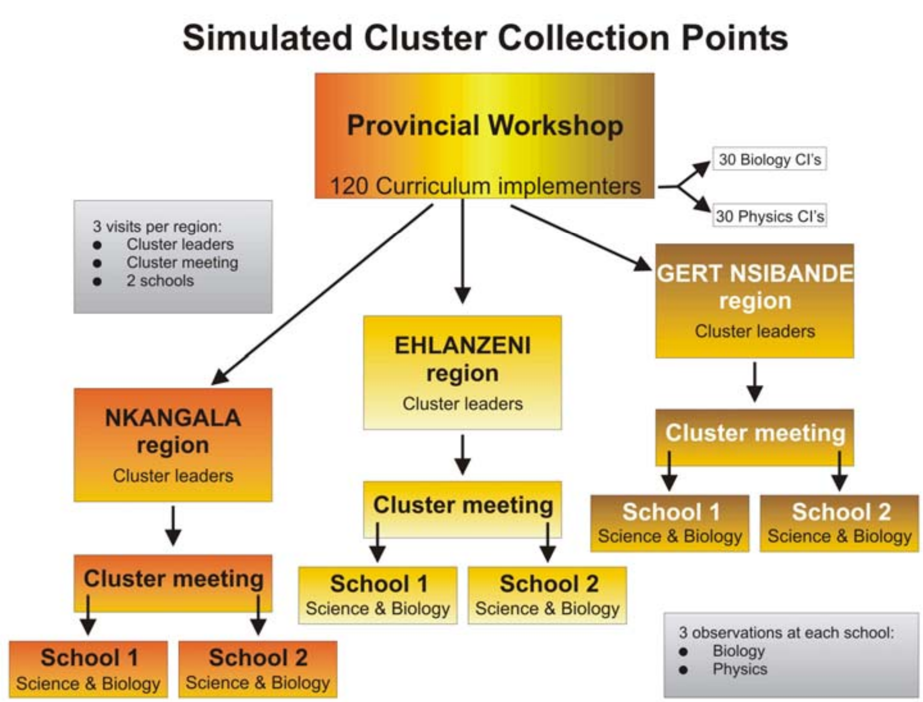
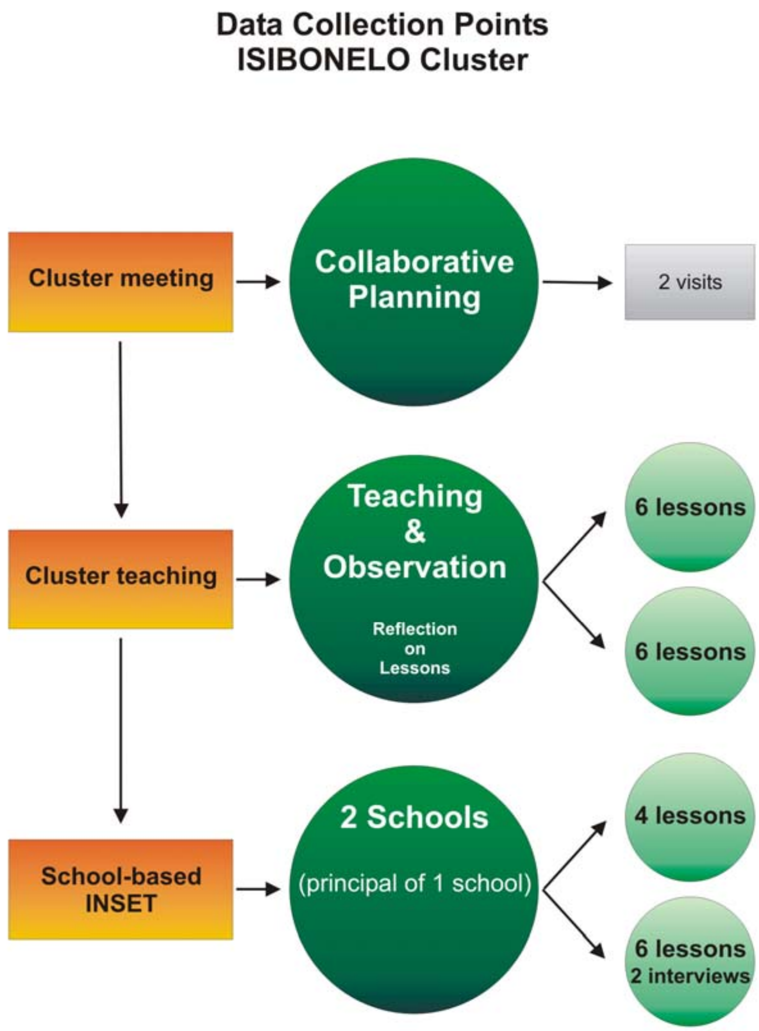


Fig.5. Illustrates data collection points at Sibonelo Cluster as an External cluster.



There were 120 registered clusters in Mpumalanga when the study was conducted in 2003 but in 2005 they had gone up to 381. For this study I chose to focus on an unregistered cluster as one case study because of its unique features and for the other I used one of the registered clusters. I have named the registered cluster as Simulated (SIM) Cluster and the unregistered Sibonelo Cluster. For the SIM cluster case study I focused on one provincial workshop for curriculum implementers and one regional workshop for cluster leaders in all the three regions as shown in Fig.2. The strategy followed on focussing on these two levels in registered clusters was influenced by the cascade model of disseminating the information to schools as practised in MSSI. The cascade model in MSSI happened at three levels of information dissemination. The first level was the level where the curriculum implementers are developed by UP and

JP on CK and PCK. The second level was where the cluster leaders are developed and assisted on strategies and ways of supporting teachers by curriculum implementers. The third level was where the cluster leaders assisted other teachers on the CK and PCK. The composition structure of the cluster leaders' workshop is shown in figure 6 on this chapter.

Sibonelo cluster's operation used a different strategy from that laid out in the MSSI project despite the fact that the cluster leader and teachers participating in this cluster are part of MSSI. Dissemination of information at Sibonelo, unlike the MSSI clusters, happened at two levels. Firstly, it happened at the cluster level and secondly at the school level, without the influence and official support of the curriculum implementer. In this cluster I focussed on the planned activities as dictated by their programme. I attended and observed science content planning workshops and cluster teaching activities. These workshops are at the level where the cluster leaders work with the teachers to improve their content knowledge, in most cases at the schools or at the teacher centres. Using two different levels of workshops was a way of exploring further the processes provided by clusters in improving science content and pedagogical content knowledge.

This study explored, in detail, these two clusters and the opportunities that were created for teachers to explore CK and PCK. The studies were carried out during provincial and regional workshops which took place in May 2004 and the Sibonelo cluster workshops which were held every month since its inception in 2001. I managed to attend all the three regional cluster leaders' workshops after the provincial workshops and observed how the information was passed on to teachers. In order to enhance this study, I focussed on a single regional workshop where I shared the proceedings and the resultant processes of uncovering CK and PCK. I visited Sibonelo cluster four times but the data for this study focuses on one specific event, namely, cluster teaching. This event had all the features of opportunities provided by clusters for teachers to shape their CK and PCK. It started with collaborative planning, to cluster teaching and to school based INSET as indicated on Fig.5.

The preceding discussion provides this study with the context of operation that enabled me to understand the concept of clustering and the re-shaping of teachers' CK and PCK.

3.2 Research Design

3.2.1 Methodological approaches used:

Qualitative design methodology was used in order to collect data that enabled this study to describe the context and the diversity that takes place in clusters. The reason for choosing this method is because clusters portray the diversity in human beings and also that the clusters operate in the entire province. As such, it provides a natural setting of uncovering CK and PCK. I found that qualitative research was better suited for investigating and probing those settings that impact on the professional development of science teachers in their own communities. The best form of qualitative research for this type of study was a case study. A case study can bring in-depth understanding of the happenings.

In order to answer the question on what clusters do to change the teachers' PCK, I used a case study of teachers participating in cluster meetings. Their participation in the cluster meetings enabled me to gain an in-depth understanding in the natural setting of the cluster (Cohen and Manion 1994). Six school visits were also conducted in order to observe and to collect data. The data collected provided me with the actual observation of teachers uncovering their CK and PCK. Interviews conducted and the documents provided at these meetings reviewed the reality of the various aspects of the clusters. Triangulation of data from these sources and through the various instruments enabled me to examine a range of issues within the clusters' processes of packing and unpacking CK and PCK. This included science content knowledge construction, reflection on practices and professional discussions.

This approach enabled me to describe the context and the social environment in which clusters operated. Multiple case studies are one of the most common ways to undertake qualitative inquiries because they enable interpretation within a context (Denzin and Lincoln, 2000). Case studies focus on a specific situation or phenomenon and as they are descriptive, they offer insights into the phenomenon that is being studied (Merriam, 1988). In this study the phenomena under examination were the two unique clusters (the SIM and Sibonelo) that were deliberately chosen. One of these clusters is situated in a deep rural area of Mpumalanga and the other was a created cluster (simulated) in a central semi-urban area. An in-depth study of what the clusters leaders did as a group that challenged and reshaped their knowledge and practices in the classroom, was carried out. Malcolm's (2001) opinion is that case studies describe and analyse the people's individual and collective social beliefs, actions, thoughts and practice. This statement is in line with the findings of this study. Mpumalanga Province had 120 clusters registered in the MSSI project and to study all these clusters would complicate the focus in describing and understanding what clusters do in changing and shaping teachers' practice.

The case study approach was suitable for this study because of the complexity of the MSSI project. The MSSI project has been implemented throughout the province which is very wide. The complexity was due to the fact that the cluster leaders were also classroom teachers, who were viewed as learners in one setting and as "trainers" in another. They had their own students that they taught daily in their classrooms and they had on the other hand learners who happen to be teachers from other schools that were to be trained. In involving all the teachers participating in MSSI was not going to give in depth understanding of the processes of clustering and reshaping of knowledge. The process of knowledge shaping in MSSI clusters was based on different cascade levels of knowledge dissemination and each had its own structural base; for example, the level of the curriculum implementers, the cluster leaders and the classroom teachers. The case study approach intended to understand the roles that each of these levels play in the provision of opportunities in clusters for teachers in reshaping and influencing their content and pedagogical knowledge.

The cluster leaders from registered clusters were provided with training on support as instructional leaders by the University of Pretoria. In this setting the cluster leaders were themselves learners. At the other level they were expected to run workshops for other participants in their cluster as trainers. This study attempted to capture these processes of knowledge dissemination that impact on clustering at all the cascade levels. Guba and Lincoln (1989) argue that,' case studies provide detailed description of the cases, analyses of the themes and issues, and the researcher's interpretations or assertions about the cases. The events and operations in clusters provided dynamics that could be best captured by describing those events that provided information on those issues which are key to teacher development. Yin, (1988) points out that, although case studies are narrower in scope, they are more thorough and more qualitative than surveys and are therefore more enlightening and reliable. The information gathered from MDE documents and reports had some limitations. It might look similar to the outline of the course or workshop proceedings but failed to bring the in-depth observations and descriptions of events that might lead to interpretations on clusters that appear similar but operated differently. These differences in the way they operated would enrich those interested in clusters as an approach to teacher development. Each case examined and explored the following activities:

- formation of clusters;
- leadership in clusters;
- activities in cluster;
- enhancement of PCK in clusters; and
- sustainability of clusters.

Six visits were made to each cluster used as a case study. Each visit lasted a day, and happened at provincial and regional workshops. These workshops proceedings were captured on video and notes were also taken. Six cluster leaders, together with the participating teachers, were interviewed in 2004. Five teachers from each cluster were interviewed. In addition, informal discussions were conducted with the workshop participants from other clusters who were not part of the selected cases. The purpose of these discussions was to gather feedback from the workshop participants and to refine my own notes and understanding of what I observed in the selected clusters. A semi-structured questionnaire was used to capture the data on cluster leaders on leadership skills. The interviews enabled the study to explore more issues that would have been left out if the questionnaires were structured.

The data collected from these case studies was analysed, and documented. Data from interviews was captured through note-taking and audio tapes. This data was categorised in order to identify common themes and patterns. The themes and patterns that emerged were linked to the way in which opportunities that are created by clusters for teachers to explore and improve their pedagogical content knowledge. Examples of these themes are given in the results of the proceedings of the workshops, for both clusters, in chapter four. The case study participants were given pseudonyms in order that they remain anonymous.

Face to face interviews were conducted at different levels. The three regional managers were also interviewed on the structure and the purpose of clustering schools. Each interview lasted for an hour each. Their responses were also captured on the audio tape and notes on important points were written on my field journal. In order to gain an understanding of the support given to cluster by the four curriculum implementers active in the case studies, they were interviewed for 30 minutes each on issues of cluster activities and support. In order to do these interviews I had to reschedule some of the dates on which I visited the clusters. The selection of the dates to visit the clusters depended on their programmes and the nature of meeting they were conducting. Some cluster leaders had planned to discuss content knowledge and others to talk about the MSSI project. The notes resulting from this data collection was analysed and documented as findings in chapter four.

Semi structured interviews with other registered clusters, which were not part of the selected cases, were used in order to verify some of the issues that came out from the two cases. I was trying to elicit, through interviews with the cluster leaders and the members of a cluster, the activities of the cluster leaders and the types of opportunities that are made available to teachers that participate in the cluster, to shape their classroom practices. The data that I collected filled in the gaps on the data that I had on the roles of cluster leaders and confirmed the events in clusters. The interviews were transcribed in order to check on the quality of data and some of the direct words of the interviewees form part of this study.

Further, I had to review the programmes and the work plans of the clusters leaders in order to get an understanding of the cluster activities. The documents were reviewed and analysed in order to gather the data on the specific content knowledge that the clusters were handling. These documents attempted to give light to the nature of activities that the teachers were struggling with in the classroom as well as the work that was demanded from the teachers by the provincial or regional offices.

The data collected was divided into categories that made meaningful themes, using procedures described by Cohen and Manion (1994). The data collected from MDE's registered clusters and from cluster leaders' workshops, together with the data that emerged through interviews, was used to formulate the pattern that emerged through the activities and practices of the clusters. These activities were classified into themes that were linked with literature on clusters. These themes included the following themes:

- formation of clusters;
- leadership in clusters, and
- ownership of clusters.

Information on the types and dynamics of clusters in Mpumalanga kept emerging as I visited and observed clusters. About two days a week for 10 months were spent on visiting clusters and in most cases one day was used to analyse data.

In analysing data I focused on the activities that were related to the changes of pedagogical content knowledge. I spent one day a week over a period of three months watching videos, listening to audiotapes and analysing data. In some cases I had to spend more than a day depending on the nature of data that I was busy analysing. The data that I collected on flipchart from workshops was analysed and documented immediately after the workshops. This data formed part of the information that provided the nature of activities that took place and the examples of PCK that the teachers handled. The data analysed as well as adding new categories that emerged as data being analysed. The created categories on clusters were checked on the emerging patterns making use of the clusters that were selected. The findings were linked to the reviewed literature on clusters/ networks as viewed by researchers like, Lieberman, (1991); Guskey, (1986); and Adams, (2000). The data was interpreted and documented for this study.

3.2.2 Sampling

In South Africa education policies are issued at the national level and the nine provinces are expected to implement these policies. Each province has its own way and strategies of implementing policies. Teacher Clusters is one such policy recommended by the national government for all provinces. I chose to use Mpumalanga Province as a sample to study clusters out of the eight other provinces because of the involvement of the University of Pretoria and the Japanese on the MSSI project.

MSSI has a variety of activities. The major MSSI activities are: material development, Cluster leaders' workshops, Cluster meetings, Cluster teaching and School-based INSET. For this study I selected the following activities for data collection: Cluster Leaders' workshops, cluster teaching and cluster meetings. These activities occurred in different parts of Mpumalanga. The study sampled these events in various areas. These events were targeted with the aim of attempting to understand the formation of clusters and the activities that teachers do in clusters that help teachers to reshape their CK and PCK.. I further wanted to understand the kinds of scientific knowledge teachers brought into cluster meetings, how it is shared and used in the context of clustering as envisaged by MSSI and its partners.

3.2.2.1 Sampling of documents

In view of the purposeful sampling strategy chosen, the cluster documents were reviewed according to their relevance and importance in answering my research questions on the formation and the operation of clusters.

Titles that focused on MSSI clusters as a project on the issues outlined in the research questions and the relevance of content regarding the topic, e.g. the formation of clusters and the roles of cluster leaders. Only documents written between 2002 and 2005 were selected as samples, since this was the period in which MSSI phase 2 operated. Consequently, documents that were selected for analysis were those that were written by curriculum implementers, cluster leaders reports, MSSI evaluation reports, records of meetings as well as JICA documents.

The effects of adopting purposive sampling were that all documents and records that were supplied by MSSI could be found for both regional and provincial level and that the information on registered and unregistered clusters would be of help in data collection.

3.2.2.2 Sampling of Clusters

(i) **MSSI Internal (Simulated) cluster**

MSSI had 120 registered clusters when this study was initiated. These cluster leaders became the best sample for the province wide registered clusters for MDE. These entire cluster leaders participated in the MSSI regional workshop for professional development by UP and the Japanese team. The reason for using them at the regional workshop is that they all knew their roles as cluster leaders, how clusters operate and how clusters should assist teachers in improving their content knowledge. Instead of them being cluster leaders at this workshop, they were used to simulate what should happen in a cluster meeting. The simulation activity took into consideration the aims and the goals of MSSI in using the teacher clusters as a structure to improve CK and PCK in the classroom. The simulated cluster became a sample of what a real cluster should do in supporting teachers. The 120 cluster leaders were divided into their subject areas; Science, Biology, Maths and Agricultural Sciences. Each group had 30 teachers engaged in an activity as members of a real cluster. Although the number of participants was higher than in a normal cluster, the outcome of the task provided useful information. Three of these simulated cluster meetings were observed in each region.

(ii) External Clusters

External clusters are those clusters that fall outside MDE operation because they are not formed by MDE and they do not follow the MDE policies, they operate on their own unregistered. Since these clusters are seen by MDE as 'unofficial' it became difficult to know how many of them exist in the province. In order to understand its formation and operation, one such cluster became a case for this study.

The second cluster was a sample of external clusters and how they operate on their own on voluntary basis. One cluster was selected on the basis of its activities and willingness to participate in the study. This cluster was also selected because it operated long before MSSI before they knew about MSSI cluster activities (see Fig. 5 on this chapter). This cluster was in a region which was in a rural setting and was already established. Four cluster meetings and cluster teaching sessions were observed over a period of nine months. Four cluster activities were observed during cluster meetings where lessons were taught by different teachers who are members of this cluster: viz. the cluster meeting, the cluster teaching, the reflection meeting and the classroom lessons.

3.2.2.3 Sampling of Schools

(i) **Schools from registered clusters**

Six schools were chosen from officially recognised clusters in which there were an effort to implement cluster ideas. Two schools from each region were selected. The purpose of selecting these schools was to investigate how much of the work done during cluster meetings was transferred to the classroom. Two science lessons, taught by different teachers, were observed in each school. These lessons made use of the materials that were discussed in the MSSI regional workshop.

(ii) Schools from external clusters

Three schools were chosen from those that participated in the external cluster with the aim of observing the effort of teachers in implementing ideas from the cluster meeting. Two science lessons conducted by different teachers were observed. Principals of these schools were interviewed on the functioning of clusters and their roles in clusters.

3.3 Research Instruments and Data Sources

The data was collected through interviews, observations, and informal discussions.

3.3.1 Interviews

Using interviews as a tool for collecting data was an ongoing process in this study. Initial interviews were conducted as early as 2002 with MDE personnel. These interviews focussed on broad policies and practices of the MSSI project in the regions. The second set of interviews used in the study targeted focus groups during the simulation workshop. Focus group interviews involved discussions with subject area cluster leaders and responses to a questionnaire after the activity. The purpose of the focus groups was to give the cluster leaders an opportunity to share their experiences and to modify their original perceptions about the clusters. Group interviews did not replace individual interviews but served to provide another level of data gathering. Four group interviews were organized for this purpose based on the four subjects. Open ended interviews were used in group interviews. The responses were recorded, grouped and then analysed in order to establish meanings.

The third set of interviews was conducted with the cluster leaders of the selected clusters before and after cluster meetings. An interview guide was used for this purpose (see appendix 6). This guide enabled me to ask the cluster leaders different questions in accordance with their experiences, roles, leadership and responsibilities in the cluster. This interview guide was designed and developed because it was viewed as the best way to gather data from cluster leaders who had different experiences about the operation and the function of teacher clusters.

3.3.2 Observations

I adopted the role of a participant-observer in some instances and that of a passive observer in others (Burgess 1984). As a participant-observer, in a simulation workshop I gathered data from flipcharts used during the meeting and from video recordings. Passive observations took place during cluster meetings, cluster teaching activities and lessons in the classrooms. Most of the observations that were conducted focussed on the interactions of the group in cluster meetings and the nature of scientific content knowledge and pedagogical content knowledge that were explored in cluster teaching and in the classrooms.

3.3.3 Instruments, Structure, Purpose and the process of data collection

3.3.3.1. Classroom case scenarios

In reviewing the literature on teacher development programmes, the issue of inadequate content knowledge has been a topic of research for many years (Fullan, 1993; Gunstone, 1994). The issue of teachers' PCK has always been a problem which has been described as a "missing paradigm" in research into teacher education (Shulman, 1986). The choice of classroom experiment clips as instruments to collect data intended to review the pedagogical content knowledge that cluster leaders brought to clusters. In knowing the CK and PCK that teachers use in their own classrooms, the instruments assisted in challenging and reflecting on CK and PCK in order to make changes where needed. The process of engaging and challenging the teachers' content knowledge through debates and discussions was more valuable than their responses. This was more valuable as the study was focussing on what clusters did to challenge the teachers' pedagogical knowledge so that the teachers change their classroom practice.

Three sample student responses were given to curriculum implementers to allow them to consider each student's response in order to provide an opportunity to monitor their thoughts about the student's understanding on a scientific topic. These responses were chosen from real classroom examples that usually created confusion and misunderstanding amongst learners. The curriculum implementers and the cluster leaders were then asked to design a lesson which would address the problems raised by the learners' responses.

Example of a Science experiment clip on *work and energy*

Themba and Thula are the best students in a science class at Zamokuhle Combined School. They are also very good friends and often talk about their subjects during their free time. On one occasion, the two friends engaged in a conversation about one of their weekend activities.

Themba says to Thula: After cycling all weekend, I have lost all my energy.

Yes, you have lost all your energy and your bicycle has gained it, responds Thula with a smile.

Nonsense, how can a bicycle gain energy? What has it got to do with energy anyway? Themba responds, a bit amused by his friend's argument. Well, we should ask Mr. Zikhali [their science teacher] about this, retorts Thula.

In class, the two students begin their conversation again, this time engaging Mr. Zikhali and the rest of their classmates in this discussion.

Student A: Thula argues: When you work hard, you loose some of your energy and half of it goes somewhere for example in my case it went to the bike…..but when you sweat some of it is lost forever.

Student B: Themba responds: Well, energy has to do with work. Thula and I did not do any work. We just cycled all weekend. Cycling did make us tired and exhausted I agree but it had nothing to do with energy.

Put yourself in Mr. Zikhali's position……

A]. What do you think of the first student's (Thula) response?

Why do you think so?

What does this student understand?

B]. What do you think of the second student's (Themba) response?

Why do you think so?

What does this student understand?

C]. If you could imagine the ideal student's response to the teacher's question, what would it be?

D*]. What would your students need to know and/ or be able to do to respond to this task well? Be specific about the details of the content you would want them to know (not just a list of topics).*

E]. How might you go about teaching the pedagogical strategies you will use and exactly how you will use them with the content you have identified/

[hint: plan an actual intervention lesson for Thula]

F]. How might you go about teaching Themba to bring him to the ideal student's response level? Be specific about the pedagogical strategies you will use and exactly how you will use them with the content you have identified.

[hint; plan an actual intervention lesson for Themba].

An example of a biology experiment clip on *how a seed grows*

Uphumelele wanted to know how a seed became a big tree. She designed the following experiment:

1. She planted a seed in 100 grams of dry soil in a pot.

2. She then added only water to the plant for the rest of the school year.

3. At the end of the year, she dried out the plant and the soil in the oven overnight to remove all the water.

4. She weighed the soil and the plant. The dried plant weighed 600 grams

After presenting her experiment and findings to the class, the teacher posed the following question to the class: What do you think the soil might have weighed at the end of the experiment? Explain your thinking.

Sharon: I think that the soil would still weigh 1000 grams, because sunlight is food for the plant.

Themba: I think that the soil would weigh about 400 grams, because the plant took 600 grams for its own weight.

A] What do you think of the first student's response?

Why do you think so?

What does this student understand?

B] What do you think of the second student's response?

C] If you could imagine the ideal response to the teacher's question, what would it be?

D] What would your students need to know and or be able to do to respond to this task well? Be specific about the details of the content you would want them to know (not just a list of topics).

E] How might you go about teaching Sharon to bring her to the ideal student response level? Be specific about the pedagogical strategies you will use and exactly how you will use them with the content you have identified. [hint: plan an actual intervention lesson for Sharon]

F] How might you go about teaching Themba to bring him to the ideal student response level? Be specific about the pedagogical strategies you will use exactly how you will use them with the content you have identified. [hint: plan an actual intervention lesson for Themba].

The purpose of using this type of instrument during cluster workshop was to simulate the process of uncovering, shaping and constructing new knowledge through sharing in clusters. The instrument also intended to assess the level of the teacher's content and pedagogical content knowledge before the cluster intervention. It always becomes a challenge of not knowing how much content and pedagogical content knowledge teachers have at any workshop. The purpose of the feedback from the teachers' responses was to give us an idea on the teachers' level of content and pedagogical content knowledge, on the selected topics, before the cluster workshop. The study took into consideration the importance of teacher's knowledge as being the key to improving the knowledge of their learners. In order to change classroom practices, the teachers' PCK should be challenged (Shulman, 1986).

The discussions that took place after the presentations opened up a line of questions that were related to the topics.

3.3.3.2 Cluster Simulation at the Curriculum Implementers' Workshop

As mentioned earlier, the JICA-funded MSSI project provided the research for my study at various levels of participation in Mpumalanga. The MSSI project is structured to provide support and guidance to cluster leaders in a variety of meetings and workshops. It is in those meetings and workshops where much of my data collection occurred. The data on the support and the activities that are prepared for the development of the cluster leaders were done at the curriculum implementers' workshop. The curriculum implementers' workshop was attended by representatives from the University of Pretoria, JICA and MDE officials. The role of these university representatives at the curriculum implementers' workshop was to conduct and facilitate activities for curriculum implementers. A schematic representation of the structuring of the MSSI activities is given below:

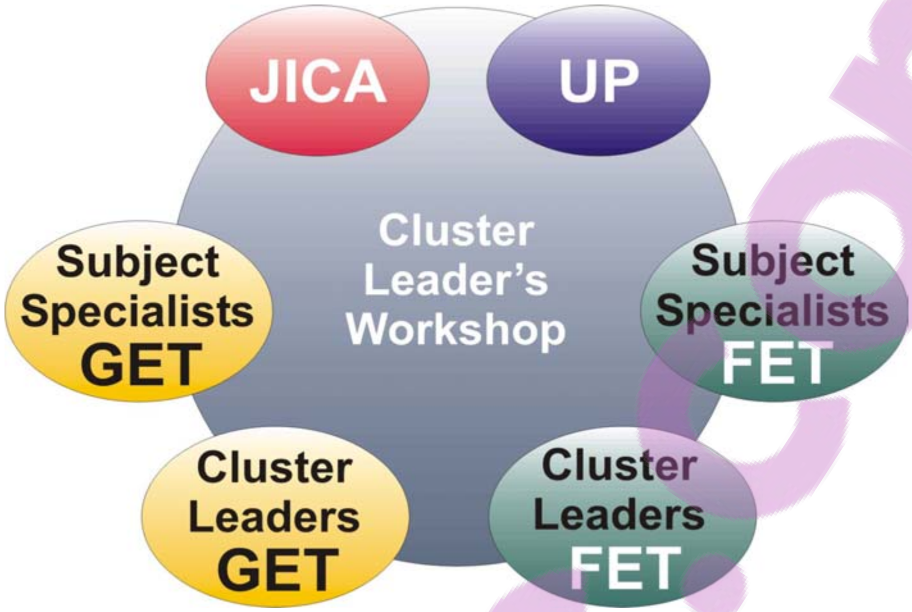
Figure 6. Curriculum implementer's workshops

My role at this meeting was to train and develop curriculum implementers on content knowledge and the facilitation of workshops for cluster leaders. The data on the activities of the clusters from all three regions was shared and distributed in form of handouts, to all the participants. Each cluster leader was expected to share his or her activities and how they were progressing verbally for the benefit of the entire group. This is the information that became vital for me to note where the various clusters were and what they were doing. This forum also provided important insight on checking some gathered data on clusters, as each person was required to discuss the status of clusters in his or her region. For example, the number of workshops conducted in the region and the nature of the activities at those workshops.

3.3.3.3 The Regional Cluster Leaders' Workshop

The second data on cluster leaders' activities was collected at the cluster leaders' workshop where the curriculum implementers took a lead in facilitating the activities during cluster meetings. After these workshops, each cluster leader was expected to conduct workshops or meetings in their areas. All three regions were visited and observed the cluster leaders conducting workshops in their regions for their teachers. The purpose of the observations was to confirm and to justify the process of clustering teachers and schools for the purpose of teacher development.

Figure 7. Cluster Leaders' Workshop



Cluster Leaders' workshops were composed of the parties that are shown on this schematic diagram. It was during these workshops where most of the data collection took place.

3.4 The Process of data collection based on research questions

3.4.1 Research question 1

What kinds of clusters operate in the Mpumalanga Province and how are they formed

3.4.2 Clusters in Mpumalanga

In order to distinguish the kinds of clusters that exist in Mpumalanga and how they were formed, policy documents from MDE were reviewed. Clusters have to be registered with the MDE, who made a detailed list of all the registered clusters available to me. The information on registered clusters collected from the MDE documents is given in appendix 3.

During my participation in the training and support of cluster leaders in the province, I was able to collect data and information by talking to the cluster leaders on issues of clusters. The purpose of talking to cluster leaders was to gather information on the schools that are registered, the curriculum implementer working in that area and the number of schools that form the cluster.

Cluster leaders during workshops confirmed the validity of data on the formation of clusters. They were asked to give their names and how they were selected as leaders. The data collected was used to verify the information from MDE document by comparing it with the already given documents. This information further highlighted some structural formation of clusters and the nature of selection to leadership either by vote from teachers or appointments by curriculum implementers.

For further validity the research team from UP developed an interview instrument to collect data on the following aspects of clustering in the province on cluster formation, selection to leadership and the structural position to the MDE structure.

Additional information on the positions and the selection of the cluster leaders was collected through participant observation strategy at both the Cluster Leaders' workshops. It was gathered this way in order to verify the list of cluster leaders that was reviewed on the formation and the selection of cluster leaders by MDE. The information gathered through this instrument was compared with that collected as part of the reporting routine monitoring by the Mpumalanga Department of Education. This data is regarded as routine monitoring data because MDE collects information on the aspects of clustering for routine monitoring purposes. This information usually reflects the number of cluster meetings or cluster leaders selected and the numbers of schools attended but fail to describe the context and the nature of the workshops that were conducted.

(i) Focus Group at a regional cluster leaders' workshop

"Focus groups generally range from six to twelve participants, the exception is where the topic needs to be explored in great depths and where people had great experiences related to it" (Anderson 1990:224). Focus group in this study was of a different nature as against the numbers recommended by researchers. However, while training a group of 120 cluster leaders I was able to use this large group in order to collect data using a group brainstorming technique and the consolidation of the responses for agreement and disagreement on the spot. The purpose of using this technique of data collection was to get the groups' perspectives on their roles as Cluster Leaders and be in better position to compare and contrast it with the one reviewed from the MDE documents. The question that was put on the overhead projector was:

What do you perceive as your roles as Cluster Leaders?

The group was allocated 15 minutes to brainstorm their perceived roles as cluster leaders on a flipchart. I ran through the list with them to clarify what they meant by some of the roles that appeared on the flipchart. For example, as they had written *support teachers*, I asked them to clarify the nature of support. As they reached consensus as a group on their roles, this information was later adopted as an official document of MDE on the roles and tasks of cluster leaders. This data therefore gave me a base to work on as I was trying to understand clusters and the roles of cluster leaders in Mpumalanga. In order to validate these data further, focus groups of 5 to 6 cluster leaders at regional workshops were asked about their roles and responsibilities. These were documented and cross checked against the document from MDE Further, the individual cluster leaders were interviewed on their roles and tasks every time a cluster meeting is visited and observed. The data collected from individual cluster leaders from their cluster meetings penetrated the perspectives and meaning of their responsibilities and tasks on their new roles.

3. 4.3 Research question 2

How do these clusters challenge and support teachers of science in re- shaping and changing their knowledge and practices?

3.4. 3.1 Challenging teachers' PCK in clusters

In order to understand the complexity and dynamics of clusters in improving teachers' pedagogical content knowledge, the cluster workshops were used to simulate teachers 'cluster meetings. This approach to data collection has been chosen in order to be in line with fieldwork on science teacher development and the nature of science and science learning. My data collection adopted this technique and extended it further by designing classroom case scenarios based on the two topics in science. One topic is a physics topic on *Energy* and other one is on a biology topic on *Seeds and Growth*. Specifically, UP team of facilitators created classroom scenarios as responses from learners. These scenarios were used as instruments to asses the content and pedagogical content knowledge that teachers, as learners, bring to the cluster workshops. These instruments were used at two levels; provincial MSSI workshop and at regional MSSI workshops. The qualitative data that was collected at both levels, enabled me to take into account the importance of both human resources beliefs and practices in terms of CK and PCK in influencing the classroom practices.

This approach to data collection engaged the cluster leaders to open-ended classroom case scenarios that intended to specifically measure the content and the pedagogical science knowledge of the teachers. These scenarios were chosen in order not to reflect directly on the content knowledge of the teacher but to the responses of the learners. The assumption is that teachers are sometimes not aware of their own content knowledge until they are challenged by the learners' responses in the classroom. These case scenarios were designed by the team of facilitators at UP. These scenarios captured some real responses that they usual get from their own classrooms, but were modified for the MSSI SIM cluster activity. False names were given to the learners that responded to the cases. The instruments intended to uncover content and pedagogical content knowledge on these topics based on the learners' responses on science and maths. The targeted subject content moved across junior secondary schools grade up to senior grade of schooling. The use of these instruments for data collection intended to give evidence on the PCK of the teachers based on the learners' responses on these specific topics.

3.4.3.1 Simulation as a tool in clusters to determine PCK

(i) Proceedings during the simulation

Step one: Curriculum implementers were divided into four groups as according to the learning areas in MSSI. Each person was given the task on a piece of paper as an individual. They were given 30 minutes to respond to the task as individuals. They were expected to write their responses on the paper and submit the paper after completion. They were not expected to write their names on their responses nor to discuss their responses with others. Monitoring and supervision of the participants was strictly carried by the UP staff. There were 22 participants in the physical science group and only eight that opted for biology. While all the subjects were considered for this activity, this research focused only at the two groups; science and the biology. The individual responses were captured and presented into each group for sharing purposes.

Step two: Curriculum Implementers were requested to share their responses in groups as according to subjects. As the responses were written and in some cases people still remembered their responses, they were asked to justify each and every response. At the end of the session of an hour, each group was expected to come out with the best responses. The group best responses were captured and presented to the entire workshop members. Changes were highlighted by groups after discussion and identification of mistakes or misconceptions. The UP and JP facilitators assisted where help was needed. Data was collected for analysis.

Step three: Cluster leaders' workshops

The cluster leaders' simulation workshops took place at all the three regions of Mpumalanga following similar proceedings as discussed above. The only difference here was that the participants were the cluster leaders who are teachers engaged in the teaching and learning situation, unlike the curriculum implementers who are a support structure to clusters. Although the cluster leaders took place in all the regions, for the sake of this study only responses from one region were analysed and discussed in order to highlight and understand the knowledge "gap" that existed on the topics Energy and Plant Growth in cluster leaders.

Step four: All the individual's written responses, groups' written responses and comments on the flipcharts were collected for analysis.

Step five: When visits were done in some clusters in the regions that were not part of the case studies, months after the simulation cluster, the cluster leaders were asked informally on what they recalled on the processes that led to the change of their views on that day. Some of their responses are quoted in this study. The purpose of asking such question was to find out whether the cluster processes impacted on them or not.

Their responses also helped in checking with the other cluster leaders' responses from the two cases.

3.4.4 Research Question 3

What is the nature of resulting knowledge and classroom practices?

Four cluster leaders from two different regions were asked to plan and prepare lessons on these topics. Two cluster leaders taught the biology topic while the other two handled the science topic at their schools. These lessons were observed and captured on the video camera. The instruments were modified for the learners and the pedagogical part was left out. For example:

If Thabo says he is tired because he has been cycling over the weekend and lost all his energy on his bike, do you think he is right? Learners were then divided into groups to discuss why he is right or wrong. Learners were not asked to come out with teaching strategies that would be used to assist Thabo and his friends. At the end of the session the teacher clarified the misconceptions and used the similar strategy that was used at the cluster leaders' workshop.

3.4.4.1. Observation and field notes

As an observer, I documented the highlights and the lowlights of the events as they happened in each workshop. At the cluster leaders' workshop, I compared my notes with those that were written by my colleagues or curriculum implementers in order to check and refine my own ideas and observations. I also used the opportunity of one to one interviews with the cluster leaders to clarify my notes. For further critique these notes were discussed with colleagues at the University of Pretoria and with MDE officials. The field observation journal became useful in collecting some of the descriptive details of the events in clusters, at schools and during cluster meetings. The shared reports with the Japanese counterparts added value to my field work.

3.4.4.2 Interviews and classroom observation

The interview data that was obtained from cluster leaders and the information gathered from MDE regional officials on clusters was compared. This step was taken in order to establish whether there were differences of opinions or agreements on the operation of clusters and to provide explanations for any differences that may have occurred. A variety of methods, multiple-data sources, triangulation of various types of interviews were used in this regard. The prolonged involvement with MSSI project in Mpumalanga and with the other clusters on the various sites helped me to check the collected data and to understand the meaning of clustering and helping each other with the aim of changing CK and PCK.

3.5 Reliability and Validity of Data

Cross-checking was done with members of the clusters in order to correlate their impressions about the activities and educational events in clusters. This was done by correlating their notes with my detailed notes. During breaks I conducted informal discussions with colleagues and with the Japanese partners as to whether they agreed with my interpretation of the proceedings at the reflection meetings. The MSSI meetings conducted reflection meetings at the two levels of workshops (cluster leaders workshops and curriculum implementers' workshops).These reflections focussed on the core issues of MSSI which are classroom practices and content knowledge. As each partner had to reflect on clusters and the way they functioned, I got a chance to test ideas on people and got their views on the events that occurred. During the process of reflection the person that facilitated the session would share his or her own opinion and the other facilitators that were observing were allowed to air their views on the activity. This process enriched my study and erased some of the biases I had on the specific activity. Triangulation was practiced in this study by listening to the views of my colleagues and checking their field notes.

3.6 Problems and resulting limitations

My plan was to collect data on the activities in cluster leaders' workshops twice a week in three schools per month. Such data collection process would enable me to study the patterns of knowledge that teachers bring in the cluster and how it was shared within the cluster. However, one of the most frequent problems encountered in the study is that although the dates were arranged before hand, these were not always adhered to by the teachers in the schools. Some of the reasons were:

- dates changed by cluster leaders on the last moment
- other national events cropping up on the same date
- meetings of the cluster leaders scheduled on the same dates. For example, three Clusters Leaders had their meetings on the same date. This deprived me chances of seeing more clusters in order to be able to compare how these events are done in other clusters.

The other limitation that I experienced at teacher cluster meetings is that it became very difficult to interview the cluster leaders after their cluster meetings because the meetings started in the afternoon and finished very late in the afternoon. They were feeling that they were delaying the other members who share the same transport with them after school. In most cases the interviews were rushed. It was not possible to organise the interview for another time as data and information would be lost in the mind of the cluster leaders if it is kept for long.

Another limitation also was the quality of the reports of the curriculum implementers participating in the cluster meetings that were used to monitor the progress of events during my absence. Their reports lacked the quality description of what really took place at the cluster leaders' workshop. The cluster leader's report on the activities of the workshop was also reviewed. These reports are part of their cluster portfolios that are kept in the regions. However, these reports lacked the richness of what really happened during the workshops. The cluster leaders' reports indicated the schools that were represented at the workshop, the names of the teachers, the topic that was handled and that was all. Their reports did not mention or indicated the participation and the issues that were raised during those workshops. I supported this data by requesting the video clips that they used during the workshops and also the journals and the minutes captured and provided by the cluster leaders. This data was very critical for my study as I wanted to know exactly what content knowledge was explored in a cluster meeting and how. The other limitation was that the selected cluster members of the SIM cluster, that participated as cluster leaders were promoted to senior positions of being implementers; it became difficult to follow them for feedback on how they taught the sessions on Energy and Growth in their own classrooms.

3.7 Research Ethics in my role as a researcher

The context of this research study is on teacher development and the opportunities created for teachers to develop and improve their science knowledge with the aim of influencing the classroom practices. MSSI, the Japanese project introduced teacher clusters with the aim of improving teachers' content and pedagogical content knowledge. University of Pretoria in partnership with the Japanese lecturers provide support on content knowledge. My role in this project is to provide such support in the form of workshops. As my interest in doing my PhD. lies on science teacher development, I used this opportunity to examine the opportunities that clusters provide for science teachers to improve their classroom practices. As mentioned in my chapter one, I was also a cluster leader and I believe I grew from the cluster activities, but what still remains a puzzle for me is the way in which clusters contributed and influenced my classroom practices. This is a puzzle that I have lived with for more than 20 years. Finding myself working within the same context on clustering, I think time came for me to explore this concept further. My interest in this study was to examine the activities and the opportunities that are created by clusters to develop science teachers**.**

As the SIM cluster was operating under the jurisdiction of the MDE and UP as partners, I managed to collect data at all entry points. Permission that allow UP to do research was part of the contract for working and supporting clusters as indicated earlier on my wearing of two caps in the MSSI project. Access to entry was negotiated with the parties concern. For example, if I had to go to school to talk to the cluster leaders, permission was obtained from the school principal. Individual requests were made to cluster leaders that were to be interviewed and detailed explanations were given on why the information was needed and how it was to be used. The collection of data from the regional managers was also negotiated with the individuals. Explanation on the use of data was clarified to all the people that participated in this study. In order to balance my contradictory roles as a researcher and a trainer, I made use of the team from UP in data collection. For example, in interviewing the regional managers my colleague led the interviews and in collecting data on uncovering the content knowledge we also worked as a team of three people (experts); science, maths and biology. My dilemma being in this situation was to wear the two caps. Being a participant observer, working with the team and using a variety of research techniques helped my situation.

My involvement in the provision of support to the cluster leaders might have developed some biases towards this study, as I was playing dual roles (researcher and supporter) Macmillan, (2000) suggests that, "since the data contain the researcher reflections on his or her experiences as well as those of the 'real participants' the dual role researcher must be exceedingly sensitive regarding which voice is represented in the study". I had a very complicated situation of being a trainer of the cluster leaders and curriculum implementers in Mpumalanga to wear two hats. The researcher’s hat became problematic as it had experiences of MDE officials and their perceptions towards clusters. Involving them in data collection in registered clusters removed my biases towards the way clusters operated in Mpumalanga. Making use of the curriculum implementers’ reports helped the study in representing the voice of the province. Lensmire (1999) experienced major problems doing research on his own teaching as, "my actual methods as well as my analyses were greatly influenced by my aspects of my teaching and by my commitments as an educator”

In doing this study I found myself in a similar situation. I was wearing a trainer's hat by being involved with the training of curriculum implementers and cluster leaders; while my other hat was that of a researcher. Although the training did not happen on daily basis, there was few times during which my interest was diverted to reflect on the issues that were handled during the course and how they were handled at this particular course and that might have affected my field notes. I was in a better situation because I saw the teacher leaders in various situations, as leaders, teachers and learners. The informal discussions that I had with other researchers, curriculum implementers and centre managers were of great assistance in helping me to decide whether data was biased or unbalanced. In assessing and uncovering the CK and PCK in one of the case studies we worked as a team with the specialists in the various subjects in data collection. Their involvement in the cluster (SIM) reduced the biases on the data collected.

In order to avoid such conflicts further, I used various methods for this study; such as capturing of data from different sources. These multiple sources included a fieldwork notebook, audio taped meetings, flipchart paper and activity sheets provided to teachers and to cluster leaders during training sessions. Some active cluster leaders kept field journals where they kept records of all the events that were happening at their clusters. In addressing each question, specific strategies and techniques were used to address each question as indicated earlier. The different strategies and varieties helped me to weigh some of the data collected.

Informal discussions with and reports of the curriculum implementers participating in the cluster meetings were of great value as mentioned before, despite the fact that they contained inadequate information for my study. It became difficult sometimes to get this data from curriculum implementers as they felt somehow that I was monitoring their work. In order to avoid such misunderstanding I had to share my own written notes collected from other clusters and made them to feel free to ask me questions on them. I also used this opportunity to get more information on the clusters that they visited and observed the activities during my absence. The cluster leader's report on the activities of the workshop also helped me to back up the information from the curriculum implementers' reports, however, these reports lacked the richness of what really happened during the workshops as mentioned earlier on. This data was very critical for my data collection as it reflected and presented the actual proceedings at the workshops or cluster meetings on how teachers interrogated scientific content knowledge. The limitation for me in a nutshell, was that observation was not possible for me to see and get feedback from teachers on how they taught the session on CK and PCK in their own classrooms.

Objectivity of the findings was ensured by providing description of how the data was collected and the responses that came from the cluster leaders and teachers that participated in this study. Informal discussions and the data collected and cross checked with my colleagues solved my personal biases in data.

3.8. Data Analysis

A volume of data which I collected from the various data sources was reduced as part of analysis. This was done by providing summaries of data derived from MSSI documents, MDE documents, interviews and cluster observation data. Conclusion drawing and verification of the data gathered was compared, contrasted and used in confirming the results of the study. The analytic process of data was guided by Huberman and Miles's (1994) analytical framework.

Analysis of data took place on an on-going basis from phase to phase as indicated above. The data collected was divided into categories that made meaningful themes, using procedures described by Cohen and Manion (1994). The data collected from MDE's registered clusters and from cluster leaders' workshops together with the data that emerged through interviews was used to formulate the pattern that emerged through the activities and practices of clusters. These activities were classified into themes that were linked with literature on clusters. These activities included the following themes:

- formation of clusters;
- leadership in clusters, and
- the nature of CK and PCK covered.

This information on the types and dynamics of clusters in Mpumalanga kept on emerging as I visited and observed clusters frequently. About two days a week for 10 months were spent in clusters and in most cases 1 day was used to analyse data.
This data was analysed according to responses of the cluster leaders from individual responses to group responses. These were categorised into themes and patterns that I thought made sense to me. They were presented in a table form before the group discussion and after the group discussion. This process created a simulated cluster that intended to compare individual responses before the cluster meeting and after the cluster meeting. These themes were highlighted as according to the themes that emerged based on what Cochran–Smith and Lytle (1999) refers to the interrelationships between knowledge for practice, knowledge in practice and knowledge of practice. Also cross comparison of collected data from the

implementers' workshop and one region was used for validity. In one of the cluster meetings, some of the cluster leaders were asked about their feeling on this activity. Some of their responses are verbally captured in the next chapter.

Loughran and Mulhall (2003:376) argued, that "a CoRe derived from one group of science teachers should not be viewed as static or as the only or the best correct representation of that content. It is necessary but incomplete generalisation resulting from work with a particular group of teachers at a particular time." This statement implies that the content knowledge expressed by one group of teachers at a setting might not be taken as the final best representation of all teachers.

For further investigation on the construction and the use of this knowledge two teachers were asked to teach these topics and reflect on their experiences with their cluster members in one of the cluster meetings. The lessons were captured on video for further analysis.

In analysing data I focused on the activities that were related to the changes of pedagogical content knowledge. I spent one day a week over a period of three months watching videos, listening to audiotapes and analysing data. In some cases I had to spend more than a day depending on the nature of data that I was busy analysing. The data that I collected on flipchart from workshops was analysed and documented immediately after the workshops. This data formed part of the information that provided the nature of activities that took place and the examples of PCK that the teachers handled. The created categories on clusters as reflected in chapter two, were checked on the emerging patterns making use of the clusters that was selected. The findings were linked to the reviewed literature on teacher clusters/ networks as viewed by researchers like, Lieberman, (1991); Guskey, (1986); and Adams, (2000).Triangulation was extensively used to confirm the findings in this investigation. This included the variety of sources used to collect data at the selected areas, coded and analysed. Comparing and contrasting findings from the data obtained was used to highlight the individual and the group perspectives on teacher clusters.

3.9 Summary

This chapter examined and analysed the research design of the present study. Firstly, approaches, procedures and strategies were described. Secondly, the reliability and validity of data collected was discussed. Research questions were further outlined in order to show their relevance to the methodology approaches used in the study.
The analytical framework developed by Miles and Huberman (1994) guided this section of my work. It involved the interaction of the components of data analysis which reflected themes, trends patterns, triangulation contrasts and comparisons.

The research design adopted enabled the study to focus on the issues of teachers' content knowledge in clusters as well as processes and the opportunities provided for improving scientific content knowledge. The next chapter discusses the findings of the study in detail and highlight those areas that helped teachers to improve their scientific content knowledge in clusters.

Chapter four

The Structure and Formation of Clusters

4.1 Introduction

In this chapter I discuss the findings of the research regarding the structure and formation of the clusters that exist in Mpumalanga. In order to understand clearly how and why it is that clusters are well placed to provide opportunities for teachers to challenge and change their Content Knowledge and Pedagogical Content Knowledge, we first need to understand their structure, and the dynamics of their formation and basic operation. MDE and its partners opted to form clusters that will be the base and the context where INSET activities take place. Mpumalanga province is very wide and most of its areas are rural. The province is divided into three regions with very few scattered infrastructure. Most of its infrastructure is far from schools, for example, teacher centres, regional offices and circuit offices where the Curriculum implementers are based. Taking into consideration all these factors, it does make sense to make schools INSET structures where teachers can meet and work together as groups, as this reduces travelling and save money to travel to the centres. The school level, facilities and location is taken into consideration when selection is done for cluster's centre school for INSET. GET schools meet together at GET schools while FET meet together at FET schools for specific subjects. The immediate human resource support to teacher cluster is a teacher leader who is termed a *cluster leader*.

The rationale for introducing teacher clusters in Mpumalanga is to bring INSET activities to the teachers and let them own the programmes on their development internally, with little support from the experts. The underpinning strategy on cluster formation is to create opportunities for teachers to explore and share CK and PCK as peers. This sharing can take place continuously as long as it is teacher centred and addressing crucial issues of CK and PCK. We know that effective implementation on content and pedagogical content knowledge needs a little bit of both, as teachers experience difficulties in implementation of innovative ideas they undergo, ' implementation dip' (Fullan,2001). External support is provided by JICA and UP in order to strengthen the cluster activities in a variety of ways. Programmes on materials development, subject specific content workshops and classroom support are conducted. Mpumalanga as a province has 368 clusters that are registered and a few that are not registered because of the complication of numbers of schools in the area. These registered clusters are officially recognised by MDE and these I have decided to call them *dominant clusters* for the sake of this study. Farm schools are very isolated from other schools and besides, there are two teachers in some cases teaching almost all the subjects. Most of these schools did not register to any clusters. They are in a way not part of any cluster. The only support that they benefit is from the Japanese volunteers that frequently visit their schools if they have invited them for help. There were other clusters that existed before the MSSI intervention and most of them still operate as before without registering with the MDE; these I have called *external clusters*. The following discussion explores the structure and the formation of the *dominant* clusters and will later discuss the case of an *external* cluster.

The formation and structuring of clusters in Mpumalanga is a complicated process. The process is complicated primarily by the fact that not many in the province had prior experiences of working with and leading clusters prior to this MSSI initiative on clusters. Furthermore, the place of the clusters within the hierarchical structures of the Mpumalanga Department of Education was not always clear, if desirable at all. This was largely because of the fact that the structures of educational control in the province are themselves fairly complex and have been changing rapidly in the past few years, such that although I had been involved with the MSSI project more than 5 years, I had never fully understood the finer details of this complex structure of administration and control in the province. This MDE structure had a major influence on the teacher communities and clusters in the Province who had to be officially sanctioned from these structures of educational control in the province. In order to understand the operation of the Dominant clusters, we need to briefly understand the complication of the MDE management structures.

4.2 Summary of the Administrative and Management Structure of Education in Mpumalanga

The administration and control of education in Mpumalanga province is divided into three regions namely; Enkangala, Ehlanzeni and Gert Nsibande. Each region is responsible for between 15 – 25 circuits, and is headed by a Regional Director whose task is to make sure that the policies of the department are implemented across the Region. The Curriculum Implementers are appointed at and report to the regional office, even though most of them are based at the circuit offices. The Curriculum Implementers take most of their instructions directly from Head Office supervisors even whilst they are appointed in the Regions and are sometimes based in the circuit offices. The Curriculum Implementers work directly with the cluster leaders in implementing the teacher development activities at schools. The Curriculum Implementers are supposed to be the service personnel for the clusters and teachers in the province, providing the necessary guidance and expertise on CK and PCK.

4.2.1 Formation of Clusters

This discussion on the formation of clusters was arrived at through interpretation and analysis of several sources of data, including several MDE policy document on clusters, policy document on clusters prepared by JICA (the funding agency) and the notes written by one of the External Clusters (the case study for this research). In addition, I interviewed senior officials of the MDE, to get their interpretations and perspectives on the policies and their implementation with regards to clusters in the province.

For purposes of this research investigation, I have characterized basically two major types of teacher clusters in the province of Mpumalanga, viz. the Dominant Internal Clusters and the External Clusters. The major difference between the two kinds of clusters being that the Dominant Internal Clusters are sanctioned and formed by the MDE through its officials and are compulsory, while the External Clusters are formed through the initiative of the teachers themselves and are voluntary networks with no official recognition per se.

4.2.2 Dominant clusters

These clusters dominate Mpumalanga province as they are officially recognised and are formed within the existing structures of the Department of Education. I have decided to call these clusters Dominant Internal clusters. The SIM cluster discussed in chapter three is an example of a Dominant Internal Cluster in Mpumalanga. These clusters were formed under the jurisdiction of MDE. They are registered with the Department and their operations fall within the hierarchical structure of MDE. Guidance on the formation and functioning of the Dominant Internal Clusters was provided in the MDE policy documents as follows: The MDE "draft policy" on clusters stipulates that the Curriculum Implementers should form clusters of teachers in the regions based on the following guidelines:

- the phase of education of the participating schools and teachers i.e. the CIs were to separate the teachers and their clusters into General Education and Training (GET) and Further Education and Training (FET) levels;
- the subject area of focus i.e. the clusters were to be split by subject area of focus, e.g. Science versus Mathematics or Agriculture, etc.
- the geographical location of the schools in terms of their location within the circuit, region and sub-region of the MDE structuring;
- the registration of the schools as a cluster participant in the circuit;
- the election of the cluster leaders who would be responsible for the facilitation of cluster activities and finally on
- that new cluster leaders were to be selected at the end of each year.

The formation of the Dominant Internal Clusters based on these policy guidelines of the MDE is illustrated in Figure 3 below:

Figure 7: The composition of the dominant structure in Mpumalanga

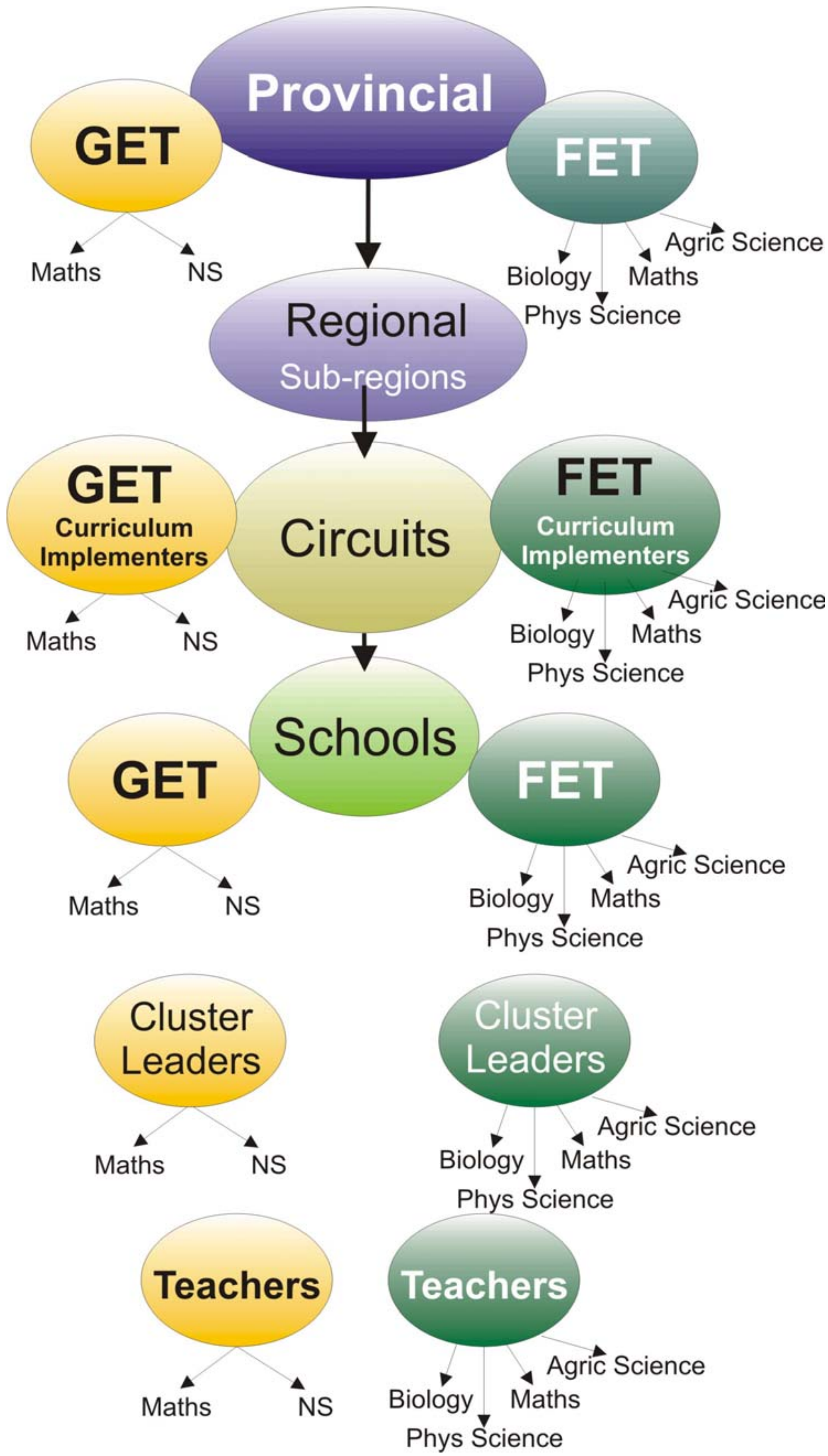


Figure 3 shows clearly the alignment of the Dominant Internal Cluster to the hierarchical structures of administration and control of education in the Mpumalanga province. The provincial structure for the leadership and control of science and mathematics education is divided (at the Head Office level, Provincially) into both GET and FET units. Within the GET unit, there is further demarcation between mathematics and natural sciences. Similarly, for the FET levels, there are demarcations between Physical Sciences, Agricultural Sciences, Biology and Mathematics. Each one of these subject areas (Four areas for the FET and Two areas for the GET) is officially led by a Deputy Chief Education Specialist (DCES). All the DCESs in a level of education report to one Chief Education Specialist (CES). This structure of control is replicated, although in a somewhat reduced manner, at the Regional office level of the MDE. Unlike at the Head Office, there is only one CES responsible for both GET and FET at the Regional levels, and the DCES in the region oversees all the subject areas in a phase of education (DCES-GET and DCES-FET).

The Dominant Internal Clusters are formed at the school level – a collective of neighbouring schools and are first and foremost split by levels of education (GET versus FET). Each of the subject areas then form their own clusters and select their own cluster leader from the participating teachers. The clusters are roughly divided by circuits – with each circuit making roughly one cluster. In one circuit, a total of six subject clusters (2 GET and 4 FET) provide for the science and mathematics teachers in the province.[1]

Figure 3 shows clearly the linkages between the various layers of control and administration of education in the province and how the clusters were co-opted into this hierarchy of the MDE structures.

In the interviews conducted with the Regional Directors and Subject Specialists at the Head Office, I was able to confirm that the formation of the majority of the clusters in the province was actually done based on the policy prescriptions as described earlier.

[1] Increasingly, more subject cluster has been formed to provide for teachers of other subject areas. However, for purposes of this research, my focus has been largely on the science and mathematics clusters that were the first to form in the whole province at the instigation and provision of the MSSI project.

Of the 30 cluster leaders interviewed, 25 confirmed that their clusters had been formed using the policy guidelines and under supervision of at least one senior education official, mostly the Curriculum Implementer. On the one hand, this structuring of the Dominant Internal Clusters within the overall framework of the MDE hierarchy clearly illustrates the commitment of the MDE to the implementation of clustering as province-wide approach to the professional development of science and mathematics teachers in the system. The MDE had bought into the idea of clustering as a more promising approach for providing teachers with opportunities for growth and development. In its current implementation in the province, clustering is likely to be sustainable and to receive official recognition within the province. Teacher clusters and networks thus received the appropriate support for their activities within the system. The official support for clusters was confirmed by one Regional Director as follows:

the subject committees had no status in the department, clusters have high status in the department and are receiving support from the CI's. They receive the incentives from the department; they are registered and the programs of their duties are demanded from them. The cluster leader that leads the cluster is a recognized official unlike the subject committee leader that was unknown

Furthermore, this senior official noted that:

the cluster leaders' structure is based on the structures of the department which make them to know exactly whom they report to at the circuit and at which level; this is very useful and important for us as a region

It is clear from this discussion therefore, that the formation of clusters was somewhat of an extension of the MDE structures designed to reach the schools efficiently by extending the hierarchy that exist presently. The obvious problem off course with this arrangement of clustering is its potential for over-bureaucratization and corruption of its purposes sand intentions in terms of teacher learning and growth. As will be discussed later in the text, these threats were actually very real in the functioning of the Dominant Internal Clusters in the province of Mpumalanga.

4.2.3 The Dynamics of Formation and Structure of Clusters

The authority structures of the MDE are so complex that they are sometimes never understood even by senior officials of MDE itself. Consider the following comment by one of the regional directors of the MDE on the selection of the cluster leaders for the teacher networks, for example:

the duration of cluster leaders is one year, but in this region the cluster leaders are not going to be changed. I do not understand why we appoint people, train them and get rid of them the following year.

From this comment, the contradictions of policy regarding the formation and leadership of clusters become obvious. These contradictions often impact on the way the cluster leaders operate within the province. For example, a Curriculum Implementer working in the same region was working on the basis of the provincial directive to elect new cluster leaders and was unaware of his direct supervisor's challenge to that policy. Here is how the Curriculum Implementer expressed his dilemma:

we were told by the provincial office that every year new cluster leaders will be selected; this now creates problem for us, because the head office tells us something and the regional office decides to do its own things.

This is just one example of the complications of policy regulating the formation and functioning of the dominant clusters that exist in the province.

Another complication brought to the fore through the comments from both the Regional Director and a Curriculum Implementer is the issue of line functions within the MDE. The Curriculum Implementers are in a precarious position because, while they are based at the regional offices and appointed by the Regional Directors, they receive instructions from Provincial Head Office. This frustration of this complicated line function structure was expressed by another Regional Director as follows:

Curriculum implementers are appointed by the region and they take instructions from the province and this is disturbing. In between, you will receive instruction from the head office saying the CI's are going for training like on a specific area (when we have programmes for them in the Regions).

This complicated structure of operations in the MDE tends to impact negatively on the formation and functioning of clusters, especially the dominant clusters in the province.

For the Curriculum Implementers the supervision of the cluster formation process was the easiest task because they used the existing departmental structures (for example, the circuits, the sub-regions etc.) to form clusters. Teachers that fell under one circuit and were teaching at the GET level formed one cluster. This means that if there are 15 schools that are GET, they will meet as a circuit for a specific learning area (Maths or Science). FET level teachers from a circuit also did the same, but separated themselves along specific subject areas (for example; maths clusters were separate from biology clusters and physical sciences clusters etc.). This division between GET and FET teacher clusters constrained the choices teachers had in forming their clusters and networks. For example, teachers across different circuits were not permitted to form a cluster, even when such a cluster would be made up of more likeminded people, friends, or residential neighbours. This point of division was clearly demonstrated by one of the teachers, who was at a school which has both levels of education and who teaches at both levels when she said:

I don't know which workshops should I attend whether FET or GET as I teach both. I prefer to join the FET phase as their schools are nearer to me but they happen to be in another circuit, I need to negotiate with the CI to be transferred. I do not want to spend a lot of money attending cluster meetings, as the department does not pay for our transport

Another complication in the structuring of the Dominant Cluster into FET and GET clusters resulted from the fact that the FET cluster leaders were paid for their work on clusters while the GET clusters were not paid for the same work with teachers. This created serious divisions and perceptions of inequity amongst the teachers.

It seems as if the FET cluster leaders are better and more competent than us, was the way one of the GET cluster leaders captured it.

The number of schools in a cluster varied from three to ten depending on where the schools are situated. In some cases, FET schools were few and isolated and as a result, their cluster meetings consisted of two to three teachers. The dialogue and interaction in these cases were minimal. This was especially so for farm schools and other schools located in the most rural settings. Lieberman and Grolnick (1989) argue that the voluntary participation of teachers promoted the feeling of belonging and ownership. The evidence from the clusters suggests problems with regards to keeping to schedules of meetings and committed engagement from the teachers generally. Here is how one cluster member and leader captured the point:

As *we were the only two high schools in our area , we did not see any need to meet as this was not useful, instead we worked as individuals as before. If I have to meet the other teacher I had to travel more than 25 km. and it means taking two taxis, this was not useful. The CI did not take into consideration the distances between these two schools as he was forming clusters. I sometimes join the primary school clusters but in most cases they do the OBE work. We only met once after the initial formation of clusters but it was not possible after that because of the reason that I have mentioned.*

From the six cluster leaders that I interviewed on the attendance of teachers, they mentioned a concern with the grade 10 and 11 teachers who were not participating in clusters because*,*

there was little or no content done; as the clusters were mostly engaged in examination questions and tips on drilling learners for the final year question paper. The grade 10 and 11 teachers are really problematic because even if they come, they do not contribute anything said one of the cluster leaders.

The point the cluster leaders were making is that within the phases there were further splits by grade levels created by the activities prescribed for the cluster by the Curriculum Implementer as policy of the MDE. This implies that the grade 10 and 11 teachers who attended the clusters for enrichment on the CK and PCK in order to improve their classroom practices were excluded by the required focus on examinations and improvement of learners' performance. For them the clusters were not catering to their needs and thus their attendance was irregular. This point is confirmed by Cooper, (1989: 51) when he emphasizes that "……when teachers are trapped between what their judgement tells them should be done and what is actually done, and when they see no recourse, they become alienated and disaffected .

When teachers sense that the proposed activities have less to do with how students learn and how they teach them effectively, they absent themselves from such courses and rely on their own inadequate CK and PCK. One of the teachers who participated in both the external and the dominant clusters commented as follows:

I sometimes attend the cluster meetings for MSSI for the sake of the project but I no longer benefit from MSSI clusters as before. They are now more into policies in this project than the subject matter content knowledge that the Japanese professors used to do.

Again, this comment reflects the perception of this teacher on the activities she prefers; and the fact that for her the activities are a main driving force for her commitment and regular attendance.

The issue of boundaries created by the structuring of the clusters for example in circuits, or GET/FET also raises an important concern of the creation of artificial boundaries in knowledge for the teachers. One implication of this division was a perception that FET teachers cannot benefit from the GET teacher and vice versa. This division and artificial boundaries in knowledge and sharing was not only limited to the teacher level and their clusters but also right up to the level of the curriculum implementers who are departmental officials meant to oversee and support the teachers in their development. In one of the meetings the curriculum implementer for GET said, "FET teachers are not going to participate in the GET training because they will not benefit "(CI workshop Nelspruit, June, 2004). This split and boundaries in CK and PCK was again emphasized by the curriculum implementer for FET that "I do not want to lie to you; we have never met with the GET cluster leaders in the region we feel there is no need; they do their own thing and we do ours." This is a clear indication of the boundary that exists in teachers' thinking on CK and PCK for teaching at the two levels of education. This statement has a great potential of dividing teachers physically and mentally. The spirit of peer learning is indirectly destroyed by these boundaries of knowledge assessed by the phase of teaching at school. It is a pity because some of the teachers teaching the lower grades have reasonable content knowledge sometimes more than some of their FET counterparts which is not available for sharing with peers.

Consider another example on the articulation of this artificial separation of knowledge and the teachers: As stated by one of the education specialists

the *FET teachers should meet as FET teachers because their content knowledge is more advanced than the GET*. It *is further not a good idea to combine the two phases. They will not learn anything from them.*

For this subject specialist, knowledge of the teachers depends on which level they happen to teach not on the levels of education and experience of the teachers concerned. This is a bureaucratic approach to knowledge sharing and clustering that characterized the Dominant Internal Cluster in the Mpumalanga province. The Dominant Internal Cluster, in general, reflected this top down structure that was characterised by segmented operational and functional duties. As discussed earlier, complications were created by the fact that the clusters were expected to function within very strict, and sometimes contradictory, policy guidelines of the MDE.

For training and communication of curriculum policy issues the clusters became ideal if there were issues that needed sent to individual schools, the clusters made it easy for the subject specialists to reduce travel costs. This practice had bad implication of depriving the schools of visits from the curriculum implementers and subject specialists. The curriculum implementers are also classified as FET/GET implementers. This structure as indicated above made their support role easier than visiting individual school. This information was further confirmed by the three Curriculum Implementers who argued that *the presence of the cluster leaders at the schools make our tasks easier and saves us time, instead of visiting all the schools, we visit the cluster leaders and leave instructions.*

The major problem occurred when these clusters meet on the same dates because they would not be in a position to know the proceedings of the cluster meeting. One of the curriculum implementers emphasised this point by saying,

cluster leaders should submit their programmes so that I can check on the dates to avoid clashes. I don't want them to do things without me knowing.

This statement provides further evidence on the authority and power that curriculum implementers have on clusters and cluster leaders. Besides the hierarchical organisations and structures of MDE, that duplicated the regional structures, the clusters were left in the hands of Curriculum Implementers whose subject Content Knowledge might not be competitive because of their academic qualification and experience. The survey conducted by JICA (2000) reflected that very few curriculum implementers had university degrees in their subject area. This inefficiency in CK and PCK of curriculum implementers was further confirmed by one of the Regional Director during an interview when he worried that:

CI's who are supposed to be supporting these teachers, are very weak in content knowledge, and some teachers are better than them. The presence of the CI at the school is to show that teachers have support from the region. I prefer collaboration amongst teachers than an outsider. If we use teachers to teach other teachers it will be very useful and effective than sending CI to teach. These teachers on their own can agree on when to meet and how to meet. They should be given a chance to share ideas and new information.

The cluster leaders who in most cases were selected from the schools that participated were tasked with the role of facilitating and managing cluster activities and not so much free to pursue their own subject matter interests. It is quite clear therefore that the dominant clusters were formed for a specific purpose of pursuing and facilitating the MDE tasks, besides the sharing of CK and PCK with the aim of improving the classroom practices.

Among the many types of clusters identified by the researchers on teacher networks (Lieberman, 1999; Adams, 2000; and Lieberman and Grolnick, 1988); this type of the Dominant Internal Cluster in the province of Mpumalanga can be regarded as an example of the hierarchical structure with top down operations that provide for little or no consultation with the participating teachers. Fullan (2001) warns against this type of structure as, "top down management that hinders progress in organizations" Cochran- Smith and Lytle (1990) also makes the point that, "the key to reform are initiatives managed largely by teachers themselves, and involving dedicated school, time and resources for co-operative experimentation, access to external expertise, participation in local decision making when questions of goals and resources are on the table." I now turn attention to the other type of cluster that operated in the Mpumalanga province, viz. the External Cluster.

4.2.4 External Clusters e.g. The Sibonelo Cluster

The Sibonelo cluster is an example of some of the clusters that exist in Mpumalanga. Most of these clusters are not formally registered by MDE as a result I have called them External Clusters. In order to understand the operation of this cluster, one has to look at the way teachers in this area run their cluster meetings**.** Sibonelo cluster will represent the many external clusters that exist in Mpumalanga. The Sibonelo cluster can be what Fullan, (2001) referred to as a' bottom up' structure. This implies that the structure of this cluster is very strong at the bottom (grass root level) and very weak at the top administrative level. This cluster has its own programme and filled up with activities of their choice and the timeframes that match their needs in the classroom. The schools where the teachers that participate in this cluster come from are more knowledgeable with its existence and its operation. They became knowledgeable because the initial stage of participation on this cluster was shared and accepted by the headmasters of these schools. Teachers from these schools are fully supported by their headmasters; for example, the schools provide flipchart paper, photocopying paper and other resources. The cluster is conducted in a very informal peer relationship and trust. Every teacher in the cluster has something to contribute; in other words, teachers are the 'experts' of their own learning. Teachers that participate in this cluster rely more on sharing science knowledge and explore the strengths of each other by discussing the, 'how do you teach this concept/topic, While schools accepted the negotiations on participation, teachers were not compelled to attend the cluster meetings. These were done on voluntary basis.

This group of teachers believe that knowledge has no demarcations. They meet as GET and FET teachers to discuss matters of common interest on specific topics. One of the participants commented and said:

Having the limited knowledge of science because of my qualifications, I am being capacitated and improved by the FET teachers that are in our cluster. I knew the basic information on electricity, but the presence of the FET teachers and their contributions have added value in my content knowledge on electricity. This is very good. Guys, we must continue to meet as GET and FET and you have to bear with us slow learners!

This comment at the reflection meeting expressed the inner feelings of a teacher who has benefited and appreciates the work that the cluster is doing. The comment itself is an indication that knowledge cannot be divided and be segmented into knowledge for primary school teachers and knowledge for secondary school teachers. Both teachers can benefit from each other through sharing.

The involvement and the support from the regional office is appreciated if it offered through the invitation. Curriculum implementers cannot simple come without invitation. We had to ask for permission from the cluster members for each visit made to the cluster. Whilst we were there as resource people, our services were never utilised. It was encouraging though to see the Japanese volunteers that are based in the region becoming part of the cluster composition. They were regarded as members of the group although they were not teaching. One of the lessons, on the day of the cluster planning the Japanese volunteer conducted a model lesson on Le Chatiers" principle while the teachers were observing. This process of knowledge sharing and collaboration by the Japanese strengthened their beliefs and attitudes of the cluster members. One of the participants at the workshop commented that:

I have never conducted this experiment before at my school but after seeing Chikusa doing it at this meeting I feel I will do it in my next class. Japanese are good in technology; we are pleased to have them as part of this cluster. We must suck all the information.

It was quite clear that this teacher appreciates and acknowledges the inclusion of the Japanese volunteers in their cluster because of their skills in practical work. The culture of learning from each other as peers becomes the major success of this cluster; especially content knowledge.

There were still few clusters, which despite the rules and regulations on cluster formation from the MDE, were operating outside the parameters prescribed latter by the officials. In these clusters, teachers had organized themselves long before the introduction of the new departmental clusters. As they explained, in our conversations, most of these 'external' clusters existed as an attempt to break the isolation and lack of support from the MDE, since they were mostly located in deep rural setting or in a school where the roads are bad and discouraging to education officials.

There are other critical issues that shaped the clustering of teachers in Mpumalanga province. Many of these issues have to do with locality, content issues, management and structural issues; including historical and personal interests of the teachers. Some clusters or teacher groups as described were in existence before the formal clusters of the MDE. Groups of teachers from these clusters still meet to discuss and share their classroom practices. Some of these groups focus on content knowledge and others on issues of interest. As one of the cluster a member that participates in the external clusters summed it up:

We started our clusters long time ago before the conceptualisation of the MSSI and we have always focused on the subject matter and what happens in the classroom. We had our own plans and programmes, and we called ourselves a zone. The word zone is linked to the area where the circuits are based.

The external clusters are clearly voluntary and based on shared interest among the participating teachers. They have a fairly long history of existence both inside the province of Mpumalanga and throughout South Africa as I illustrated in Chapter One earlier.

4.3 Summary

This chapter highlighted the conceptualisation of clusters by various stakeholders. The findings confirmed some of the theories from the literature on clusters. Lieberman and McLaughlin, (1991) argued that "networks could be powerful and problematic." In this chapter, I have discussed how powerful the dominant clusters are in the province of Mpumalanga and how these structures for teacher learning and growth can sometimes be bureaucratised and diverted to perform administrative and management tasks of the Department. The bureaucratization of teacher cluster may have an unintended consequence of discouraging the many teachers who wanted an opportunity to improve their CK and PCK through sharing and collaboration with their peers.

The chapter also began to examine the potentialities presented by the alternative clusters (referred to as the external clusters) for teacher growth and development. The point to be made is not so much how the alternative can become the mainstream but more what can be learned from these alternative arrangements of opportunities for teacher learning and growth.

Chapter Five

Challenging and Changing Teachers' Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) through cluster activities.

5.1 Introduction

The study of teacher networks or clusters was motivated first and foremost by my desire to explore and understand what underlies the trust that many researchers and practitioners have on teacher networks as a more promising approach for the professional development of teachers. In chapter two, I discussed this latent trust on teacher networks or clusters as highlighted by several scholars on teacher development (Adams, 2000; Gottesman, 2000; Fullan 2001).To explore the issue further and in the context of a developing country, I investigated how the clusters became a (safe) forum for teachers to expose their Professional Knowledge (CK and PCK) for challenge and change with their colleagues. In this chapter, I explore two case studies of clusters, looking at issues of structure and function and more specifically how each of these two networks of teachers provided opportunities for teachers to challenge and change their Professional Knowledge. I wanted to understand what is it that clusters do to challenge the teachers' CK and PCK and how they do it. The strategies and ways of uncovering and improving the teachers' CK and PCK are not always easy as many teachers, in most cases, are not even aware that they have a problem. When one considers more abstract scientific concepts like the structure of an atom, heat and energy; the complexity of the teachers' tasks in the classroom becomes even clearer.

As mentioned earlier in chapter three, the context of this study focussed on two case studies that are teacher clusters in Mpumalanga. These cases are both targeting the science and the mathematics teachers at a secondary school level

In the first case study, I describe and analyse the opportunities created by a less conventional cluster, a Simulated Cluster forum – where groups of teachers were asked to come together in their subject specific groups to explore a given task during a professional development workshop. This Simulated Cluster forms part of the

Internal, formal cluster registered by MDE as described in the previous chapter. As this cluster was used for my research to examine the kinds of opportunities that clusters create for teachers to challenge their CK and PCK, I will call this cluster, the SIM cluster.

In the second case study, I describe and analyse a different set of opportunities created by another cluster, a non-traditional cluster also operating in the province of Mpumalanga. In the latter type, teachers voluntarily came together and structured their cluster activities based on their own needs and interests and operated on their own terms outside of the bureaucratic prescriptions of MDE. As a result, this was somewhat of a semi-formal cluster and provided an interesting contrast to the formal structuring of many clusters in the province including that of the SIM cluster. I shall call this second type of a cluster, the SIBONELO cluster, which loosely translates to "the Exemplary Cluster."

I now turn to the SIM cluster, to explore its structure and function, and how the cluster attempted to create opportunities for challenging and reshaping the teachers' professional knowledge and classroom practice.

5.2 Case study One: The SIM Cluster

Breaking down the barriers, overcoming the fear and confronting the teachers' knowledge gaps

As I have discussed previously, the context for this study was a professional development intervention for the improvement of science and mathematics teaching and learning in the Mpumalanga province. This professional development programme was carried out through a partnership between UP, MDE and JICA. The modus operandi for the intervention was the creation of teacher clusters or networks that would provide the platform for the teachers to learn together and challenge each other's Professional Knowledge in order to grow and develop collectively. To understand how the cluster approach intended to assist the teachers to change their Professional Knowledge, especially their CK and PCK, in order to improve their classroom practice, we began by sampling through the entire province to explore what levels of knowledge cluster leaders brought into the professional development workshops. Clandinin, (1986), argued that it is important to first understand the teachers' "Practical Knowledge" and build on it. Clusters were designed to uncover the teachers' CK and PCK, among others, in order to structure better opportunities for its improvement. Fullan (1982) noted that, "the crux of the change is in how the individuals come to terms with the reality of the change in the context of their familiar framework of reality." It is for this reason that in this study we opted to uncover the teachers' CK and PCK through questions that employ the familiar classroom based responses of the learners. Using an imaginary discourse between two learners in a classroom situation, we developed a set of instruments that were subject based and designed to uncover the cluster leaders' CK and PCK. The nature of the instruments used at the SIM Cluster created opportunities for cluster leaders to challenge their CK and PCK by responding both individually and collectively as a cluster, to the questions in the research instruments. Teachers were first asked to respond to the questions on the instrument individually in order to uncover their own approaches and levels of CK and PCK. Subsequently, after the individual response session, the teachers were then asked to come together to form a Simulated Cluster Meeting. These simulated cluster meetings represented the both the structure and functioning of the Dominant forms of cluster activity in the province of Mpumalanga, that of subject specific clusters. The research team collected both the individual and the collective responses of the clusters for analysis and sharing with other cluster leaders at the next professional development workshop.

This study sampled a group of science teacher leaders, who are referred to as Cluster Leaders. The Cluster Leaders constitute a group of senior exemplary teachers who have been given the responsibility to coordinate the activities of the groups of local teachers (clusters) who come together periodically for sharing and other professional development activities. The purpose of creating such a Simulated Cluster (SIM) was to explore and to capture the teacher's CK and PCK to use as a basis for the professional development intervention of these teachers. We further intended to encourage Cluster Leaders to practice and to work as a community of teachers by sharing their classroom experiences and professional knowledge.

5.2.1 The Structure of the SIM Cluster

To make the SIM cluster more relevant to the Cluster (teacher) Leaders' own situations, leaders of biology were given a task with Biology learners' responses and the same was done with Physical Science and Mathematics Cluster Leaders respectively. The SIM cluster accommodated each of the major Science subjects taught at school level, including Mathematics. Cluster Leaders first worked as individuals in their seats and when they had to share their responses and knowledge on the subject they came together to form Subject Groups. Four groups were formed, for Physical Science, Mathematics, Agricultural Science and Biology respectively. Each group had two or more facilitators who were the Subject Specialist (or Subject Advisors) from the MDE, often called the Curriculum Implementers (CIs). Curriculum Implementers are groups of specialists who were once classroom teachers themselves and over the years were promoted to a specialist role to support the teachers. Part of their role includes helping teachers with CK and PCK in order to improve classroom practice. Within each of the subject groups (SIM Clusters), there were two types of participants, viz. the FET and GET Cluster Leaders (Classroom teachers who have the extra responsibility to led other teachers in their respective clusters and schools).

As mentioned earlier, my interest in this study was more on the responses and the discussions of two science groups, the Physical Sciences group and the Biology group. The Physical Sciences group focussed on the topic of 'Energy and Work' in Physics while the other group dealt with the topic of 'Plant Growth and Soil' in Biology.

The concepts of 'Energy and Work' represent one of the key areas of study at both the primary (GET) and the secondary school (FET) levels in South Africa. It is therefore an appropriate and relevant topic to explore with all the Cluster Leaders of both primary and secondary school levels. More specifically however, the concept of Energy and Energy Transfer, Conservation and its application to Work represents one of the fundamental topics of Modern Physics. Similarly, the concept of Soil and Growth in Biology is a key study at both primary and secondary level. For the purpose of our SIM Cluster, we focussed on teachers' knowledge and understandings of science concepts because of our beliefs that; to change classroom practice in the direction proposed by the new reforms in South Africa - the National Curriculum Statements (NCS) - much research is needed first and foremost to examine and document current practice across South African classrooms. As Loughran et al. (2004:370) observe, “teachers professional knowledge is difficult to categorize and therefore exceptionally difficult to articulate and document”. In creating the SIM cluster, we attempted to, among others, articulate and document cluster leader’s CK and PCK on the selected topics using the sample of 120 Cluster Leaders from Mpumalanga.

5.2.2 Cluster (Teacher) Leaders’ Content Knowledge (CK) and Pedagogical Content Knowledge (PCK)

An interesting finding based on the responses of the teacher leaders was that the cluster leaders’ responses reflected a similar pattern as was noted by researchers who study misconceptions of learners on these given topics (Driver and Bell, 1986). These similarities are indicated by the results of the responses as discussed below. The responses basically reflect misconceptions and insufficient content knowledge of the participants on the specific subjects.

5.2.2.1. Conceptualisation of Energy

In general, the findings seem to indicate some confusion between the concepts of Energy, Fuel, Friction and Work. The confusion was based on the observable consequences of Energy Flow e.g. sweating and tiredness. As the cluster leaders’ responses were analysed, four major themes emerged. These four themes were not mutually exclusive however, and in some cases could be found exhibited in a single person’s responses:

Theme1: poor organisation of the knowledge about ‘Energy and Work’
Theme 2: rote learning or recitation of facts about ‘Energy and Work’
Theme 3: confusion about the law of ‘Conservation of Energy’
Theme 4: anthropocentric framework of Energy

Theme 1

The first theme that reflected poor organisation of the knowledge on 'Energy and Work' was found to be the most dominant theme throughout our data set. Many of the Cluster Leaders, even when they seemed to have adequate knowledge on 'Energy and Work' seemed to have a problem in presenting this in an organised and coherent manner. For example, one Cluster Leader had this to say about the first student's response:

The first student knows the concept of energy and its relationship to work, but he fails to link these two concepts to the bike and to the sweating which he claims is lost forever. His understanding of the conservation of energy is problematic.

It is not clear from this Cluster Leaders' response what he identifies to be the learners' problem in this case. His response is not well organised and/or well articulated.

Another Cluster Leader, argued as follows:

You do loose energy when work is done and when displacement and distance is brought into account. Displacement and distance is to do work, you have to move something in a certain distance before work can be done

Again, this cluster leader seems to know somewhat that movement in the direction of the applied force is an important consideration in discussing 'Work and Energy Transfer in general, but is not very coherent about how this relationship works.

Similarly, another cluster leader argued that:

Thula has some insight on work energy because he understands the fact that work done is always equal to the energy expanded. Work and Energy cannot be divorced, they go hand in glove. Work was done while Themba was paddling the bike in a straight line and in order to do this energy must be expanded and some of the energy was lost through friction.

In the latter case, as before, the teacher leader seems to have a clue about the fact that Work and Energy are related concepts but her expression of this relationship is fairly clumsy and does not communicate a good sense of mastery of the subject matter.

Theme 2

The second theme reflected rote learning or recitation of facts with minimal understanding by the Cluster Leaders. The analyses also uncovered a fairly substantial number of responses with statements that could have been taken directly from the textbooks, with very little indication on how the teacher leaders understood the statements. One example of this kind of recitation is illustrated in the following quote from one of the Cluster Leader's response:

Thula is right, work has been done, that is cycling is using energy. She understands that for any work to be done there must be energy because it is the ability to do work. But Thula is also wrong because for the bike to move one has to push / pull or cycle it. The energy from potential energy has been transformed into kinetic energy. She does not understand that energy can be transformed from one form to another.

This cluster leader's response contains all the appropriate statements such as "Energy is the ability to do Work" and that a force or "Push, Pull or Cycle" is required for movement of the bike and "Energy can be transformed from one form to another." Also the idea of sweating surfaces in this response. There were many such responses that fell into this theme, indicating some degree of rote learning probably from these teacher leaders' side.

Theme 3

The third theme reflected cluster leaders' confusion about the Law of Conservation of Energy. In addition to the problem of rote learning or recitation of the facts, some of the responses demonstrated confusion about the concept and their relationships. This was more so for the principle of Conservation of Energy. As an example, one of the respondents argued that

it is not practical, an object cannot gain or loose energy. Thula understands that if one looses energy because of performing some work, it means that work gains your energy.

This teacher leader does not seem to understand the notion of the Conservation of Energy within an isolated system, although she probably has heard about Energy lost being equal to Energy gained.

Theme 4:

The last group of responses were those where the teacher took an anthropocentric view of energy. That is the view which considers energy as property of living things only. A case in point is that where a leader agreed with one of the responses from student (Themba) in the case study who questioned how a bike could gain energy. The teacher agreed that:

Some of the energy used is somewhere but does not go to the bike. It makes muscles to move. To ride a bike requires energy, which must be generated by the body to the cells for the muscles to move. The movement of the body shows that you are living and that you have energy.

These responses from Cluster Leaders attempted to capture their level of CK and PCK as opportunities were created for them to share, explore and (re)construct meaningful classroom intervention through the SIM Clusters.

The situation was no different in the Biology sub-group as discussed below.

5.2.2.2. Conceptualisation on Growth and Soil

The biology group at the SIM cluster was exposed to a similar activity of reviewing hypothetical responses of learners in a Biology class. After reading and re-reading the Cluster Leaders' responses, the responses were categorised into three themes as indicated below:

Theme one: poor organisation of facts

Theme two: misconceptions on the concept Photosynthesis

Theme three: lack of appropriate content knowledge

From the three themes that emerged from the data analysed based on the cluster leaders' responses, the summary of these responses are highlighted below:

1. Soil provides food for plant growth

2. Soil loose weight as the plant grows

3. Photosynthesis is food for the plant

Theme 1

As with the Physical Sciences group, in the Biology Cluster, we picked up some confusion in the organisation and/or presentation of the Content Knowledge and Pedagogical Content Knowledge. The Cluster Leaders seemed confused about Photosynthesis as a process. They seemed to argue that Photosynthesis was actually the food for the plant. This confusion could be created by the fact that for food to be manufactured in plants, the process of Photosynthesis should take place. This confusion was picked up from a majority of the cluster leaders' in the Biology Cluster:

the plant obtains its food from photosynthesis and the soil. The learners should first be taught photosynthesis and the soil which is needed for food.

Again there appeared to be a major confusion created around the fact that soil produces mineral salts that are used by the plants. Instead of the mineral salts being the food for the plants, the cluster leaders seemed to think that the soil itself was the food for the plants, as indicated in the previous response.

Theme 2

The second set of responses reflected the misconception that the soil was actually used up as the plant grew and developed. This misconception could be based on the thinking that the soil is food for plants, and as such would have been consumed by a growing plant resulting in an observed weight loss. Many of the Cluster Leaders' responses indicated that the soil would be expected to weigh lesser than before. For many of these teacher leaders, the nutrients that are in the soil are not as visible as the soil particles, and therefore it is (for them) the soil that is food and not the nutrients that are in soil. Some examples of these responses from the teachers are captured below:

Response 1

The soil will weigh lesser than before because it has been used up as food for the plant

The idea of the soil being used up for Plant Growth is highlighted by this Cluster Leader's response.

Response 2

When the soil has lost all its nutrients it will be difficult for photosynthesis to make food.

Similarly, this response illustrates the point that for photosynthesis to take place the plant needs nutrients from the soil. This is a misconception because for the process of photosynthesis to take place the plant needs sunlight, air and water.

`Theme 3

The conceptualisation of the concept of growth and the way in which the cluster leaders responded reflected lack of scientific language and understanding on this concept. The responses indicate the way in which this topic was taught (PCK) as indicated in these cluster leaders' responses.

Response1

The plant eats soil and absorbs light and air for transpiration which gives rise to the process of photosynthesis.

From this response it is clear that the cluster leaders perceive the soil as food for the plant and therefore the plant is regarded as a living nature that eats and breath in order to grow, just like human beings. The usage of the word "eats" reveals some misconception. The soil is regarded as food itself and the nutrients that are in the soil which are food are not taken into consideration. This response is a misconception.

Response 2

If soil is regarded as a system of growth then plant growth is called photosynthesis as it helps in synthesizing others.

It is clear from this response that the concept photosynthesis is related to growth. This statement implies that the cluster leaders do not know the meaning or the understanding of the concept. As a result of the cluster leaders not being clear on this concept, they tend to generalize issues; for example, "it helps in synthesising others"

Response 3

Plant growth results in addition of tissues and cells, the soil has nothing to do with plant growth

Again, this response implies that the soil has nothing to do with growth, the importance of soil providing the plant with nutrients for growth is not taken into consideration. This response leaves one wondering what the main function of the roots are in the soils if plants can grow without soil.

Unlike the Physical Science Cluster Leaders, the Biology Cluster Leaders had far fewer responses and did not elaborate much on what they wrote out. In the follow-up interviews that were conducted with some of the participants at the end of the workshop, I asked them on how they responded to questions four C and D on the worksheets (How might you go about teaching Themba to bring him to the ideal student response level? Be specific about the pedagogical strategies you will use and exactly how you will use them with the content you have identified? {hint: plan an actual intervention lesson for Themba.})

The dominant response to this question from the Biology Teacher Leaders was:
I did not write anything on question two and three because I did not know what to say. The group members helped me to think and to sharpen my learning curve.

The cluster leader in question was honest enough to admit the inadequacies of his CK and PCK on soil and growth. Furthermore, his response not only tells about his inadequacies but also points out his openness to learning from others in the cluster. The SIM cluster, in this case, made it possible for the biology cluster leaders to uncover their CK and PCK by debating and clarifying the different responses in order to make sense of their responses and perceptions on the topic. This is how another cluster leader saw the whole process of discussion, challenge and change within the SIM cluster.

After the discussion and the clarification by the team members I realised that my understanding of the term photosynthesis as a product and not a process was incorrect. I thought the leaves produce photosynthesis which is food for the plant.

Overall, our data seems to suggest that on the topics of Energy and Plant Growth as discussed here, there are serious gaps in the teachers' conceptual understanding of these concepts.

Misconceptions are bound, and may have arisen for several reasons. My findings on the cluster leaders' views on Soil and Plant Growth correlate somewhat with the findings from Driver (1988) on the learners' misconceptions on the topic of Soil. According to Driver (1988) when students are exposed to the question of Growth, they appear to believe that the necessary conditions for all stages of Plant Growth include both food and light. However, prior to instruction they do not understand that light is a requirement for the plant obtaining its food and not a condition for growth itself. I was a bit surprised by the teacher leaders' responses in part because I expected cluster leaders who have teaching experience and more CK from higher institutions to have a better grasp of these concepts. From these teachers' comments, I began to get a sense of how the SIM cluster helped to challenge their instructional practices by connecting immediately with their weaknesses on CK and PCK. The support generated by teachers' collaboration seemed to play a key role in changing the teacher' views and perception on Energy and Plant Growth.

The discussion below will explore further the question of how the intensive discussions and dialogue within the Biology SIM cluster seems to have assisted teachers in uncovering their CK and PCK.

5.3 Uncovering Teacher Leaders' CK and PCK in the SIM Cluster

One of the objectives of creating a SIM cluster as stated before was to review and reflect on the function of teacher clusters in creating opportunities for teachers to share and learn from each other as peers. At the SIM cluster discussed above, I observed cluster leaders breaking down the barriers and confronting the inadequacies in their content knowledge. I will now focus my discussion on how the SIM cluster seems to have managed to break down these barriers and teachers' fears to allow for them to confront the gaps in their CK and PCK.

5.3.1 Barriers to sharing.

In most cases teachers often work in isolation in their schools, and more specifically in their own classrooms. There are few or no opportunities for them to talk about their classroom practices with one another. When they are confronted with new scientific concepts and theories they tend to rely on themselves and the textbooks. This experience was quite evident when teachers were asked to respond as individuals to the learners' problems. When I in interviewed the cluster leaders about their feelings and attitudes towards their individual responses, this is what one of them had to say:

I took some time to respond on the learners' work as it made me to think and come with the best answer. I thought that I was familiar with the topic energy but the students' answers complicated and confused my thinking. I then wrote what I thought was the best answer, but it was rated very low by the group .At first I was disappointed and ashamed of myself but as many of us were wrong I became confident, especially because the FET cluster leaders were also wrong.

It is clear from this cluster leader's statement that he felt isolated and rather helpless in responding to the questions when he was alone. Initially, also the sharing was not very easy and comfortable for this teacher leader. What he consider the best of his CK and PCK were challenged by the group.

Another cluster leader captured the experience in the following manner:

my initial response as an individual thought of energy as something that is stored within the body of an object, I never thought of energy in any moving object. My thinking was that the energy within you put power or pressure to the bike for it to move, but the bike does not have any energy as it is not living. However, through collaboration and discussion, my CK was modified by peers.

The SIM cluster provided this cluster leader with an opportunity to talk about his knowledge, experiences and classroom practices. The notion that emerges from the SIM cluster experience points to the group setting as a powerful vehicle for bringing about change in both CK and PCK. Certain norms, beliefs and attitudes are needed, however, within the group setting for such change to happen. These norms include amongst other things; trust, support, and a sense of identity within the group. The question of identity, trust and support were raised by one of the cluster leaders when he argued that:

my response fell under the last categories which were taken by the members of the group as not clear and unorganised. This experience was an eye opener to me especially because I am the only science teacher at the school, I have no one to talk to and if I do not know something I will use the textbook explanation as it is. It is difficult for me to ask from the teachers of another school, how do I approach them? I *might be exposing myself as incompetent. It is better in this situation many of us did not have the correct answers.*

It becomes clear from this cluster leader's response that the SIM cluster seemed to succeeded in breaking' a variety of barriers as far as the sharing of CK and PCK within this group of teachers. Among others, the following major barriers to sharing were identified by the cluster leaders: isolation of teachers in schools; FET cluster leaders being viewed as better than the other teachers in CK, personal confidence and self image as a barrier to social interaction as expressed by one cluster leader when he said : I *might be exposing myself as incompetent.*

5.3.2 Fear and confrontation of knowledge

As the teacher leaders were given a chance to look at the students' questions individually, they had to draw on their previous CK and PCK and experiences in the classroom. As discussed previously, this background was found to be lacking in many respects. For the research, it became very difficult to articulate the levels of CK and PCK that these teacher leaders brought with them from the classroom. Generally, teachers always feel uncomfortable at being assessed through testing and classroom observations. Using an instrument with students' questions and responses therefore indirectly challenged the teachers' CK and PCK without creating such fears of confronting their professional knowledge. The setting in the SIM cluster promoted a feeling of empowerment on the part of the teachers as they were interacting and clarifying their own experiences using their combined resources of CK and PCK. A sense of collegiality began to develop among this group of cluster leaders. This process of collegiality was very critical to the successful functioning of the SIM cluster in this particular case. Our interviews with the teachers confirmed this sense of collegiality as important in breaking the isolation amongst this group of teachers. For example, when the cluster leaders were asked to comment about what factors might have contributed to the changes in their responses (as an indicator of the changes in their conceptions and knowledge), they mentioned such comments as:

the importance of the informal setting, informal discussion, sharing personal experiences in the classroom and the variety of ideas on the same topic instead of one person leading and imposing his or her idea.

The important idea in these phrases is the emphasis on the absence of formality in the discussions on teaching and exploring content knowledge in this collaborative setting of the SIM cluster. Teachers collectively owned this process of development through sharing as peers and colleagues.

When one of the cluster leaders was asked to reflect on his experience of the cluster activity, this is what he had to say:
I did not specialise in physics but teaching physical science which is both physics and chemistry is a big challenge. When it comes to topics like energy I rely more on the textbook information. Using the learners' responses demanded from us both content and methodology. Since our responses were different I was not scared to share my views, especially because the questions mentioned the fact that you had to write your opinion. Our level of understanding and backgrounds are different and we shared those differences.

It is clear therefore that the SIM cluster members felt like they had adequate resources within themselves to enhance each other's strength and competence on CK and PCK. Those whose CK and PCK was at a higher level assisted the rest of their colleagues to understand through discussion and debate of concepts. These interactions within the SIM Cluster seem to have promoted the co-construction of new knowledge by some of the members of the cluster. That is, there is some evidence of learning and growth that resulted from the interactions within the cluster. In the next section, I explore in some depth how it might be that the leaders were able to construct new knowledge through the interactions in their cluster.

5.3.3 Construction of knowledge

One of the instrumental factors shaping the changes resulting from the SIM cluster was the use of information from the individual cluster leaders' as a basis for generating collective insights and ideas and thereby the construction of new knowledge. The building blocks of information that were used to construct CK and PCK came from the cluster leaders' individual responses. In one example of this phenomenon, I followed one cluster leader to her biology SIM cluster. A segment of a discussion between herself and other teacher leaders in her group is captured below. They were exploring the concept of Photosynthesis and its role in Plant Growth.

The segment of the discussion captured in the SIM Cluster Biology group

Sara*:*	*Photosynthesis is the manufacturing of food in plants.*
Thoko:	*It is not the manufacturing of food in plants but in the leaves of the plant to be specific.*
Sihle:	*It is in the green parts of the leaves that have chlorophyll.*
Nomsa:	*Should we then say photosynthesis is the process of making food or is food?*
Mpho:	*It is the process of making food in plants and this process takes place in the leaves of the plant in the presence of sunlight*

It is quite clear that this discussion from the biology cluster leaders provided opportunities for them to construct knowledge through their views and opinions based on their responses. If we explore Thoko's response on *photosynthesis being found in the green leaves*. It is clear that Thoko assumes photosynthesis is a product that is found on the green leaves of the plant, as Mpho and Sihle are questioning and discussing this statement, Thoko came to grasp that photosynthesis is a process. I captured her on my field work journal talking to herself saying: *hhmmmm, I now see the difference. Photosynthesis is a process and not a product.* I noticed as she dashed out of her group, taking out a small note-book from her handbag and jotting down something; which I assumed were her notes on the major points of the discussion.
For me, this experience was a clear indication of how a gap in content knowledge (*knowledge in practice)* on the topic Soil and Plant Growth had been identified in Thoko by her peers during the SIM cluster meeting. Thoko's response was challenged by Sihle, Sara, Nomsa and Mpho, up to a point where Thoko realised the gap in her Content Knowledge. Through reflection on her knowledge of practice, she adapted and modified her knowledge *(creating a new knowledge for practice*) which Fullan (2001) refers to as the "new knowledge."

The technique used for data collection in this case, was also designed to enable the teachers to reflect on and challenge their content knowledge at the simulated cluster workshop. As the teachers debated issues and explored alternatives, they reflected on their own practices without consciously taking notice of it. They were able to construct new knowledge as peers through sharing. Shulman, et.al. (2004) who studied such processes of sharing content and pedagogical content knowledge noted that, each individual person in a group creates his / her own unique construction out of the rest of the participants and their goals, of the interaction between herself and others and of all the events that occurred in the classroom.

It is this unique construction of knowledge resulting from the collective experience of sharing on professional knowledge in the SIM cluster that each of the cluster leaders took back with them to their schools and classrooms. As I visited cluster leaders back in their cluster meetings and interviewed them on the experiences they had from the SIM Cluster workshop, their responses confirmed two major issues: their recognition of the inadequate content knowledge and the value of opportunities for teachers to meet and share their classroom practices. In each case, I asked the cluster leaders the question: Having participated in the SIM cluster workshop, can you share with me your experience on the activities conducted?

These are some of the responses that came out from the interviews:
the questions demanded one to scratch hard on the content knowledge that we did some years back and most of it evaporated. Sometimes we do not take the students' responses seriously, we just teach facts from the textbook

Similarly another teacher interviewed also affirmed this disposition toward the challenge given in the SIM cluster when she said that
I fumbled alone and as a result I failed to recall CK that I did long time. I only remembered the definitions on photosynthesis as appeared on my grade 10 textbook. I could not think about the learners' response as a result my own response did not make any sense to the group. Fortunately I had members of the group to make sense of the learners' response and I learnt from them.

It is clear from these responses and the foregoing analyses of the processes at the SIM cluster workshop that the teachers' CK and PCK were challenged during the SIM cluster workshop. By removing the barriers to sharing and collaboration, through the establishment of the SIM cluster, the cluster leaders were offered a unique opportunity to work with peers on issues of content knowledge and on issues of classroom practice. The evidence presented seems to suggest that for most of the cluster leaders, removing the barriers to collaboration was an important and necessary step to effective peer learning and coaching. Removing the barriers, however, is more of a structural change that seems to be necessary for clusters to create the kinds of opportunities for teacher learning and change that is often anticipated.

Overcoming the fear of exposing oneself to one's peers, seems to require more than just a structural change. Removing the fears seems to be more of a process and requires some measure of personal change. As many of the teacher leaders confessed, it took a while for them to open up and expose the inadequacies in their CK and PCK. The cluster processes, where each member of the cluster was expected to bring in something from their individual work, to contribute to the discussion was an important process for the cluster leaders to open up. Each teacher leader felt obligated to the group members and therefore took the leap of faith and exposed themselves to the group.

Finally, the co-construction of new knowledge as discussed by several of the cluster leaders that interviewed seems to be an important stage in the functioning of a cluster. Many if not all, the cluster leaders who participated in the SIM cluster were unanimous about how the group discussions and debates enabled them to learn more, know more and better organise their CK and PCK regarding the topics under discussion.
The modus operandi of the cluster and how it seems to have created the opportunities for the teacher leaders to shift their CK and PCK is comparable to the ways other researchers have suggested in dealing with the issues of conceptual change and learning.

Driver (1986) for example, recommended the following steps that might lead to changing pupils' thinking on specific topics.

- Develop existing ideas
- Differentiating existing ideas
- Changing existing ideas

- Introduce new ideas

For the SIM cluster workshop, the existing ideas would have been the teachers own individual CK and PCK, which was shared with peers in the cluster. The processes of sharing allowed the teachers to weigh and reflect on their professional knowledge with peers and begin to shift their own CK and PCK. These changes were displayed on the flipchart and role-played in mini-lessons that they taught with peers afterwards.

The difficulty of changing teachers' professional knowledge and practice is well documented. In the cluster approach, however, there appears to be some hope in the opportunities created for reflection and practising with a group of peers. The evidence presented in this chapter suggests that clusters are able to structure the opportunities where teachers work in groups to reflect on their own CK and PCK with a better potential for influencing their classroom practices. The ability of the group members to base their discussions on their everyday classroom experiences helped to make explicit the link between CK and PCK and thereby provided a better chance for changing classroom practice. As one of the cluster leaders reflected during the interviews: *These cluster activities helped and motivated me in taking into consideration the learners' answers and link them with the scientific knowledge I am teaching.*

It is this clear link between CK and PCK that stands a better chance of helping teachers to change their classroom practices. And the evidence suggests that the SIM cluster was able to provide enhanced opportunities for the teachers to make this link more explicit.

The foregoing discussion on the structure and function of the SIM cluster has provided some empirical evidence on how knowledge and practice are related, and how teachers learn within communities and other contexts as suggested by Cochran Smith and Lytle (1999). The SIM cluster experience seems to indicate that cluster leaders needed to challenge and change their CK and PCK, as conditions for shifting their classroom practices. Although we could not observe the major shifts in practice in their classrooms, the suggested lesson plans they developed collaboratively as part of the activities of the SIM cluster did provide evidence of the shifts they were making in at least what they considered important to teach and in how they themselves now understood the concepts and content topics they were dealing with.

The discussion in this chapter has therefore contributed to knowledge related to theories, opportunities and approaches to uncovering teacher's CK and PCK and how these might function as conditions for changing classroom practice. To further understand the dynamics in clusters which function to create the better opportunities for change, another case study of a unique cluster was selected in Mpumalanga. The Sibonelo cluster was selected primarily because of its interesting operational issues as well as the way in which it was formed. This case study is intended to describe further, the concept of clustering with an attempt to focus again on the three research questions for my study, viz.

What are the kinds of clusters that operate in Mpumalanga and how were they formed? How do clusters help teachers to uncover and challenge their CK and PCK? What are the resultant knowledge and practices of the teachers?

5.4 The Second Case study: The Sibonelo Cluster

Challenging Structures, Norms and the Policies in Changing Classroom Practices

This cluster is seen as an external structure as it does not operate in the same way as the Dominant Internal Cluster forms of Mpumalanga in terms of its formation and operations. The Sibonelo cluster has its own interesting ways of challenging the teachers' CK and PCK, all with the aim of improving their classroom practice. The Sibonelo cluster incorporates the classroom- level implementation experiences of the teachers in the cluster. The narratives in this case study recount the teachers' experiences and their views and beliefs about the Sibonelo cluster.

5.4.1 Challenging the structure

As mentioned earlier the formation of this external cluster was initiated through the influence of an outsider - a retired lecturer from the University of Cape Town (Joe). Joe, who had worked with clusters in the Western Cape, initiated this cluster in consultation with the regional structures of the MDE. The point of entry was at the regional office and the cluster was based on teachers' commitment and voluntary participation.

During the first meeting with the teachers, Joe shared his experiences on teachers working together and sharing as peers. He shared the values and the benefits that were expressed by the participants. Reflecting on this first meeting, one of the teachers pointed out that:

I attended the first meeting because I did not want to disappoint the professor who had travelled all the way from Cape Town, It was during school hours so I had nothing to loose. We are familiar with such questions by outsiders.

From this teacher's comments, it is clear that he had no inherent commitment and/or trust on the new cluster and attended the meeting just for exploration. This teacher continued to show how his lack of commitment and/or interest was challenged further:

it became even worse, when we were given tasks to prepare for the following meeting which was to take place on a Saturday.

Given that Saturday is not a working day for most teachers, many were reluctant to attend the next scheduled meeting but came because they were promised science apparatus, lunch and the reimbursement of transport fee. As one of the teachers put it:

I did not prepare much for the day, but I took one of my old lesson plans on the topic that was to be handled, and now that I think of it, I feel bad, but at least I am honest

This was an honest reflection by one of the teachers, three years after those uncertain beginnings of the Sibonelo cluster. Forming a cluster or bringing teachers together for collaboration and discussion of professional knowledge and practice is not easy. Furthermore, working out of the existing structure is indeed an effort that demands a lot of commitment (Ovens 2000).

The presentations of the lessons, in the second cluster meeting, were meant to simulate a discussion about teaching and learning in the real classroom. Joe, the retired professor, facilitated the session and suggested that a leader be chosen for future meetings. Raj, who is one of the teachers that came from the six participating schools, was selected to be the cluster leader for future meetings. Each presenter focussed his/her presentation on how the topic was taught in class and the problematic areas encountered by learners in understanding the topic. After each presentation, the teachers were asked to reflect on the following:

- positive things about the session;
- things they would like to change; and
- how they would like to change those things.

Joe closed the sessions with a summary and suggestions to the teachers on some classroom improvements. It was after the second meeting of the cluster that the teachers decided to work on a year plan for the cluster and decided to use learners from the six schools to put into action and practice whatever suggestions came out of their discussions to improve their teaching and learning. Their plan began by scheduling a teaching session with learners on the same topic that they had presented and discussed at their previous cluster meeting with Joe.

Subsequently, Raj was promoted to be a principal at a school 50 km away from the participating cluster schools. Although he participated actively in the cluster meetings, a new cluster leader had to be elected to replace him. Mandla, the new leader, mentioned how difficult it was initially for him to share his teaching skills primarily because he had never done it before. Although the teachers knew one another as teachers from the different schools, teaching the same subject, they had never shared their professional knowledge and methodologies "in public." Furthermore, according to Mandla, Raj was the only teacher that showed confidence in sharing his experiences in the cluster during the initial stages of the cluster. He thought that Raj's confidence emanated from the fact that he was not a South African, and was probably used to sharing ideas with peers in his country of origin (Pakistan). It was seemingly because of this confidence that Raj who was originally chosen to be the cluster leader, unfortunately lasted for only one year before he was promoted to a principal position. Mandla was then selected to be the next leader of the Sibonelo Cluster. In our discussions, Mandla noted the difficulties he experienced in filling Raj's shoes when he said:

it was difficult to fill his shoes, but by the time he left I had learnt a lot from him. I had learnt to give teachers an opportunity to talk about how they teach a specific topic and to allow them to freely share their classroom experiences about the topic in discussion.

The leadership of the Sibonelo cluster seems to have played a critical role in its attempts to provide teachers with opportunities to challenge and change the CK and PCK. In sharing their knowledge and teaching experiences on specific topics, Joe (the professor) had challenged the teachers to think about the differences that were reflected in their experiences and helped them to make changes to their lesson presentations. Joe would probe and probe in order to create opportunities for the teachers to think about their own ideas.

What was interesting is that the changes that he made came from each one of us but he consolidated them to one. No one felt bad about his approach or method being inappropriate or useless.

In addition to the training, Joe initially presented the cluster with a gift of R500 to take care of administrative costs, refreshments and stationery. From this discussion with the cluster members, it became clear to me how this cluster broke all the existing barriers and protocols of the MDE on clusters. First, the six schools that participated came from three different school circuits instead of one as the MDE prescribes for its Dominant Internal clusters. Second, the cluster leader was not a HOD or senior official of the MDE as the department would have in its own clusters. The leader was an ordinary science teacher at one of the participating schools. Thirdly, the cluster was not officially registered with the MDE as is prescribed for the others. Sibonelo was a voluntary group that met out of interest for the participating teachers. Fourth, the support structure for the cluster came mainly from an outsider, Joe the retired professor, who encouraged the teachers to meet on Saturdays. Significantly, after the first few sessions, Joe was only able to attend very few of the Sibonelo cluster meetings and specifically only when he was invited by the members of the cluster. He, therefore, gradually phased himself out of the limelight and/or leadership of the cluster and allowed the teachers to take over the cluster for themselves. Exploring the involvement of the education department within this cluster, one member of the cluster asserted the absence of support from the MDE by saying that:

there is no support from the department (and) they do not know that we exist even; as educators we work as a team for the betterment of our teaching

The cluster was self-sustaining and the participating teachers all seemed concerned about improving the teaching and learning of science in their own classrooms. Although all the teachers in this cluster participated actively and collectively, it is remarkable to observe that they had never discussed nor agreed on a definition of what a cluster is. They all had their own working definitions that focused on what their priorities in clustering were. Consider the following discussion with one of the participating teachers about their cluster:

Interviewer: What would be your definition of a cluster?

Nomsa: *A cluster I can say is a group of people based on educators that you know well that meet together to share ideas and try to support one another, so that they can perform better individually in their classrooms.*

Thulile: *A cluster is a small group from one particular group like we have a circuit then the schools within a circuit can form different clusters for operational purposes. Schools that are nearer to each other whether they are from the same circuit or not.*

Nkululeko: *It is a smaller group of individuals trying to share information.*

From these responses grappling with the definition of a cluster, it becomes clear that the major foci of these teachers are on: support, location of the school, sharing of information and the group. These responses confirm the findings of the research by

Grolnick and Lieberman (1988) who studied a total of about 16 teacher networks. Similarly for the teachers in the Grolnick and Lieberman study, the teachers in the clusters all had different conceptions and definitions of what they considered a cluster to be. . In spite of these differing conceptions of what a cluster is and/or is expected to do, the teachers in the Sibonelo cluster were able to collaborate and share. The common denominator for them, like the teachers in the Grolnick and Lieberman (1988) study, is the sharing of CK and PCK. This is where the Sibonelo cluster differs slightly with the Dominant Internal cluster, whose purpose was officially to promote sharing among the teachers but which practically, as discussed earlier, functioned as more of an administrative arm of the MDE.

5.4.2 Challenging the structure through collaboration

The agenda for the next meeting of the Sibonelo cluster was based on the topics suggested by the teachers themselves, unlike the first ones where Joe had initially suggested the topics. This took place, as usual, on a Saturday. Joe was present at this meeting, and I was also a participant observer at this meeting, mainly for researcher purposes. On this day of the cluster workshop, a whole day series of lessons were conducted for the learners. The purpose of this meeting was to put into practice the changes and the plans that had been discussed collaboratively by the members of the cluster, in the real classroom setting. The feedback and the proceedings from these lessons would help the teachers to improve their PCK. Each school, from where the participating teachers came, had been requested to select and send 25 learners in the Grade 12 class for the extra Saturday lessons. This approach, of discussing the ideas in a cluster meeting first and then trying them out with some real learners in the classroom became the 'ethos' of this cluster. The collaboration of the teachers involved preparation and modification of the lesson plans, sharing equipment, exchanging examination question papers and co-teaching with each other on some specific topics. In setting the scene for the next section, I explore this collaboration by describing my experiences as a participant observer at one of the Sibonelo cluster meetings.

A verbatim transcript of a recording made during the visit to the Sibonelo cluster captured the conversation below:

In this conversation, I wish to draw attention to how the Sibonelo cluster became a rich opportunity for the teachers to challenge and (potentially) change their CK and PCK.

Interviewer: Can you give me one good example that shows that you have been successful in achieving your goal?

Peter: *I think it's different because there are many people now with different opinions because you find that if we are three schools we arrange the meeting and when you come to a meeting you found that there are only two educators from a cluster because the others are combined schools and they are in groups. So if you share ideas with two or three other people; you benefit a lot. There are many things that we usually do, like the methods of introducing the topic that is why I think the cluster helps us a lot.*

This response values the cluster effort of meeting and sharing ideas that are aimed at improving teaching and learning of science. The more people attending the cluster meeting, the richer the ideas and experiences. This notion of sharing teaching strategies was further mentioned by Dick, one of the cluster leaders who visited Sibonelo cluster to watch and observe what they were doing:

I think it is very true because you see we learn, we learn an idea from person who is practically involved like as I said in the beginning you learn new ways of introducing a topic. Once you are having your own method and it is from one person your experiences are not enriched but if you share amongst yourselves you share how you will introduce this topic. We are also free to talk with each other. When there is someone from outside we have fears of being seen as stupid and not committed. When you are with a friend it is easy to tell peers about the particular topic that is giving you problems and it is easy for them to help you.

Interviewer: What makes you to meet on a Saturdays?

Respondent: Because we want to support each other……but if we are told by somebody senior to come on a Saturday we will not come. We support each other on this is how I teach this …. and this is what I have done in my class .The kids will experience the real experiences from different

> *teachers. When they meet on Monday at their various schools they will be talking about those teachers…..hey…. they were good.*

This cluster leader linked the value of their clusters discussions and activities directly to the classroom practices. Their target is to change classroom practice through sharing and discussion among peers. Furthermore, he linked the benefits of clustering to changing teachers' confidence and self image. The stuff that makes for the teachers' identity. The key to the Sibonelo cluster was the sense that the participating teachers had that they were benefiting from interacting with each other about classroom practice.

5.4.3 Sibonelo cluster teaching

Other than meeting and discussing ideas on Content or Planning lessons together, or even observing each other practice the lessons, the Sibonelo cluster also conducted actual teaching sessions as an important part of their learning about CK and PCK. is one of the activities. The cluster members conducted lessons for Grade 12 learners from different schools in the area, once a month. The purpose of the cluster teaching is to test the ideas on CK and PCK that were discussed and observe the changes that follow in the actual classroom setting. . The members of the Sibonelo cluster call this the 'Cluster Teaching.' I now discuss a typical session during one of my visits and observation of Cluster Teaching:

It was a Saturday morning, the first weekend of the month. I came to the school at 7:40 in the morning. As I looked at the surroundings, the buildings were not striking in any way. There were students all over school and a few goats grazing along the edge of the school lawn. There was also a small kraal where there were two cattle and a hen and chicken were running around the schoolyard. I had not been told that the school was an agricultural school and thus was a bit surprised by this co-existence between humans and animals. There was no decent parking space at the school, as there were trees that had big roots protruding all above the ground. This was the school where the teachers in the Sibonelo cluster has chosen to come together and conduct lessons for the selected groups of learners. As I was passing through the gate, fifteen minutes before eight, two minibuses full of students and an open truck overloaded with students also arrived. They were singing, laughing and were all in their casual clothes (as opposed to wearing uniforms on a normal school day). I parked my car under a tree, and as I was coming out a gentleman came and led me off to the staff room. In the staff room, there were long tables that reminded me of the days of Sunday school classes. These were covered with plastic cloths. It was clear to me that this area was rural and very deprived as there was no other building nearby.

Two teachers were busy discussing and debating about the topic on velocity. Another teacher was trying to find out from a colleague how this topic was usually introduced. I captured some of this talk in my field journal, as no one seemed to notice my presence. One of the teachers responded by saying*, I think I will start of with the concepts associated with velocity as a brainstorming session for a few minutes*. The second teacher responded by saying: *doing experiments first will be better so that the learners will see and learn the concepts as they observe them.* The first teacher that had asked for the introduction responded by saying, I *think I will try your way of introducing this topic but if it does not work well then I will use my usual approach*. Both these teachers were writing some notes, which I could see clearly from where I was sitting. 210 learners from the six participating schools were expected to attend the academic activities planned for that day. Talking informally to the teachers, this was the third cluster teaching workshop that year. They usually scheduled four such workshops per year.

The teachers had prepared volumes of handouts for the learners in the form of worksheets and notes. The teachers appeared ready to teach as the learners were divided into six groups. Each group of learners was then moved to a different classroom.

Six classrooms were used. Six teachers were to rotate amongst the groups, handling one-hour sessions, each covering their own assigned topics. The cluster leader moved between classrooms monitoring what was happening during the teaching activities. He also had to distribute the late-comers (students) amongst the groups in order to balance the numbers. He seemed very helpful and organised, and even prepared a timetable for me to visit the different classrooms during the sessions. Part of his reasoning was for him to let the teachers know when I would be visiting their respective sessions. Observing and visiting the classrooms did not seem to worry the teacher at all. The cluster leader explained to me that they encouraged lesson observations by outsiders as well because it strengthens their confidence in the lesson presentations. I sat and observed and took notes from one classroom to another as the lessons progressed.

5.4.4 Classroom experiences

I went to the teacher allocated group one, which was packed with 48 learners seated in long benches and desks in rows. Raj was presenting the topic of velocity. He had a couple of apparatus on one of the desks in front of the class. He started of by distributing worksheets to learners that had a summary of what he was going to handle and the questions to be answered by the learners. Learners were given 15 minutes to complete the worksheet. They were made to exchange the worksheets and check on each other's responses. Raj thereafter demonstrated to the class by using the apparatus that was provided in class.

As the learners were responding to the worksheet, he showed them the concepts using the ticker timer. In some cases he used his (foot) paces to demonstrate the idea of motion. Learners were given a chance to ask questions which were often directed (by Raj) to the other learners for a response. Raj distributed the handout notes to the learners and moved to the next classroom. I also moved to another classroom at the same time.

The teacher in this next classroom was presenting a chemistry lesson on the reaction of group seven elements (Halogens). Handouts in the form of worksheets were given to the learners. The teacher made the learners identify these elements on the periodic table. They repeated these elements from a periodic table in a chorus form as he was pointing on them (the elements) in their order. He had already prepared some chemicals that were brought into the classroom and they had very distinct colours. These chemicals were kept in a test tube rack and were labelled with white paper written in black pen. The colours of the chemicals varied from white to violet. The reading on the labels indicated the following: Iodine, Fluorine and Bromine. After which the teacher demonstrated and discussed the experiments making use of the other test tubes to show the reactions. As the teacher was demonstrating to the learners doing the experiments, the learners responded in the worksheet provided. The teacher used question and answer method to reinforce the important concepts like reactivity series. The learners' participation was very good in that they asked questions on the colour changes and did manage to discover the relationship and the order of these elements on the periodic table. Towards the end of the lesson, the teacher intended to relate the scientific concepts to the everyday experiences of the learners. Here is a segment of the lesson towards the end:

Teacher: *Look at these household chemicals and tell me what they are. (the teacher displayed a tube of toothpaste, a bottle of bleach, table salt and a dark bottle with some liquid.)*

Fikile: *Fluoride toothpaste, salt with iodide, chlorine and iodine ointment.*

Teacher: *Excellent! What do we use these chemicals for?*

Tim: *We use them for cleaning. We clean our teeth, clothes and we make our food tasty by sprinkling salt .Eh……I don't know the iodine solution.*

Teacher: *Iodine solution is used as an antiseptic to clean the throat…*

Fikile: *Why do we say fluoride toothpaste instead of fluorine tooth paste, what is the difference?*

Teacher: *It is one and the same thing but the other one is different, your textbook will tell you the differences. You must read chapter 7 on halogens you will know and you will tell me next time we meet, If it is not explained there, I will explain to you next time.*

Tim: *All these household chemicals fall under group 7 elements but at home they are not put together why? You cannot put salt and bleach together.*

Teacher: *Some of these households are strong dangerous chemicals and the others are not, they can therefore not be kept together*

It was clear from this lesson segment that the teacher struggled with the presentation of the CK and to relate it meaningfully to the learners' experiences. During the lesson, the teacher presented the content knowledge as facts and never considered the learners' questions. As this classroom experience occurred during the Sibonelo cluster workshop, the teacher was able to take his classroom experiences to the cluster meeting during the reflection session. The cluster members engaged the discussion and clarified the difference between fluorine and fluoride in a meaningful way for the teacher who raised the question. Their explanation centred on the fact that the fluorine is an element and the fluoride is a compound. The cluster members explained even other ways of explaining these differences by using the periodic table and by taking each of the group seven elements and show the halides. It was clear to me that the opportunity provided by the cluster to share experiences helped the teacher to understand the content knowledge better in a larger professional context that enabled him to learn from his peers. This was evident when all the teachers gave their views and suggestions on this issue. At the end she actually led the discussion by saying that, "from your explanation I now know that iodine halides will be iodide". The collaboration in the cluster placed this teacher's classroom experience centrally in the context of their professional development as it was shared and discussed with the other teachers. The teacher identified the gap in his CK and PCK, which he tabled for discussion during the reflection session in the Sibonelo cluster.

Talking to this teacher after the lesson, he explained to me that although he was familiar with the content of the lesson, there was more he still needed to learn on the content and how to teach it: *I have taught this lesson several times but I still want to learn, more on it,* he said. I discovered from the interview with him that he had just joined the Sibonelo cluster and he was still learning from the other teachers on how to present learner-centred lessons. When he met with the other teachers (for a reflection on his lesson) he had already written some points of improvement that he shared with me before the reflection meeting.

These included: *I will allow the learners to do experiment themselves; I will show them the household materials first and ask them to identify the elements on the periodic table. They will be given a chance to complete the worksheet while they are doing and observing the chemical changes. I will write the chemical equations on the chalkboard to reinforce the chemical formulae.*

Reflective teaching is about focussing on one's own teaching with the aim of improving classroom practice. This was evident when I talked to this teacher about his experience of teaching the chemistry lesson. Since the teacher had already identified his shortcomings in the lesson, it was easy for the other cluster members to endorse his thinking on improvements and to give recommendations during the reflection session. Reflection is therefore a critical component of the strategy of the Sibonelo cluster. Such reflection enables the cluster to focus its sharing and discussions a lot more on the relevant issues for learning and development.

My next experience in the Sibonelo cluster was in a class next door where the teacher was teaching acids, bases and salts. The teacher had household chemicals and the worksheets that the learners needed to respond to. You would have thought that it was going to be a cooking session or home economics, as there was a basin full of water and a variety of vegetables and plants. Amongst those, I identified the carrots, beetroot, red cabbage and some flowers. Learners were working in-groups of four performing experiments following the worksheet. The teacher facilitated discussions in-groups in a very unique way as captured in the following segment of the lesson:

Teacher: *group one, discuss how the experiment is conducted and share your results with group two. Group three discuss your experiment with group four. Each group should come with one example of results that differs from theirs.*

Group one: *the colour changes are different from ours, we think (group two) they cheated.*

Group three: *the red cabbage colour did not change, why?*

Teacher: *You must now work together as two groups and come out with the reasons.*

Towards the end of the lesson, the teacher summarised the learners' responses and closed the lesson. When the bell rang for lunch, some learners were still working on the experiments rewriting and verifying some information from the teacher. The teacher asked a group of girls to collect the test tubes and wash them before the next, lesson begins after lunch.

When I talked to this teacher about his lesson, he was excited about it and felt that he would not change anything:

I am very happy my lesson went very well, thanks to the team members. I want my learners to work together and help one another. Science is a practical subject that needs to be proved and be investigated.

It was clear from this teacher that collaboration and peer learning from his colleagues in the cluster has also been extended to his own classroom. He was adamant in his beliefs on group-work and collaboration even in his own classroom practice.

The collaboration of teachers and the learners during teaching in the cluster was further extended to their schools that had to pay R30 for each meeting. This money covered refreshments and the stationery. Over and above, each school was expected to send a ream of photocopying paper for its learners' notes and worksheets to the hosting school prior to the teaching sessions. The lunch took less than forty-five minutes for teachers because they were already analysing and reflecting on some of their presentations in class. They continued to talk informally during lunch about the learners' responses and their participation during their sessions.

5.4.5 Challenging CK and PCK through reflection

At the end of the last lessons for the day, all the teachers gathered in the staff room for a reflection meeting. The chair of the session invited the teachers to comment on the following questions based on their lesson topics:

- What worked and why?
- What did not work and why?
- What could be changed and how?

Reflecting informally and jokingly, Musa, one of the cluster members mentioned to me that his learners did not participate freely because of my presence in the classroom. *I gave them individual work instead of group work and they failed to concentrate on their work.* Although the comment was meant as a joke, it made me reflect on my presence in the various classrooms. I later found out, however, that the learners were used to having more than one teacher or adults in the room.

Observation and sharing among the teachers occurs all the time in the Sibonelo cluster.

Lindiwe, one of the three women that were members of this cluster, also mentioned how she enjoyed the participation of learners in her chemistry class. *"They all participated well. I wish I could have them for more than one hour*," she reported.
Her comment clearly indicates the positive feelings of a teacher who felt she had achieved something and was free to share it with the cluster members. She could not wait for the formal reflection meeting of the cluster.

At the formal reflection meeting she started by saying: *Hey guys, I had a very wonderful day today. Everything went as planned until the time where I had a mind block on differentiating between Fluorine and fluoride. I felt that my knowledge on the halogens was limited. I was worried about it and I had to consult before this meeting some members who explained to me the differences. When I met the two other classes that were taught after lunch I became an expert. Thank you colleagues for helping me.*

Mandla asked her to explain how she taught the session before break and how she taught the sessions after break. She stood up and made use of the periodic table that was hanging on the wall. She pointed out the halogens and mentioned the atomic structure of each element. She made emphasis on the fluorine and drew the energy levels to show what happens when the processes of ionic bonding takes place.

Similarly another teacher reflected on his teaching as follows:
Sihle: *I did well and followed our plan but the time could not allow me to handle all the things we had agreed on. We need to review our plan and take into consideration the concepts that needed to be explained in the classroom. The learners find it very difficult to understand the issue of a PH value. I had to clarify it for them. Some of the indicators that I had did not show clearly the colour changes.*

Thoko responded by suggesting that: *when you do the same activity in class next time it helps to bring a colour chart and some of the experiments that you have done on colour changes so that the learners can compare theirs to yours.*

Ingrid: *I do not think it will be a good idea to bring samples of experiments that you have already done, the learners might think you are cheating. It is better to explain why their colour is different from the one they see from the book. The difference might be caused by the weakness and the strength of the acid or something else.*

The other teachers also felt that their sessions went well and appreciated the work that Mandla as a leader did to make the meeting successful.

I asked Mandla whether he enjoys the task he was performing as a leader and his response was:

Every one of us should taste what it is like to be a cluster leader. It needs responsibility, planning and co ordination.

This responsibility of a cluster leader included the organisation of learners to be at the school where the lessons are taught. The participating schools rotate in hosting learners at different schools for their cluster teaching lessons. The other main responsibility for the cluster leader is to compile lesson plans during and after cluster meetings as agreed and approved by all teachers in the cluster. It became clear that the cluster leader considered the support he had from the teachers in his cluster as key to his role as a leader. He described a cluster as *a group of dedicated teachers that work together to improve the way they teach science in their schools with the aim of improving the learners' performance.* His conception of a cluster places emphasis on the dedication required from the teachers and the collaboration for the improvement of learning. His definition and understanding of a cluster is informed more by his participation in a voluntary cluster engaging peers in strategies that aim at improving classroom practice working directly with real learners.

Some of the key successes of this clusters as mentioned by Mandla were:

- talking and sharing of classroom experiences ;
- trust and respect for each other as professionals and adults
- belief that everybody has something to contribute that could improve your teaching;

- work as a team and commitment to the tasks of the cluster; and
- regular attendance.

Indeed, as a regular participant observer at the Sibonelo cluster, I was able to observe many of these qualities and values in action.

5.4.6 Challenges of Clustering for the Sibonelo Cluster

Besides the CK and PCK issues that were addressed at the Sibonelo cluster teaching, there were other administrative issues that needed to be clarified by the cluster leader. The challenge for the Sibonelo cluster was not only about setting dates for the cluster meetings but also about collaborating to organise successful cluster teaching sessions. This involved not only working with a limited group of teachers who participate in the cluster, but also coordinating with the respective schools for the selection and transportation of the learners to the selected venue. Since the cluster leader at Sibonelo cluster shares his leadership tasks, these issues were usually discussed by all the members and decisions were taken collectively. A model of collaborative or distributed leadership (Spillane et al. 2002) seems to be operative in this cluster with all the participating teachers not only taking turns but also sharing the leadership tasks and decisions with the cluster leader.

Secondly, a constant challenge for many activities of teaching and learning generally involve time. Time allocation for the different lessons posed a particular problem both for the teachers, who were themselves learners in this context of professional development and for the learners. Growth and development are processes that require a great deal of time investment. While the cluster leaders had chosen Saturdays to allow themselves more time to learn and engage with students in real contexts of teaching, many of them still found time to be a limiting factor in what they wanted to do in their classrooms and specifically for what they still wanted to learn and improve about their own practice. It is therefore important to remember that while the Sibonelo cluster seemed to be successful in many ways, with more time the benefits of clustering could even be more obvious.

Thirdly, certain external factors also made the development of the cluster difficult. The prevailing norms and policies of the MDE worried the teachers as they were also expected to a part of the Dominant MSSI clusters that were formed according to departmental circuits. The Sibonelo teachers were, however, very critical of the dominant clusters in the province. As one of the teachers put it:

Very little content knowledge is discussed at the department's cluster meetings. It is all OBE or CASS moderation. We need content knowledge in order to improve our classrooms.

Their collective criticism of the Dominant Clusters and commitments to the Sibonelo cluster led these teachers to make a decision to keep the Sibonelo cluster separate from the MDE cluster and rather sacrifice their time and attend both. They took responsibility to be all accountable in case they were taken to task by the senior department officials. *We are to continue as before even if we have to meet every weekend*. explained one of the teachers who had been a participant observer. This commitment and dedication towards the cluster was affirmed by one of the teachers, Donnie who said:

for instance, I am new in this school I joined them this year. I have never taught grade 12, so from the help of this mall group I have leant so much. I can come to a cluster leader anytime and he can help us. I was not very clear with Newton's Law, I am now confident about it. We have no support from the department whatever, whatever…. But as educators we are volunteering to work during our free time.

5.4.7 The Sibonelo Cluster – A Re-examination

Looking at the activities that the members of the Sibonelo cluster did, the cluster seems to have succeeded in giving the members the opportunity to construct knowledge by sharing their teaching experiences on such topics as Velocity, Acids and Bases, Halogens and Motion. The sharing by the teachers relied more on the *knowledge in practice* that the teachers shared. This means that the teachers shared their classroom experiences as knowledge that they practice in their classroom. This knowledge *(knowledge in practice*) was further refined and developed through debates, conversations and dialogues as illustrated earlier. It is these processes of dialogue and debate that helped the teachers to push and challenge their CK and PCK and consequently their classroom practices as well. The teachers in this cluster had an opportunity to share their practices and to restructure their ideas by exchanging ideas on how a specific topic could be taught better. The differences and the similarities on teaching ideas with others and possible contradicting ideas contributed to each individual's CK and PCK. This, in brief, is the theory of how new knowledge was constructed using the social constructivist learning approaches where the teachers collaborated on producing new knowledge for their teaching. As the Sibonelo cluster gave the teachers a chance to try out their changed ideas in the classroom in a variety of situations, they were afforded a rare opportunity to continuously review their practices based on the ideas discussed prior to the lessons (Driver and Oldham,1986).

While the Sibonelo cluster was formed by Joe, an outsider, with the aim of improving the teaching of science, it is clear that the teachers in the cluster quickly developed ownership and commitment to it. Their participation in the cluster was entirely voluntary. The participating teachers did not mind coming in to teach and learn on Saturday. Furthermore, over a period of time, the teachers have begun to develop trust and mutual understanding of each other through sharing and by creating opportunities to practice what they do and believe in. As a consequence of this trust and respect of each other, a culture of collegiality had been established and practiced in the cluster. Hargreaves (1989) described collegiality as being characterised by initiatives such as joint planning, mentor teaching and peer coaching. In other words, the Sibonelo cluster is better placed to fulfil the form of collegiality that is based on voluntarism and collegiality as described by Hargreaves (1989). In order for teachers to change their attitudes about themselves, their ideas need to be acknowledged even when they are not correct. The role played by Joe in this cluster provided the necessary guidance, support and assistance on organisational skills needed to run clusters and the skills to learn from one another through sharing classroom experiences; reflecting on these experiences; making changes and modifications; and practicing in the real classroom situation.

The Sibonelo cluster members were meeting on their own accord based on the needs of the members of the cluster. As one member of the cluster commented: *as long as I* *teach science in my school, I will continue to come because I learn a lot from my colleagues.*

The kind of knowledge and expertise that were created during the reflection sessions did not end up only at the cluster meetings but was taken further into the classrooms during the teaching of the respective topics. Learners that attended some lessons conducted at the Sibonelo cluster mentioned that they had never used science equipment at their respective schools and therefore benefited from the cluster meeting as well through exposure to more refined and discussed ideas of the teachers.

Adams (2000:165) confirms this notion by saying, "networks facilitate implementation to the extent that they foster professional discourse, which lead to a common definition of practice." The major trends in establishing a fairly successful cluster emanating from the in-depth study of Sibonelo highlights the importance of

- Voluntary participation in a cluster
- Learning from each other as classroom practitioners
- Focus on content knowledge and how to teach it in the classroom
- Reflective practice for improvement on classroom practices
- Continuity in attending the cluster meetings and
- Ownership and belonging to this cluster

5.5 Comparing the two case studies

The study presents two case studies of science teacher clusters and examines the interactions and mechanisms by which the clusters constituted resources for teacher learning and improvement in teaching practice. The major findings of this research are that teacher clusters indeed provided better resources for changing classroom practices of science teachers by allowing them to focus on specific CK and PCK. The interactions that we saw in the two cases are different. In this session I attempt to contrast and compare these interaction processes.

Five issues of comparisons became a point of focus on my research findings on these two cases. In the analysis I make the case that the two cases are similar when we explore them from the point of view of opportunities provided for teachers to meet as peers and to break isolation from schools. They are, however, very divergent with respect to needs of the teachers, collaboration, commitment and autonomy. To illustrate, let us examine the issue of providing opportunities for teachers to meet as peers. Teacher development programmes have isolated individuals in identifying, prioritizing and finding ways of meeting their developmental needs in a collective of peers as professionals.

Fortunately, both clusters provided such opportunities in clusters. Unfortunately the part played by the teachers in identifying professional development needs, making choices about priorities for meeting those needs and about the appropriate methods to be adopted to meet those needs is significantly different in each of them. In a SIM cluster teachers acted in specific subject matter groups and responded as both individuals and a collective. This is, of course an ideal approach to professional development. In contrast the Sibonelo cluster is characterized by the extent to which teachers make choices about needs, priorities and provision at the group and at the individual level. In this cluster, choices form part of a coherent and planned process of school development. There was substantial evidence that through the opportunities provided by the Sibonelo cluster, there was an emerging strong sense of ownership of the INSET by teachers and the view that the training was far more relevant because it was directly related to content issues. This issue of relevance was captured from the Sibonelo cluster as one of the participants expressed her thoughts:

what is valuable for me in this cluster is the relevance of the content as it also considers the departmental pace setters. The cluster will deal with the needed content for the month.

Although this teacher see the value of participating in the cluster, her response suggests that he participates in order to solve the immediate programs of CK and PCK.

This sense of ownership and relevance was strong resulting in teachers assuming increased responsibility for their own personal and professional development which in turn was releasing considerable impact and professionalism in many schools visited. As eluded by Brown, (1989) that "in such a system teachers determine their own needs and looked predominantly to higher education and teacher centres to meet with consequent problems of relevance and transfer application of learning to their work settings" This statement implies that teachers know their needs better than anybody else and that they are capable of searching for help if needed outside their territories, but knowledge is not imposed on them. On the other hand this statement is pointed out by Stones; (1994:9) that current practitioners' skills and knowledge are confirmed to their own experiences and therefore are limited. The implication of this statement is that teachers themselves know the limitations of their CK and PCK based on what they do in their classrooms .However, I still think that teachers need experts to validate the quality of CK and PCK on what goes on in classrooms. This is where the presence and the participation of an outsider become valuable.

The Sibonelo cluster expressed the issue of ownership as most participants referred to this cluster as, our cluster and our cluster leader. This was further observed when the participants organized the classrooms, cleaning and helping one another in setting up apparatus in classrooms before presentations .There was little evidence of ownership associated to SIM cluster. The teachers at the SIM cluster focused on the task that needed to be done and the instructions that were to be carried by the group. This was due to the group approach to teacher development linked to the specific tasks that needed to be done at this specific workshop.

Many scholars have argued that for teachers to improve their classroom practices they should be competent in their content knowledge (Senge, 2000; Ovens, 2000). The major issues to examine with respect to teacher competence in subject matter are the content and pedagogical content knowledge. Lieberman and Grolnick (1989) argue by saying," teachers have not yet develop a tradition of sharing their own expertise among themselves". This view still implies that teachers are familiar with those training where experts come and tell them what to do and how to do it Fortunately, the two case studies described in this study have allowed us to look at these issues with fresh eyes as illustrated in the discussion below:

In the SIM case study, CK and PCK was explored by a group of teachers teaching the same subject through sharing, discussing and reflecting on their classroom practices. Furthermore, the SIM case illustrates the issue much clearer when we draw out the fact that teachers have vast experiences on what content and how the content is handled in their own classrooms. Further the SIM cluster highlighted the shortcomings and the limitations of teachers' CK and PCK but the level and the depth of this knowledge was not known. This means that the opportunity provided by the SIM cluster enabled us to understand the depth of both CK and PCK of the teachers that participated in this activity.

Similarly, the Sibonelo cluster illustrates the fact that teachers can learn from each by sharing, discussing and reflecting on their classroom practices.

In the latter case study, the critical point to examine is the fact that sharing is a strong link between CK and PCK.

In a sense therefore, the two clusters represent two sides of the same coin in that they both explore content knowledge and pedagogical content knowledge with the aim of influencing the classroom practices. The idea of teachers changing classroom practices by exploring and sharing their experiences is further explored by Lampert (1988: 158).

In her work she summarizes the conditions under which classroom changes are most likely to occur, in the following way:

"Teachers change their practice when they can observe new practice being used in actual classroom situations, when they can try them out and get feedback on their attempts; when they can discuss new techniques with peers and when they can smoothly the new behaviours or new technology into their existing classroom routines". In analyzing this statement, basing it on the observations from the two clusters, we observed the following:

We observed teachers sharing with the colleagues how they have taught specific topics and the responses of the learners. In sharing this knowledge, the teachers thought deeply on what they have been doing in the classroom. This sharing challenged the daily practices of the teachers as they observed and listened to the experiences of other teachers.

This statement implies that when teachers are given opportunities to share, reflect on their actual classroom experiences they stand a good chance of changing their classroom practices. When they share and observe one another teaching as peers, their own practices are challenged up to the level of being changed. This process of debating and arguing on classroom practices was evident at both clusters. At the SIM cluster teachers changed their long standing beliefs on meaning and explanation of some of the concepts. For example, in SIM cluster some teachers in a biology focus group believed that the term photosynthesis is a product not a process. The discussion and the debates influenced the teachers' conceptual understanding on the meaning of this term as indicated in the previous chapter.

This observation at Sibonelo cluster confirms the issue of voluntary participation to clusters as eluded by Lieberman and Grolnick (1999). They acknowledge the success of clusters to teachers who meet voluntarily in order to explore content knowledge based on their needs. Louckes-Hoserley et.al (1987) also makes the same point when they argue that if science and mathematics teachers need to improve on their subject matter, they need to sacrifice their time beyond their teaching time. They should be engaged into communities of teachers that allow them to talk about their classroom teaching. From these cases, we have been able to contribute a perspective from a developing country on this issue. To date, there has been no literature on this issue that relates to experiences of teachers in the developing world.

5.6 Teacher collaboration

In the literature review, chapter 2, an argument was raised that across the world most teachers still teach alone behind closed doors in isolated environment of their own Hargreaves and Fullan (1992). What this mean is that teachers are working in isolation and have no opportunities provided for them to receive feedback on their value, worth and competence. The cultures of collaboration are not well organized. This study further explored this argument by investigating how the teachers in the two case study clusters collaborated in solving their problematic content areas without involving the outsider. My approach was informed by research conducted by Grolnick and Lieberman (1999) who studied 16 clusters.

In spite of the fact that both clusters were successful in creating such opportunities for the teachers to engage with one another, there were some subtle and important differences in how they went about creating these opportunities. In the SIM cluster for example, the dominant approach was orchestrated, managed and limited in its inclusiveness. It only involved a number of selected schools structured along the

MDE lines of authority and communication as either GET or FET and operating under the same circuit. The schools from two different phases were not expected to participate in the same cluster, despite the fact that they teach the same subject. This was for some of the teachers very limiting and contrived. As one teacher put it:

I prefer to choose schools and teachers to work with in the cluster because of their competence and the good results they always get in grade 12.but the department has already selected cluster for us. I am not comfortable to work with some teachers and other schools around.

This implies that the boundaries created by MDE in the dominant clusters were imposed to teachers. Here we see boundaries being drawn by MDE on knowledge and knowledge location which might frustrate other teachers. Hargreaves (1992) has discussed extensively the concept of contrived collegiality. He makes the point that contrived collegiality is always associated with bureaucracy as they do a lot of administrative work. In some specific ways, the SIM cluster, and the dominant approaches to clustering in Mpumalanga fall within this idea of contrived collegiality.

Contrived collegiality is often accompanied by frustrations, limitations and disappointment. Some of these limitations and frustrations were evident in a number of clusters that we observed in the province. For example, the programs and agendas for cluster meetings dictated by curriculum implementers and the nature of activities that needed to be done. Another respondent who was active in the dominant clusters for example, captured these feelings in the following way:

We hardly get time to do most of our needs because during cluster meetings there are always deadlines on CASS activities demanded by curriculum implementer as a result little time is spent on our subject matter.

It is clear from this comment that the teacher experiences limitations within this cluster because of the instructions that are imposed by the seniors in MDE.

In contrast of the first view Hargreaves and Fullan, (1992:226) talk about cultures of collaboration which are not formally organized as bureaucratic in nature. Contrived collegiality of this nature is informal as it accommodates the collaborative cultures of teachers, facilitative and do not evoke quickly. These collaborative cultures are assumed to be very unattractive to administrators looking for swift, quick expedients.

It was clear that the teachers from both cases were given the opportunity to meet and talk about their classroom practices. "Teacher networks provide a context within which members come to understand their practices, professional growth and development." Secada and Adajian, (1997:193). The research findings of this study demonstrated how clusters enabled teachers to work within the structure that caters for their specific subject needs and the gaps that exist in CK and PCK .However, the study investigated how the dominant clusters in the province were isolated from each other because of their organizational structures. One structure resembles the hierarchical structure of the department with a top down approach whereas the other one resembles the opposite.

5.7 The cluster operation within structure of MDE

As there are GET and FET clusters under the supervision and support of the curriculum implementer. The FET curriculum implementer supports only FET teachers. (As discussed in chapter four) The organizational structure creates barriers of learning in teachers within the same area and schools. These boundaries have an implication in the sharing and discussing CK and PCK that has a potential of changing classroom practices. While this structure breaks the isolation of teachers at the level of the school, it still maintains the barrier and isolation in terms of the circuits and school level. The theoretical issues here are based on the premises that teachers cannot develop themselves. They need somebody to develop them who know their needs and shortcomings. This issue is supported by Lieberman and Grolnick (1988), Louckes-Hoserley et al. (1987). These researchers still feel that teachers need support to 'articulate' their content knowledge.

5.8 The operational structure at the Sibonelo cluster

While the formation of the cluster was negotiated and created by an outsider, it was left to the cluster members to continue with its operation and policies. Policies are formed and agreed upon by all members. The cluster is not registered and it operates as one of the community structure with the bottom up approach. The cluster is teacher driven with no links with the department of education. For an example; during the interview with the cluster leader, he said, *We have a cluster policy that says that we* *meet twice a month for cluster meetings and once a quarter for cluster teaching on a Saturday we all agreed on this policy and we are practicing it.*

This is a clear indication that reflects the autonomy of the cluster on policies and issues that affect the cluster. This response shows autonomy and commitment to cluster activities. Taking into consideration the issue of teacher development in improving classroom practices, Fullan, (2001) argues that teachers too, have to have those opportunities of developmental process so that their understanding of what it is to be a mathematics educators in constructing knowledge. This statement implies that when teachers share, reflect and debate the content issues, new knowledge is constructed. This construction of knowledge is based on the experiences of teachers in the cluster

Networks are not a recipe to solving all the problems of professional development but only afford some opportunities for teachers to share their classroom practices and to focus on CK and PCK. There might be potential drawbacks of clusters relating to the quality and the richness of CK and PCK that is shared. In the Sibonelo cluster I observed a drawback where there are fewer external resources to support the work of the cluster. Although the cluster provided such rich opportunities for development, I am still not convinced on the quality of the CK and PCK and believe the cluster still has more room for growth and development in this regard.

5.9 Summary, Conclusion and Implications for further studies

In summing up my study I wish to examine further the nature and quality of the professional development opportunities that are provided by teacher clusters and how these opportunities are constructed to enhance and re-shape the teacher's and PCK in the classrooms. By contrasting and analyzing the findings from the two case studies of teacher clusters in Mpumalanga province studied in this research, I make the argument that clusters provide better opportunities for teachers to meet and share their classroom practices. Furthermore, the case studies provide significant evidence for the claim that teacher's CK and PCK, form the base of the new knowledge required for change to take place in teaching practice

5.10. Improving the Quality of Teachers' CK and PCK

Changing classroom practices to innovative approaches in science and mathematics involves, for many teachers, the learning of new kinds of knowledge, skills and attitudes in their subject matter (Cohen and Ball, 1993; Jita, 2004; Spillane, 2001). In South Africa, the problem of teacher change is complicated by the inadequate provision of opportunities for learning the new knowledge that is intended to influence the classroom practices of the teachers. Many of the current teacher development activities provided in South Africa, and elsewhere, have proved to be ineffective in providing teachers with significant opportunities to improve their content knowledge (Jansen, 2000; Kahn; 1999). Furthermore, Ovens (2000) draws attention to the fact that, despite the extensive literature and knowledge about the programmes that are necessary for changing classroom practices, researchers still know very little about how teachers enact these changes in their classrooms. A recent review of the literature on professional development of teachers has concluded that, detailed accounts of the gap in knowledge base of practicing teachers still need to be provided (Senge, 2000, Fullan, 2000, Adams, 2000). Little or no information exists on how this gap in knowledge base can be closed. This study has been an attempt to provide a possible set of insights on how such a gap in teachers' knowledge base may be tackled through teacher networks/clusters.

Teacher networks or clusters have been offered as a possible solution to the problem of ineffective professional development and the gaps between teacher learning in professional development workshops and the practice in their classrooms (Lieberman 1992; Lieberman and Grollnick, 1999; McLaughlin, 1999). Despite all the promises about the efficacy of teacher clusters, Gottesman (2002) points out that there is still very little empirical evidence on what makes this approach to teacher development (networks or clusters) effective and how this effectiveness is actually achieved in practice.

My account in this study, has argued that clusters or networks must be considered as a context that provides opportunities for teachers to uncover and improve the teachers' CK and PCK and thereby provide a fertile basis for teachers to re-examine their classroom practices in collaboration with their colleagues. That is, to understand the knowledge needed for effective practice, teachers have to be provided with opportunities and incentives to move beyond their own individual classrooms. This study has proposed that teachers' knowledge and expertise is best explored collectively with other professionals rather than exclusively at the individual level. Furthermore, as with the work of Stodolsky (1988), this study has affirmed that subject matter is an important and central component of the context for such collective discourse and deliberation by the teachers in a cluster or network.

It is in this light that this research sought to understand the opportunities provided by clusters or networks for teachers to explore and share their CK and PCK, in an attempt to improve their classroom practices. This study offers a particular way of understanding the depth of the content knowledge required by science teachers in practice, one that differs somewhat from what previous scholars on teachers' knowledge have presented. Most of the previous scholars have tended to treat teachers' content knowledge as if it was independent from the pedagogical knowledge (Hargreaves and; Fullan, 1992,) whereas their pedagogical practices are important because they shape their classroom practices. Consequently most of the teacher development programmes tend to focus on content knowledge that is lacking from teachers and underplay the ways in which that content knowledge is presented in the classroom. It is not enough to aim for the improvement of the content knowledge because the challenges that the teacher faces in the classroom might be the drawback, as highlighted by the experiment clips that we provided in chapter three of this study.

From this account on the dominant focus of the recent professional development initiatives, it is not very difficult therefore to see why the knowledge gap continues to exist in the classroom and why the strategies that are used have little or no chances of reshaping the teachers' CK and PCK. In this study, we have thus presented two cases that illustrate the potential for teacher networks/clusters to provide a viable alternative in trying to influence teachers' CK and PCK. The possible success of teacher networks/clusters seems to come from their character of providing the space for the teachers to (re)examine their CK and PCK collectively in a community of peers. Two major observations from the case studies in this regard therefore, are that: the clusters provided the community of peers who were available to listen, critique and support each other. Significantly, the two clusters discussed in the previous chapter clearly illustrated the other important strength of the cluster approach to professional development. That is, they not only allowed the teachers to come together and share experiences about their practice in the teaching of science, but allowed them to focus closely and specifically on Content Knowledge and Pedagogical Content Knowledge and the interaction between the two in order to improve classroom practice.

This is one of the prime successes of the cluster or network approach to professional development. This view on the success of teacher clusters to improve teachers' knowledge, by focusing on both the CK and PCK simultaneously has only been alluded to some small degree, by a handful of scholars who have studied teacher development opportunities in some first world countries (Guskey, 1986, Grolnick and Lieberman, 1988; Fullan, 2000, Adams 2000). Very little work has been done, as a follow-up, to test the efficacy of the cluster or networks' approach in this regard and even less has been done from the perspectives of a developing country. My study was therefore intended to contribute to these issues on teacher development and classroom change generally, but to do so also from a perspective and experience of teachers in a developing country.

The study developed a conceptual framework based on the work of Lee Shulman (1987) whose exploration of teacher knowledge focused attention on the various kinds of knowledge needed by classroom teachers to change their practices. Lee Shulman's concepts on CK and PCK were further extended in this study by drawing on the work of Cochran-Smith and Lytle (1996) who developed a conceptual scheme on the domains of knowledge that practicing teachers use to conduct their day-to-day classroom activities. The three domains of knowledge they identified are, first the knowledge that teachers acquire prior to teaching, then the knowledge that they use during teaching and finally the knowledge that comes from talking about and reflecting on their experiences at the developmental training workshops. Cochran-Smith and Lytle (1996) classified these types of knowledge domains as the 'knowledge for practice, knowledge in practice and knowledge of practice.' The major argument to come from Cochran- Smith and Lytle's work is that most researchers on teacher development usually cloud these different types of knowledge domains and are confused about how they relate to each other. The most important implication of their framework was in highlighting two levels of issues for teacher development and change. The first level relates to the opportunities for such teacher development and the second level relates more to the CK and PCK that teachers need to change their classroom practices. This notion from these researchers implies firstly that, there is a very strong relationship between the type of knowledge that the teachers have acquired over years through training and what goes on in the classroom. Secondly, that effective teacher development programs should attempt to tap on these knowledge in order to make sense of the new knowledge to be acquired. Teacher development programs should provide such opportunities that challenge and reshape teachers' knowledge.

5.11 The research design of the study

In the light of the qualitative research paradigm adopted for this study, I assumed that teacher clusters existed in multiple, intangible realities that should be studied holistically with respect to the role they play in influencing teacher's CK and PCK. In order to understand these realities in clusters, I therefore employed various research strategies and methods to gather and analyze the data. While some of the methods used were adapted from the works of other researchers and scholars who have worked on similar issues as focused in this study, the one innovation for this research was on its approach to generating and uncovering the teacher leaders' Content Knowledge and Pedagogical Content Knowledge during the SIM cluster. Our approach involved developing a set of instruments that presented the teachers with classroom scenarios that simulated actual learners' responses and discourse on some specified topics of content. This strategy of data collection enabled the participants to focus on the strengths and weaknesses of the learners' arguments and Content Knowledge which allowed us a window into the teachers' own Content Knowledge. It became clear to us that the teachers had to think deeply about the subject matter when they were challenged to come up with ways to intervene and redirect the learners' learning in the Case Scenarios. In many ways therefore, the classroom scenarios instruments used in the SIM Cluster directly assessed the level of the teachers' CK and PCK. Our approach to uncovering the teachers' CK and PCK was in contrast to what most researchers usually do when they give tests and questionnaires to teachers in order to asses their Content Knowledge. While such tests of teachers are problematic for various moral and professional reasons, on the research front such strategies often suffer from their failure to uncover the PCK in addition to the CK. Furthermore, the strength of our approach was in its provision for the collection of data at two levels. The first level was the level of the individual teachers' CK and PCK, which was captured and documented at the workshop as the first task of the activity as indicated in chapter three of this thesis. The second level of data collection involved the collection of data for the entire cluster. That is, where the focus was on understanding the collective CK and PCK that was generated by the (cluster) group, which in this case was the second activity as indicated in chapter three. Other than allowing the researchers to uncover the level of CK and PCK that the participants brought to workshops, it also allowed for an understanding of the changes in this CK and PCK as the discussions and collaborations took place amongst the teachers. The value of the processes of collaboration of teachers was emphasized in the various changes that could be catalogued in terms of the individual versus the collective responses at the SIM cluster.

The reliability of the data collected in this research was made possible through a process of triangulation from the observation data collected during the field visits, interview data with multiple participants, stakeholders and through the analysis of various documents relevant to the study.

5.12 Key Findings of the Study

One of the most critical contributions of this study is in its ability to share light on the structuring and operation of the teacher clusters as opportunities for teachers to improve their CK and PCK and thereby begin to reshape their classroom practices. While it was evident from the case studies discussed previously, that teacher clusters do begin to provide teachers with the opportunities to meet and discuss classroom practice as peers, it was important to note that learning and changing of views and ideas in the teachers did not come from the university experts but from the participants themselves and/or the organization and leadership of the cluster. This finding on the differential benefits of the cluster to the participating teachers is very important if clusters/networks are to be considered for a broad scale program of professional development of science teachers in South Africa and elsewhere.

It is important to dispel the assumption that clusters are monolithic and their benefits similar to all the participating teachers. A certain level of personal investment, and opening up seems to be the one condition required of the participating teachers. Furthermore, an enabling structure and leadership is another critical ingredient for success in clustering as contrasted in the two case studies discussed earlier. The teachers' commitment to the cluster and its activities and the benefits of such clustering to helping teachers to challenge and change their CK and PCK seem to be mutually reinforcing factors in this instance of professional development. As a consequence the better organized the cluster was, the more beneficial it was to the participating teachers and the more committed the teachers became to the cluster. While this may seem obvious, the present research has explored case study evidence to explore how these collective benefits of clustering seem to come about.

As discussed earlier, another key finding was in respect of the ability of the clusters to help surface for collective discussion and scrutiny, both the CK and PCK that the teachers need for classroom change. It is this articulation between CK and PCK which most teachers seem to be unable to orchestrate on their own. It is also in the latter where most professional development programmes fail. We should not be surprised therefore by the observed failure to change classroom practice in spite of large investments and expenditure on professional development programmes. The failure to help teachers articulate between CK and PCK may be the biggest culprit in this regard. The two case studies begin to demonstrate how it is possible to orchestrate this articulation in the different aspects of the teachers' knowledge base for classroom practice. Against this background, teacher clusters may provide a better alternative for interventions designed to foster classroom change.

Further, another critical finding with respect to successful opportunities created through clustering was in respect to the opportunities provided to practice in real world settings the skills and innovations resulting from an intervening programme of professional development. In the case of the SIBONELO cluster, for example, and to some extend in the SIM cluster, the teachers were provided a number of opportunities to carry out in practice under supportive guidance of colleagues what they may have learned during the development sessions. Teachers worked with real learners in trying to test out aspects of the reformed practice they had developed with others in the cluster. It is this element of practice that seems to be lacking in most professional development interventions. My account in this study suggests that teacher clusters provide opportunities for teachers to share their CK and PCK as mentioned earlier on, but the nature of the opportunities varies from cluster to cluster. Some of the research has established that effective teacher development programmes are those that enable teachers to link the training with classroom practices (Shulman, 1987; Lampert, 1989; Dennis, 2000; Jansen, 2001). Fullan, 2001 refers to this process as learning and unlearning new knowledge and the modification of what is already known in practice. Focusing on the teachers CK and PCK in clusters make sense because that is the only tool that teachers have to convey their subject matter. Unfortunately, Wilson and Berne (1999) still maintains that fewer projects had explicated their theories of how teachers learn and what professional knowledge was acquired. The evidence obtained from this study partly responds and adds value to the few projects that document the professional development opportunities that have a component of practice in them. In looking at the characteristics of the two cluster types, that help to create better opportunities for teacher change we observe that the structure of a SIM cluster was designed by the experts from the UP to uncover the CK and PCK by using scenario clips instruments that are based on the responses of the learners. The participation in this cluster is compulsory; therefore the cluster was directly driven by the experts. However, the context of development was based on classroom practices that allowed the cluster leaders to reflect on their own classroom practices. It is this process of reflection that reshaped and influenced their CK and PCK. The evidence was captured and documented as evidence of this change. The strength of this cluster, is the richness, in depth and quality of CK and PCK that the experts were able to offer to help in reshaping the participants' CK and PCK. The weakness of this cluster approach on the other hand, was its failure to put the reshaped CK and PCK in a real classroom situation and to test what works and how it works for all of the teachers that participated in the SIM cluster. Although some of the participants implemented the ideas in their classroom, there was no formal follow up to establish clearly why and how it works from the cluster to the classroom, except the two teachers from the SIM cluster. This was due to limited time available and the shortage of resources to travel right across the Mpumalanga province in order to observe the lessons.

As a learning experience from this study, there are two critical resources that teacher developers should take into consideration; one is *time* and the other one is the *field of experimenting and learning in the classroom*.

In re examining the external cluster model, Sibonelo cluster provided an alternative approach to teacher clustering which was embedded in community structures. It is teacher driven, the meetings are voluntary and it has a strong context of activities that are based on what happens in the classroom. While the participation is voluntary, there are policies that guide the cluster that are followed by all the members. The leadership of the Cluster Leader was critical in the success of the Sibonelo cluster. While the cluster leader was critical in leading the cluster as a resource person, his CK and PCK were no better than the rest of the cluster members. In one sense, the quality of the CK and PCK in the Sibonelo cluster could be suspect, but it was really the collective insights that made this clustering useful. The individual teachers playing role of leading the topics where they felt comfortable made the task of the cluster leader effective. Furthermore, the strength of this cluster is in the fact that the CK and PCK of the individual teachers is challenged and discussed openly during the cluster meetings but that the resulting collective insights are further tested in a real life classroom situation. Further improvement and refinement of CK and PCK is thus made possible based on what seemed to have worked and/or did not work in the classroom. The collective reflection before and after the teaching is yet another major strength in this cluster. The challenge that faces this cluster is to foster links with the outside agencies like universities and other similar institution and structures for support to further improve and refine the quality of CK and PCK of the participating member teachers.

In summing up the implications of this study, I refer to Stein, Smith and Silver (1999: 241) who describe what they call a new, more transformative paradigm for professional development. They point out that teachers will need to relearn aspects of their practice to counter their own prior learning experiences: Teachers need assistance that focuses on their day-to-day efforts to teach in new and demanding ways. This assistance must be embedded in or directly related to individual, daily practice. In this study, we have illustrated through the two case studies how it is possible to locate such teacher support and learning within the context of teaching and learning through cluster efforts and activities. It is the teachers in the cluster who decide on the aspects of their teaching they want to table for challenge, and change during the meetings and discussion. Similarly, their contributions during the interventions with colleagues are also grounded largely in their classroom experiences and focus tightly on CK and PCK as discussed earlier.

Last (2001) in her work with teachers reported the value of providing extended opportunities for teachers to engage in dialogue and discussion and to begin to apply new ideas and rethinking about science learning in the classroom.

The main issue at stake in this study is not only whether the teachers in the clusters can improve their CK and PCK through these professional development interventions, but more on how such opportunities are created for teachers to uncover and share this CK and PCK with the aim of improving classroom practices. Discussions and dialogues that lead to sharing, challenging and reflecting on classroom practices seem to provide better opportunities to challenge and change the teachers' CK and PCK. The facilitation of such opportunities should be focused, reflective, thought provoking and allow individual teachers to explore their understanding of CK and PCK.

As discussed in this study, the ingredients for the teacher clusters to uncover CK and PCK depend entirely on the teachers' strong sense of commitment to their collaborative learning and support in the cluster meetings as peers. This commitment is based on trust to share what happens in the classroom with the aim of improving and changing their classroom practices. This study has provided us with a window on why and how teacher clusters make it possible for teachers of science to challenge and change their CK and PCK and thereby their classroom practice. In short, the major thesis restated is that: by focusing specifically on the participating science teachers' CK and PCK, and especially the interactions through collaborative discourse and practice, the clusters/networks were able to overcome the limitations of many professional development programmes that have failed to reshape classroom practice. The cluster approach as discussed in this study allowed us glimpse of how it is possible to change teachers' classroom practice by providing the science teachers with the opportunities to engage seriously in discourse designed to challenge and change their CK and PCK and further allows them to test their emerging theories and ideas in real world settings of teaching and learning.

5.13 Implications for Further Research and Policy

Although we now know better what makes for successful clustering among science teachers, and how to account for the resulting changes in their classroom practices, we still know less about how other groups of individual teachers may respond to clustering and the various opportunities that are presented in them. That is, while we have begun to outline a theory of what contributes to the efficacy of clusters, we still know less about how such a theory might interact with identity theories for example in order to maximize benefits to individual teachers of science. Individuals make sense of every new experience and every new piece of information actively, in terms of their individual existing needs. As argued by Adams (2000), the uniqueness of individuals' personal network is responsible for the uniqueness of his or her meaning. In other words, the codes and concepts available to interpret the information are based on each individual's past experiences, which may be similar, but never identical, to another individual's. I have argued previously that learning takes place in a social context, but this does not deny the fact that learning involves active engagement between the learner and what is being learnt. Teachers construct their understanding over time, connecting new pieces of information with the existing knowledge in ways that make sense to them. One of these implications is that teachers learn accusatively but they will often resist interpretations or knowledge that they cannot easily reconcile with their existing constructs.

Furthermore, I have discussed the context of such teacher networks within the Mpumalanga province and how they are situated within a web of structural and organizational relationships existing within the education system. We are still not clear however, about what sort of relationships need to be encouraged between the existing structures and organizational arrangements with the new emerging clusters. A restructuring of sorts is necessary to accommodate and support the formation and operation of teacher clusters. Further work is needed to explore the possibilities and arrangements that are likely to support and sustain the formation and operation of effective clusters in Mpumalanga.

Hargreaves and Dave (1989) reported that, "attempts to impose change on teachers' teaching and the nature of processes have been notoriously unsuccessful". My assumption from this statement is that teacher developers have taken a generalized approach and have failed to take a realistic view, which acknowledges that teachers are people and schools are social institutions. Furthermore, I assume that many professional development programmes have failed because they have not addressed the root cause of the problem, which is content knowledge and pedagogical content knowledge. Shulman (1987) refers to what teachers do and how they do it in the classroom as pedagogical content knowledge. Although we know enough to characterize such knowledge, we still do not have many examples of how to uncover practicing teachers' CK and PCK in the sciences. The current study has provided one such example, through which it seeks to make a methodological contribution to the research agenda on teacher knowledge. Further work on developing, refining and testing out our instruments with different groups of science teachers is needed.

Unlike most staff development, this current research study investigated clusters as opportunities created for teachers to explore their PCK. The reason for focusing on clusters is because of the claim that is made by a lot of researchers that it often focuses on the content knowledge that is relevant to teachers work and assignments and is of sufficient length to be powerful intervention (Smith and O,Day, 1991: 242). Gottesman, (2002) similarly linked the efficacy of professional development experiences to collegial structures.

The research took the form of analyzing theoretical assumptions on innovative methods of teacher development; especially teacher clusters and the empirical data on what was happening in clusters. I wish to note, in conclusion that the latest version of South African National Curriculum Statements expect science teachers to show a lot of expertise as far as their CK and PCK are concerned. Unfortunately, the system itself and the structures of the Department of Education are unlikely to be successful in re-skilling the thousands of practicing teachers by enhancing their CK and PCK (Jita and Ndlalane, 2005). This study has been important in analyzing one possible response to this challenge and makes the case that encouraging teachers to form communities of clusters might be one way of dealing with this problem. A possible theory of how to think of teacher clusters as better opportunities to provide for teacher professional growth and classroom change has been presented in this thesis.

There will be challenges in trying to push the boundaries of teacher collaboration for classroom change obviously. By using the two case studies, this study has been able to present various alternatives on clustering with possibilities on how each form operated to overcome internal and external inadequacies and barriers. A possible model that incorporates features of both forms of clustering that I have discussed in this thesis may still be possible and may in fact exist in Mpumalanga. The project of science teachers' professional development for classroom change therefore does not end with the present study.

REFERENCES

Adams, J. (2000). *Taking charge of the Curriculum*. New York: Teachers' College Press.

Anderson G. (1990). *Fundamentals of Educational Research*. London: The Falmer Press .

Anderson, S. (1991). Building Collegiality: Innovation or school improvement strategy, Paper presented at the *Annual Meeting of the American Educational Research association, Chicago.*

Barth, R. (1990). *Improving Schools from within; teachers, Parents and Principals can make a difference.* San Francisco: Jossey-Bass.

Ball S. (1983). *Beachside Comprehensive*. Cambridge: Cambridge University Press.

Burgess R. (1981). *Experiencing Comprehensive Educator*. London: Methuen Books.

Burgess R. (1984) The research process in educational settings: Ten case studies: New York: Falmer Press.

Bell, B (1985). The Construction of meaning and conceptual change in classroom settings: Case studies Project. Center for studies in Science and Mathematics Education: University of Leeds Publishers.

Bell, B. & Gilbert, J. (1996). *Teacher Development: a model from Science Education* London: Falmer Press.

Bell, B. (1998). Teacher Development in Science. In B.J. Fraser, & K.G Tobin (Eds.) *International Handbook of Science Education*, Part two, 667-680.

Boyd, B. & Fales (1983). Learning by reflection: The effect on Educational Outcomes. *Journal of humanistic Psychology* **33,**1

Brodie, K. (2001). Changing practices, changing knowledge: towards mathematics pedagogical content knowledge in South Africa. *Pythagoras*, **54**, 17-25.

Brodie, K. (2003). Being a facilitator and a mediator in mathematics classrooms: A multi- dimensional task. In S. Jaffer & L.Burgess (Eds), Proceedings of the 9th *National Congress of the association for Mathematics education of South Africa*. 135-146. Cape Town; University of Cape Town.

Brown, D.E. (1989). Students concept of force: the importance of understanding Newtons's third law. *Physics Education* **24**,353-358

Brown, T. (1998). *Coordinating Mathematics across the Primary school*. London : The Falmer Press.

Candy, P.C. (1991). Alternative Paradigmas in Educational Research. *American Education Research Journal*. **16**, (3), 1-11

Cherry, M. (1996). *Education Reform Struggle Against Apartheid Legacy Nature. London*: Sage Publication.

Clandinin, D. (1986). *Classroom Practice*: *Teachers Images in Action*. Philadephia: Falmer Press

Clandinin, D.J.& Connely, F.M. (1998) *Teachers as curriculum Planners: Narratives of Experiences Toronto and New York: OISE Press and* Teachers College Press.

Clandinin, D.J.&Connely, F.M.(1996) Teachers' Professional Knowledge landscapes: Teacher Stories, Stories of teachers-school stories, stories of schools. *Educational Researcher*, **25** (3), 24-30.

Clandinin, D.J & Connely,F.M.(2000) *Narrative Inquiry Experience and Story in Qualitative Research*. San Francisco: Jossey Bass Publishers.

Cobern, W.W. (1994) Constructivism and non-western science education research. *International Journal of Science Education*, **16**, 1-16

Cochran-Smith, M. & Lytle, S. (1999). Relationships of knowledge and Practice: Teacher Learning Communities'; Article by Asghar Iran Nejad&Pearson, D. *Review of Research.* New York: Teachers College Press

Cochran-Smith, M. & Lytle, S. (1990). Research on teaching and teacher research: the issues that divide, *Educational Researcher* **19** (2): 2-11

Cohen, D. (1987) *Experience and Education; Learning and Teaching* in M. Lampert and D. Ball (Eds.) Teaching Multimedia and Mathematics Investigation of real practice. New York: Teachers College Press.

Cohen D. & Ball (1999). *Developing Practice, developing practitioners: towards a practice-based theory of professional education: In Darling*-Hammond, L; & Sykes, G. (Eds.) Teaching as the learning profession. San Francisco; Jossey-Bass Publication.

Cohen, D. and Manion (1994). *Research Method in Education*. London: Routledge. 4th edition.

Cohen, D.; McLaughlin, M. & Talbert J. (1993). *Teaching for Understanding Challenges for Policy and Practice London, New York:* Jossey-Bass Publication

Cohen, L.; Manion, L. & Morrison, K. (2000). *Research Methods in Education*. New York: Croom Helm.3rd Publication.

Cooper, M. (1989). *Whose Culture is it anyway*? In Lieberman A. (eds.) Building a professional culture in schools. New York:Teachers College Press.

Corbin, J. & Strauss A. (1990). Grounded Theory Method Procedures, Canons and Evaluative Criteria. *Qualitative Sociology*, **13;** 3-12

Dadds M. (2001). *Continuing Professional Development*: *Nurturing the expert within*. In Soler,J.Craft A. & Burgess H. *Teacher development, exploring our own practice* Buckingham: Chapman Publishing

Dawe, R. (1989). The organizational images of teachers and school implicit in experiences of peer coaching: An Exploratory Study. Informal paper. Ontorio: Institute for Studies in Education.

De Feiter, L. (1998). Towards a Comprehensive Strategy for Science Curriculum and Teacher Development in Southern Africa paper presentation at *Human Development Week at the World Bank*, March, 1988.

De Feiter, L; (2002). Creating Professional learning Communities for science education in Eastern and Southern Africa: the role of the Universities *10th. Annual Conference, SAARMSTE, Durban, January 2002.*

Denis, L. (2000). *Building Self-esteem with Adult Learners*: London: London Publishers.

Denzin, N.K. & Lincoln Y.S (1994). *Handbook of Qualitative Research*. London: Sage Publications.

Denzin, N.K & Lincoln Y.S. (2000). Handbook of Qualitative Research. London: Sage Publications

Dewey,J. (1938*)*. Experience and Education. New York: Macmillan Publishing Company.

Driver, R. (1986). A Constructivist approach to curriculum development. *Studies in Science Education*, **13**, 105-122.

Driver, R. & Bell G. (1986). Students thinking and the learning of science: A constructivist view. *School Science Review*, **67**,443-456.

Driver, R. (1988). *Theory into Practice II: A constructivist Approach to Curriculum Development in P.Fensham (eds.) Development and Dilemmas in Science Education*. London : Falmer Press.

Driver, R., Asoko, H., Leach, J Mortimer, E & Scott P (1994). Constructing scientific knowledge in the classroom, *Educational Researchers***, 23** (7) 5-12

Driver, R. & Oldham, V. (1986) A constructivist approach to curriculum development insciencestudies.*ScienceEducation,***13**,105-122
122.

Driver, R.; Newton, P.; & Osborne, J. (2000). Establishing the norms of argumentation in classrooms. *Science Education*, **84**(3), 287-312.

Eraut, M. (1994*). Developing Professional Knowledge and Competence*. London: Falmer Press Publishers.

Fensham, P. (1988). *Development and Dilemmas in Science Education.* London: Falmer Press Publishers.

Fraser-Abder, P. (2002). *Professional Development of Science Teachers*. New York London: Routledge and Falmer Press Publishers.

Fullan, M. (1982). The meaning of educational change. Ontario: The Ontario Institute for Studies in Education Press.

Fullan, M. (1991). The new meaning of Educational change. London: Cassel Publishers.

Fullan, M. (1988). *Implementing the Implementation Plan* . In Wideen, M. & Andrew S. Staff Development for Schools. Philadelphia: Falmer Press Publishers.

Fullan, M.G. (1992). Successful school improvement: The implementation perspective and beyond. Toronto. Institute for Studies in Education. Fullan, M. (1994) Teacher Leadership: A Failure to Conceptualise. In Teachers as Leaders: *Perspectives on the Professional Development of Teachers* edited by D. Walling.Bloomington: Phi Delta Kappa Publishers.

Fullan, M. (2001*). Leading in a culture of change*. London: Cassel Publishers.

Gillham, B. (2000). *Case studies Research Methods.* London. Continuum Real World Research Series Publication.

Gluck, R. & Draisma, K. (1997).Mentoring: A rich source of information to network an align student and teacher.http;//cedir.uow.edu.au/sbjects/staffdeve/LTRG/title.html

Gottesman, B. (2002) *Peer-Coaching for Educators*. Maryland:Scarecrow Press.

Gray, B. (1995). Future directions for Science Teacher Education in South Africa. *South African Journal of Higher Education***.** **9**(1): 47-52.

Gray. B. (1988). *Non-formal INSET in Natal/kwaZulu: Current Perspectives and Policy Issues.* Cape Town: Education Policy Unit Publication.

Gray, B. (1999). Science Education in the developing world; Issues and considerations. *Journal of research in Science Teaching*, **36**,3,261-268.

Grayson, D.J.; Ngoepe, M. G. (2003). A survey of South African Mathematics and Science Teachers 'Professional Actions and Attitudes. In B. Putsoa et al. (Eds.). Proceedings of the *11th Annual conference of the Southern African association for research in Mathematics, Science and Technology Education*, 1-7.

Grayson, D. & Rogan, J. (2004). Towards a theory of Curriculum Implementation with particular reference to Science Education. *International Journal of Science Education*.

Grolnick and Lieberman (1999): Educational Reform Networks : Changes in the forms of reform. In A. Hargreaves, Lieberman, M. Fullan &D Hopkins (Eds)

International Handbook of Educational Change, 710-729. Boston; Kluwer academic publications.

Grossman, P.; Wilson, S& Shulman,L (1989). *Teachers of substance: subject matter knowledge for teaching' in* M. Reynolds (eds.) Knowledge Base for the Beginning Teacher. Oxford: Pergamon Press.

Guba, E. & Lincoln, Y. (1994). *Competing Paradigms in Qualitative Research. In N.k.Denzin and Y.S. Lincoln (Eds.) Handbook of Qualitative* Research. London: Sage Publications.

Gunstone, R. (1995). International developments in improving the science and mathematics curriculum- understanding and supporting changes in the classroom. In Stoll, L. defeater, H. Vonk, J.van der Akker (Eds); *Improving Science and mathematics teaching in the Southern Africa: Effectiveness of interventions*. Book of summaries ,7-9. Amsterdam: V U University Press.

Guskey, T.R. (1995). *Professional Development in Education: in search of the optimal mix.* In T.R.Guskey and M.Huberman, Professional development in Education: new paradigms and practices. New York:Teachers College Press.

Guskey, T.R. (1986). Staff Development and the process of teacher change. *Educational Researcher*, **15**(5), 5-12.

Guskey, T.R. (2000) *Evaluating Professional Development*. California. Thousand Oaks: Corwin Press.

Hammerserley, M. (1994*). Controversies in Classroom Research*. London: Open University Press.

Hargreaves A.& Fullan, M. (1992).*Teacher development and educational change. London:* The Falmer Press Publishers.

Hargreaves, A. (1997). Four ages of professionalism and professional learning. *Unicorn* **23,** (2), 86-109

Hewson, P. & Hewson, M. (1987). Identifying Conceptions of teaching Science ; in Novak, J.(Eds.) *Proceedings of the Second International Seminar: Misconceptions and Educational Strategies in Science and Mathematics Education*, (2)182-193. New York: Cornell University Press.

Huberman, M. and Miles, M (1984) *Innovative up close: How schools improvement works* : New York: Plenum Publishers.

Huberman, M. and Miles, M.B. (1994). *Data Management and Analysis Methods*. In N.K Denzin and Y.S Lincoln (Eds.) Handbook of Qualitative research. London:Sage Publishers.

Jansen, J. (1999) *Clarify Curriculum: Studies in OBE in South Africa*: In: Changing Curriculum: Studies on Outcomes-based Education. Kenwyn: Juta &Company Publishers.

Jansen, J. (2001). Image-in teachers: Policy Images and teacher identity in South African classrooms. *South African Journal of Education*, **21**(40), 242-246.

JICA (1999, 2000, 2001). Baseline survey for the Republic of South Africa. Pretoria: JICA Publications.

JICA (2003). The evaluation Report of the MSSI project in the Republic of South Africa. Pretoria: JICA Publications.

Jita, L. (2004). Resources of Biography: Teacher Identities and Science Teaching *Perspectives in Education*; **22** (4).

Jita, L. & Ndlalane, T. (2005). How much Science do South African Teachers know? A paper presented at the *Annual conference of SAARMSTE*, January 10-14, 2005 Windhoek, Namibia.

Jita, L. & Vandeyar S. (2006) Elementary school teachers' identities and the new curriculum reforms in South Africa: *Perspectives in Education.* **24**,1;39-52

Johnson, S.: Monk, M.& Swain, (2000)' Constraints on Development and change to science teachers' practice in Egyptian classrooms', *Journal of Education for Teaching***,** **26** (1), 9-24

Johnson, S.; Monk, M. & Swain, J. (2001) Teacher Development and change: An evolutionary Perspective; In Y.C Cheng, M.M.C. Monk & K. T. Tsui (Eds.) *The Pursuit of Teaching effectiveness and teacher development*. Hong Kong: Kluwer Publishers.

Joyce B. & Showers, B (1988*).* Students achievement through staff development. New York. Longman Publishers. 1st. edition. Joyce, B. &Showers, B. (1995) Students achievement through staff development. 2nd edition. New York: Longman Publishers.

Kahn, M. (1991). Paradigm Lost: The importance of practical work in school science from a developing country perspective. *Studies in Science Education*, **18,** 127-136

Kahn, M. (1995). Some policies, processes and implementation issues facing science education and training in Post – Apartheid South Africa. *International Journal of Science Education***,** ***17*** *(2) 441-452*

Kahn, M. (2001*).* Changing science and mathematics achievement*:* Reflections on policy and planning. *Perspectives in Education,* **19** (3) 169-176

Kelly, P.; Williamson, M. & McDiamond, G. (2002) Decentralisation of Professional Development. Teachers' decisions and -dilemmas - *Journal of in-service education,* ***28****, (3), 409-426.*

Kirkpatrick M. (1987). *Roget's Thesaurus of English words and Phrases.* London; Longman Publishers.

Lampert, M. & Ball, D. (1995). Using hypermedia to investigate and construct knowledge about Mathematics teaching and Learning Ann Arbor Publication ; M1 Project.

Lampert, M. (1988). What can research on teacher education tell us about improving quality in Mathematics Education? *Teaching and Teacher Education*, **4,** 157-170.

Lensmire, T. (1999). *Intention, Risk, and Writing in a Third-Grade Writing Workshop*, **1** & **11)** UMI Dissertation Services; Michigan; A Bell and Howell Company Publication.

Last, S. (2001). Creating a generative curriculum for science teacher development. Unpublished manuscript.

Lieberman, A & Grolnick, M (1998). Networks for educational change; Powerful and Problematic, **73**-673-677. Phil Delta; Kappan Publishers.

Lieberman, A. (1995). Practices that support teacher development. *Phi Delta Kappan* **76**, 591-596 .

Lieberman, A. & Grolnick, M. (1996). Networks and Reform in American Education; *Teachers College Record 98, (1).*

Lieberman, A. & Miller, (1984). L. School improvement: Themes and Variation. *Teachers College Record 86 (1)*

Lieberman, A. &Miller, L. (1991). Staff development for Education in the 90s. New demands, new realities new perspectives. New York: Educators College. Colombia; Colombia University Press.

Lieberman, A. & McLaughlin, M(1992). Networks for Educational change: Powerful and problematic. *Phi Delta Kappan,* **73,** 673-677

Lieberman, A. & McLaughlin,M. (1995). Networks for Educational Change: Powerful and Problematic. In M. McLaughlin, & I. Oberman (Eds) *Professional development for teachers in the reform era,* 673-6770. New York; Teachers College Publishers.

Lieberman, A. (2000). Networks as Learning Communities: Shaping the future of Teacher development. *Journal of teacher Education*. **51**(3) 221-227.

Lieberman, A.; & Wood, D. (2002). *Inside the National writing Project: Connecting Learning and Classroom teaching.* New York: Teachers College

Lincoln, Y.S., and Guba, E.G. (1985*). Naturalistic Inquiry.* Beverley Hills: A Sage Publication.

Little, J.W. (1990). *The persistence of privacy: Autonomy and initiative in teachers' professional relations.* New York:Teachers College Record.

Little, J.W. (1993). Professional Community in Comprehensive High Schools: The two worlds of academic and vocational teachers. In J.W. Little and McLaughlin (Eds.) 137-163. New York: Teachers College Record.

Loucks-Horsley, S., Hewson, P. & Love, N. (1987). *Designing Professional Development for Teachers of Science and Maths. National Institute for Science Education. Thousand Oaks, Carlifornia ; Corwin Press; Inc. A sage* publications company .

Loucks-Horsley, S. Stiles, KE. & Hewson, P.W. (1996). Principles of Effective Professional Development for Mathematics and science education *A Synthesis of Standards.* NISE Brief Publication.

Loughran, J.; Mulhall, P. & Berry, A. (2004). In search of Pedagogical Content Knowledge in Science: Developing ways of articulating and documenting Professional practice. *Journal of research in Science Teaching* **41** (4), 370-391.

Lubisi, R.C. (2000). An investigation into Mathematics. Teacher's perceptions and practices of classroom assessment in S.A Lower Sec schools; Unpublished PhD. thesis, school of education, University of Nottingham.

MacMahon, A. (2000). The development of professional Intuition. In Atkinson, T.and Claxton, *The intuitive Practitioner*. Buckingham .Open University Press.

Macmillan, J.H. (2000). *Research in Education: A conceptual introduction*. New York, Virginia, Sydney, Tokyo: Longman Publishers.

McLaughlin, M.& Oberman, I. (1996). *Teacher Learning: New policies, new practices.* New York: Teacher College Publishers.

McLaughlin, M.W. (1991). Enabling professional development: What have we learned? In A Lieberman and Miller, Staff development for education in the 90s New demands, new realities, new perspectives, New York. Teachers College Publishers.

McNiff, J. (1993). *Teaching as Learning: an action research approach*.London and New York: Routledge Publishers.

Malcolm C. & Keane, M. (2001) "Working scientifically, in learner centred ways". Paper presented at the *6th International History and Philosophy of science and Teaching Conference,* Denver, USA. November 7-10

Merriam, S.B. (1998*). Case Study Research in Education. A qualitative approach. London:* Jossey-Bass Publishers.

Miller, R. (1989). *Doing Science: Images of Science in Science Education. Basingstoke.* Taylor and Francis Printers LTD.

Mortimore, P. & Sammons P. (1987). New evidence on effectiveness Elementary Schools. *Educational Leadership* **45**, 1:4-8

Munby, H. & Russell. (1989) Educating the Reflective Teacher. An essay Review of the two books by Donald Schon. *Journal of Curriculum Studies*, **21**, 71-80.

Osborne, R. & Freyberg, P. (1985). *Learning in Science: The implications of childrens' science.* Auckland, London: Heinemann publishers.

Ovens, P. (2000). *Reflective Teacher Development.* London and New York: Falmer Press Publishers.

Parker, C.A (1971). Strategies for Change. *The Journal of Higher Education* (1)9/81

Posner, G.J.; Strike, K.A.; Hewson, P.W.; & Gertzog, W.A. (1982). Accommodation of Scientific conception: toward a theory of conceptual change: *Science Education*, **66**,211-227

Prawat, R.S (1992). *Teachers beliefs about Teaching and Learning; A constructivist Perspective. New York:* Falmer Press.

Prawat, R.S (1989). Teaching for Understanding: three Key Attributes. *Teaching and Teacher Education.* **.5**, (4)315-328.

Prosser, J. (2000). *The school culture*. London. Paul Chapman Publishers.

Rogan, J. (2000). Strawberries, cream and the implementation of C2005: Towards A Research Agenda Article - *South African Journal of Education 2000, 20 (2)*

Rogan, J. & Grayson, D. (2002) Towards a Theory of Curriculum Implementation with Particular Reference to Science Education in Developing Countries: *International Journal of Science Education*.

Kahn, M.& Rollnick M. (1991). Science Education in Nearly new South Africa *Physical Science Proceedings of 14th National Convention on Mathematics and Natural Science Education*, Cape Town.

Rosenholtz, S. (1989). *Teachers' workplace*. New York. Longman Publishers.

Sabatier, P.A. (1986). Top- down and bottom- up approaches to implementation research: A critical Analysis and suggested synthesis *.Journal of Public Policy*, **6,** 21-48

Sawyer: P. (2001). Teachers Who Grow as Collaborative Leaders *EPPA Journal*

38 Phil. Delta.

Schlerechty, P. (2002). *Working on the work*. New York. Jossey Bass Publication.

Schoeny, Z. (2002). 'Educators who act as change agents', *Journal of Information Technology for Teachers (ICT*) **11**, (3) 245-252.

Schon, D.A. (1983). *The reflective practitioner*: *How professionals think in action. New York.* Basic Books Inc. Publishers.

Schon, D.A. (1987). *Educating the reflective practitioner.* San Francisco Jossey- Bass Publishers.

Secada, W.G. &Adajian, L. (1997). *Mathematics Teachers'change in the context of their professional communities.* In Fennema &Nelson , (Eds.) 193-219.

Senge, P. (2000). *Schools that Learn*. New York, London. Routledge.

Shulman, L.S. (1986). Those who understand: knowledge growth in teaching, *Educational Researcher **15**(2): 4-14*.

Shulman, L. (1987). Knowledge and Teacher: Foundation of the new reform; *Harvard Educational Review,* 57, (1)1-22

Shulman, L. (1999). *Foreword in Ma, l. Knowing and teaching elementary Mathematics:* Teachers understanding of fundamental mathematics in China and , New Jersey: Lawrence Erlbaum, (ix-xii)

Shulman, L and Shulman J. (2004). How and what teachers learn. A shifting Perspective. *Journal of Curriculum studies*, **36,** 20, 257-271.

Silverman, D. (2000). *Doing Qualitative Research a Practical Handbook.* London. Sage Publications.

Silverman, D. (2001*).* Interpreting Qualitative Da*ta*. New York. Sage Publishers.

Smith, M; O Day, J. (1991). *Systemic School Reform*. In Fuhrman, B. Malen (eds), *The policies of curriculum and testing,* 233-268 Philadephia. Falmer Press Publishers.

Solomon, J. (1983). Learning about energy - how pupils think in two domains. *European Journal of Science Education*, **28**, 17-20

Solomon, J. (1987). Social influences on the construction of pupils understanding of science. *Studies in Science Education*, **14**, 63-82.

South Africa Department of Education (2002) Revised *National Curriculum Statement for Grades R-9 schools; Natural Sciences*.

Southwood, S. (2002). *Towards a collaborative approach to teacher professional development: A journey to negotiation*. Unpublished Doctoral Thesis, Rhodes University, Grahamstown.

Spillane, J.P. (2000). Cognition and Policy Implementation: District policymakers and the reform of mathematics education. *Cognition and Instruction*, **19** (2), 141-179.

Spillane, J. (2001). Constructing ambitious pedagogy in the fifth grade: The mathematics and the literacy divide, *Elementary School Journal*, **100** (4), 307-330.

Spillane, J. Diamond J. & Jita, L. (2003). Leading Instruction: the distribution of leadership for instruction. *Journal of Curriculum Studies*, **35** (5), 533-543.

Stein, M.K; Smith, M.S. and Silver, E.A. (1999). The Development of Professional Developers: Learning to assist teachers in new settings*. Harvard Educational Review,* **69**(3), 237-268.

Stodolsky, S. (1988). *The subject Matters : Classroom Activity in Math and Social Studies. Chicago*. University of Chicago Press.

Stones, E. (1994*) Quality Teaching*. London and New York. Routledge Publishers.

Strauss, A & Corbin, J. (1994). *Grounded theory: Methodology. An Overview*. In N.K. Denzin and Y.S. Lincoln (Eds). Handbook of Qualitative research. London. Sage Publishers..

Taylor, N. & Vinjevold, (1999). *Getting learning Right*. The Joint Education Trust Publishers.

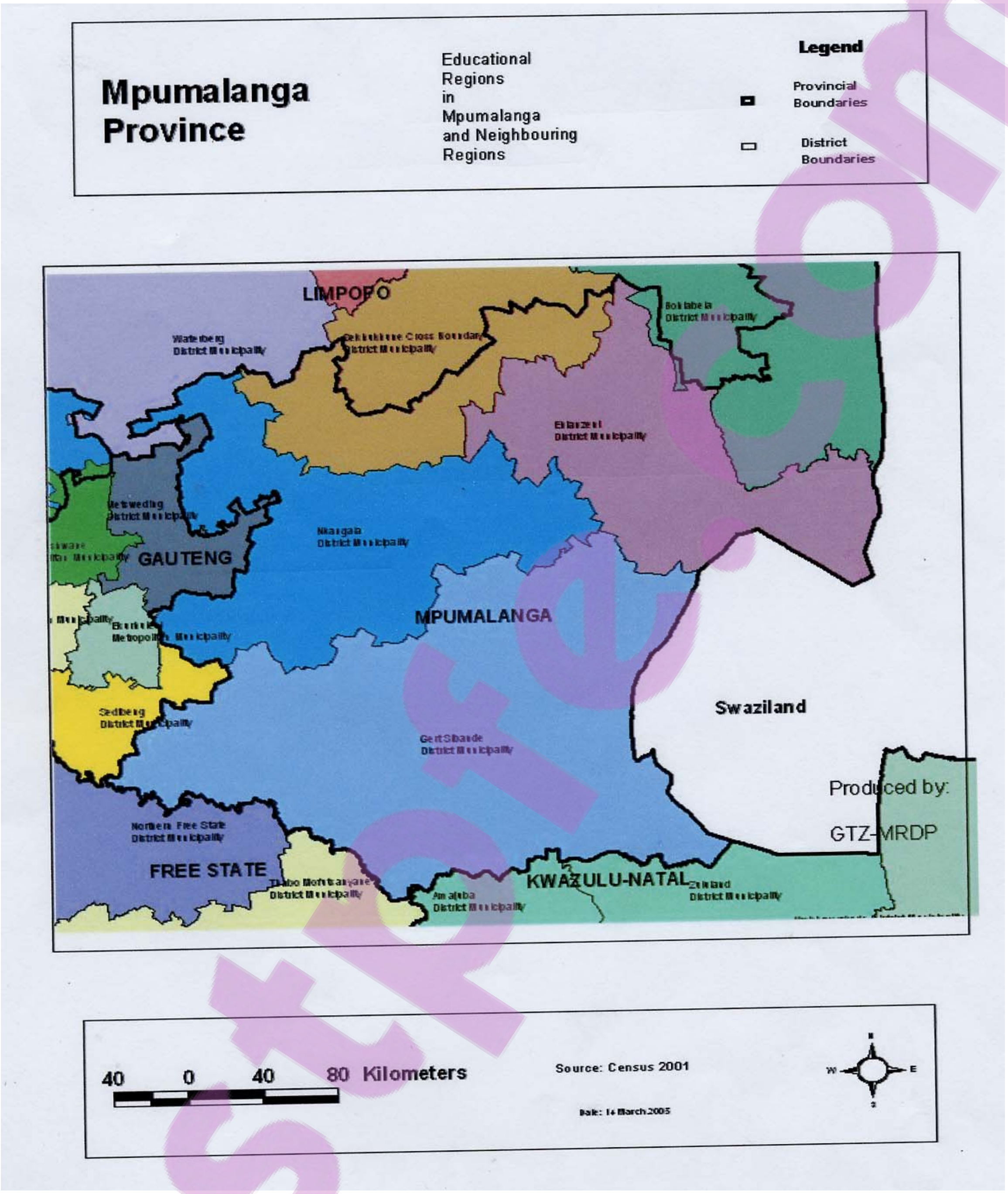
Tomlinson, P. (1988). Implicit Learning and Teacher Preparation: Potential implications of theory and research. Paper given at *British Psychological Society, Annual Conference, Brighton*

Wilson, S. and 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**, 249-306.

Wineburg, S. & Grossman, P. (2000) *Interdisciplinary Challenges to implementation.* New York ; Teachers College Press.

Yin, R.K. (1994). *Case Study Research*. Thousand Oaks.Sage Publications.

Appendix 1


Mpumalanga Province
Educational Regions in Mpumalanga and Neighbouring Regions
Legend
Provincial Boundaries
District Boundaries
LIMPOPO
GAUTENG
MPUMALANGA
Swaziland
Produced by:
GTZ-MRDP
FREE STATE
KWAZULU-NATAL
40 0 40 80 Kilometers
Source: Census 2001

Appendix 2

REPUBLIC OF SOUTH AFRICA
MPUMALANGA DEPARTMENT OF EDUCATION

MPUMALANGA SECONDARY SCIENCE INITIATIVE (MSSI)

GUIDELINES FOR THE FORMATION OF CLUSTER

REPORT ON THE IN-SERVICE TEACHER EDUCATION AND TRAINING IN SCIENCE AND MATHEMATICS

2002

Table of contents

1 Introduction

Schools are sites of learning and teaching. Society establishes educational institutions such as schools in order to prepare its members to be functional, critical and patriotic citizens.

Humanity is experiencing a rapidly changing, technology-based economy and information-oriented twenty first century. Also, in the past fifty years society has formulated a holistic and radically different conception of learning and teaching than has previously been the case. This new experience by humanity and a radically different view of what it means to learn and teach have created new challenges and have put new demands on schools and its stakeholders. Society expects schools to prepare their youth for the new world order by helping them acquire relevant, high quality, useful knowledge, skills and values.

Educators are the main link between what society wishes to achieve through the educational experience of their youth and the quality of such an educational experience, and teachers are therefore an important resource to be nurtured. The purpose of in-service training is to improve and refine educators' knowledge, skills and values so as to become effective in their role as educators. To this extent in-service training is not an add-on but an integral part of the school life and the educational experience of the learners. Findings of research studies are unanimous on the effectiveness of in-service training and they indicate that support for in-service training at all levels of the educational enterprise is a must.

In 1994 South Africa became a constitutional state and adopted democracy, non-racialism and non-sexism as the founding ideals of its new democracy. The dawn of a new political era has opened up many possibilities and challenges for the people of South Africa. This has meant amongst other things, that:

- ✓ Opportunities that were in the past reserved for a few are expanded to all citizens.

- ✓ The educational experience should equip all citizens with knowledge, skills and values that will enable South Africa to be competitive in a rapidly globalising world.
- ✓ A new value system should underpin the practice of education and the fabric of society as a whole.
- ✓ The culture of learning and teaching should be revived and nurtured.

The Mpumalanga Secondary Science Initiative, here referred to as MSSI, is a partnership between the Mpumalanga Department of Education (MDoE), the Japanese Government through the Japanese International Cooperation Agency (JICA) and the University of Pretoria (UP).

In developing this document we have used the rich experiences that we have acquired through our exposure to Japanese Educational System, visit to a private corporation and a number of educational lectures.

2 Objectives

2.1 Project objectives

- ➢ The goal of the Mpumalanga Secondary Science Initiative is to ensure that secondary school students acquire enhanced skills in mathematics and science.

- ➢ The basic purpose of MSSI is to improve the quality of teaching in mathematics and science in the province through enhancement of the capacity and experience of the teachers. The project will also aim at promoting the development of a Province-wide system of continuous in-service training for mathematics and science teachers so that this capacity enhancement effort may evolve into sustained practice.

2.2 Our objectives as Head of Departments (HODs) or Cluster Leaders (CLs) are:

- Enable HODs/CLs to gain capacity and experience in mathematics and science through exposure to the Japanese experience with the view to improving the teaching and learning of these subjects.
- To formulate guidelines and plan for implementation of cluster activities in the province.
- To formulate relevant programs for teacher centers to address the needs of schools

3 Characteristics of MSSI project

- Promote partnership among all participants: JICA, MDoE and the Universities of Pretoria, Hiroshima and Naruto University of Education.
- Promotes teaching methodologies that result in effective teaching in mathematics and science.
- Develops group consciousness by encouraging the sharing of expertise and resources and thereby enhancing classroom teaching.
- Enhances networking of professionals through discussion and collaboration
- Provides incentives through accreditation schemes.

4 Status of implementation

The first phase of the project attempted to include all schools (grades 8 –9) over three years of implementation. In the second phase, the implementation will involve all schools (grade7-12) that are committed and willing to abide by the policies of the cluster to which they belong. The implementation is expected to commence from the academic year 2003 with more emphasis on improving classroom instruction or teaching in mathematics and natural science.

5 Proposed shift in implementation MSSI phase II

- ✓ Schools shall be encouraged to form a feasible cluster and to register with the Department of Education
- ✓ Clusters shall be encouraged to share resources and expertise.
- ✓ Workshops shall be conducted frequently at regional and circuit level to support clusters and school based INSET programs
    - CIs and HODs/CLs will actively participate in cluster programs to ensure that INSET activities filter into the classroom (see section 8.3 and 8.4).
    - Circuit Managers will play a crucial role in supporting cluster activities.
- ✓ In respect of the cascade model of training; the proposed shift is as follows:

Japan	→	HOD's/CL's study mission (with few CIs) (6 weeks in Oct - December) ↓
Provincial level	→	CI/CL workshops. (1 week 3 times a year) ↓
Regional level	→	Cluster support meetings (2.5 days x 3 times) ↓
CI's role	→	Teacher center program drawn by CIs (1 day x 5 times) ↓
Circuit level	→	Cluster meetings (1 day x many times depending on the need) ↓
School level	→	School-based INSET (Once a month or more)

6 Training and development of HODs/CLs/CIs

The training of curriculum implementers has traditionally been twofold: mentoring and overseas experience. Currently the project is entering a new phase in its implementation. This has resulted in a shift of focus with the emphasis on cluster leaders. The current training has seven HODs and two CIs. Training in Japan basically involves exposure to the Japanese education system. Trainees were given the opportunity to visit and participate in a number of activities including; school-based INSET, visit to a teacher center, the Ministry of Education Culture Sports and Technology, the National Museum of Emerging Science and Innovation, a private corporation and a host of very informative lectures. The Japanese training was also enriched by cultural activities.

7 Conditions for successful school-based INSET

For school-based INSET to be successful and relevant to educators and learners we believe that the following conditions should be in place:

- HODs/CLs must be enthusiastic about the project
- There must be regular MSSI meetings, workshops and other activities
- Educators must be highly motivated and open minded to learn new approaches to teaching and learning.
- Principals must be supportive of school-based INSET activities.
- Schools must periodically (yearly) conduct a needs analysis
- Schools must ensure that they are always represented in cluster meetings and/or workshops (HODs/Subject Heads/Educators).
- Schools must have an in-service training policy and abide by it.
- Cooperative working must be fully encouraged to promote coordination in the schools.
- Educators must be prepared to sacrifice their time for all cluster activities (e.g. weekends and holidays)
- Educators must be willing to share expertise and take part in Peer Teacher Learning.

8 Cluster Formation

8.1 Definition

A group of schools in a given geographical area that come together with the aim of improving the quality of students' learning and achievements by working on a common program in mathematics and natural science.

8.2 Objectives of clustering of schools

- ✓ To develop a co-operative and collaborative approach to professional development of educators.
- ✓ To develop effective approaches in the teaching of mathematics and natural sciences
- ✓ To foster closer ties between teachers within a cluster and to encourage the sharing of expertise and resources.
- ✓ To jointly develop mathematics and natural science outcomes- based units which will facilitate a smooth, consistent and developmental transition from grade 7-12
- ✓ To facilitate dialogue and reflection amongst educators.
- ✓ To foster innovation and resourcefulness in educators pursuit of solutions to local problems.
- ✓ To enhance the status of the teaching profession in the community.
- ✓ To encourage schools to participate in cluster activities with the aim of improving educator's classroom teaching.
- ✓ To promote Peer Teacher Learning.

8.3 Roles of CIs

Under cluster formation we envisage that CIs will carry out the following functions:

- ➢ Logistic support:
  - Venues
  - Photocopying, printing
  - Resources or material
  - Drawing up annual Teacher Center programs

- Communication:
  - Circulars
  - Invitations
- Motivation:
  - Mentoring
  - Attending cluster meetings (invitation)
  - Coordination of clusters:
  - Organize regional meetings for sharing of expertise, knowledge and so on.
  - Compilation of materials developed
- Needs analysis
  - Conduct survey to collect information
  - Compile and keep a register of needs in the clusters and region.
  - Identify resource person(s) to address needs
  - Use above information to direct Teacher Center programs
  - (See annexure B)
- Monitoring:
  - One CI per region to collect monitoring forms from all the clusters to be forwarded to the steering committee.
- Conduct workshops on:
  - Facilitation skills, motivation, content and methodology of teaching for cluster leaders

8.4 Roles of Cluster Leaders

- Coordinate activities of a cluster
- Attend to problems encountered in a cluster
- Motivate educators
- Plan for resources needed

- Coordinate drawing up of cluster program and policy
- Submit cluster report to regional office
- Ensure communication (amongst all relevant stakeholders).
- Networking with other CLs in cluster programs (provincially).

8.5 Roles of Principals

Principals have a unique role to play. We believe that they are well placed to provide the following functions;

- To register their schools to participate in a cluster
- Encourage educators to have a school-based INSET programs
- Assist educators in attending cluster activities (financially)
- Provide resources for cluster activities
- Help make time for HODs/CLs to attend cluster activities
- Support the HODs/CLs in preparation for cluster activities (hosting)
- Invite CI to attend cluster activities
- Attend cluster activities where possible so that they can be well informed about such activities
- To ensure that their schools' needs analysis is done diligently (yearly)
- Encourage Peer Teacher Learning and team teaching.

8.6 Roles Circuit Managers

Circuit Managers also have special roles to perform to guarantee an effective implementation and running of clusters in the project. The following are some of the activities we feel they could perform.

- Encourage all schools to take part in the MSSI cluster activities
- Attend cluster activities where possible
- Maintain an open communication towards all the stakeholders in the Project
- Help provide resources for the cluster activities where possible
- Must reflect cluster activities in the circuit year program

- Support the cluster leader at all times
- Follow up cluster implementation.
- Must encourage Peer Teacher Learning and team teaching in Schools
- Assist in negotiating funding for cluster activities where necessary.

8.7 Roles of Teacher Center Managers

It is believed that teacher Center Managers could perform the following functions to greatly assist the smooth running of most school activities including that of clusters. Teacher center managers should:

- Ensure that clusters can access materials and other resources for their cluster activities.
- Be at the service of all schools in their area regardless of distance
- Reflect MSSI activities in the yearly program of the center
- Should participate in conducting the needs analysis of schools and ensure Teachers center programs reflect these identified needs
- Attend cluster activities where possible

8.8 Management Structure

The Cluster leader will have a committee composed of coordinators for the different learning areas.

8.9 Conditions for joining a cluster

- Commitment from schools to implement in their classes the instructional innovation and materials acquired from cluster activities
- Feedback on implementation
- Schools to submit regular reports as stipulated in the cluster policy
- Attend all MSSI activities consistently
- Schools must agree to host cluster activities
- Schools must be prepared to share resources and expertise

8.10 Sustainability of a cluster

- ✓ In order for a cluster to be sustainable it must have a policy.
- ✓ The policy must contain the following key aspects:
  - o Mission statement
  - o Vision
  - o Management structure
  - o Ground rules for any cluster activity
  - o Renewal clause
    - Effectiveness of the policy
    - Appropriateness of the policy
    - Effective date
    - Number of activities
    - Quorum for a cluster activity to take place
- ✓ Respect and encourage the professionalism and range of experience of teachers.
- ✓ Participant directed and collaborative.
  - self directed learning ensures that learning is most relevant to participants' specific needs, and encourages ownership and engagement with the process
- ✓ More visible support from Department of Education in terms of funding, incentives and workshops.

8.11 Challenges facing Cluster Leader

- Motivation of educators to attend.
- Workload on HODs/CLs
- Subject specific qualification
- Paradigm shift (e.g. methods used in MSSI cluster activities PTL)
- Finance to run workshops
- Transport.
- Teacher centers (not functioning, distant or not resourced)
- Geographical location of schools

- Time (as a result of impending work load)
- Lack of support from stake holders
- Bringing on board other stakeholders.
- Report writing and submission
- Reluctance and absenteeism.
- Ownership.
- Communication.
- Getting educators to work or attend cluster programs on weekends and holidays

8.12 Incentives

The following are possible incentives that could be looked at in view of the onerous nature of the work of the mathematics and science educator.

- Certification upon:
  - Attendance of cluster activities regional and circuit including the conducting of these activities.
- Academic empowerment of participants (scholarships to tertiary institutions)
- Paid up bonus for working over weekends and holidays
- Linking cluster activities to promotions
- Honorarium for HOD's/CL's per activity (fifty rands to be paid to HOD/CL)
- Opportunity to participate in the training in Japan
- Cluster educator and school of the year awards.

- Opportunity to attend conferences, symposia both national and international.

- Prizes for published articles and developing teaching materials

9 Criteria for selection of cluster leaders

- Dedication
- Vision
- Desire for sharing knowledge, skills and abilities and so on
- Willing to face challenges
- Innovative person – one who moves out of his/her comfort zone
- Desire to learn from other people
- Willingness to show respect to the members of their cluster
- A good listener – to the challenges and or ideas from their cluster members
- Cooperative skills
- Ability to show direction where necessary (ability to lead)
- Understanding the aims and objectives of MSSI project
- A sound understanding of the role a cluster leader has to play – in the cluster and with all the other stakeholders
- Organization skills – the cluster leader should know what to do, when to it and how it has to be done. (i.e. a good planner)
- Understand and be prepared to share responsibilities by delegating to other educators in their cluster some of the responsibilities shouldered by the cluster leader.
- Understand the link between cluster activities and school-based INSET.
- Empathy
- Cluster to choose the leader

10 Monitoring and assessment of MSSI program

10.1 Monitoring

10.1.1 Definition

Monitoring is a process of checking whether or not the in-service activities that have been identified by the individual schools and the cluster programs of the MSSI do take place as well as verifying the quality of such activities.

10.1.2 Mechanisms of monitoring or instruments.

Four monitoring instruments will be employed, namely, submission of reports, the actual INSET materials, evaluation forms by participants and visits by Curriculum Implementers.

10.1.3 Reports

There shall be three levels of reporting:

- ✓ The School based INSET Report compiled by the Head of Department – Natural Sciences
- ✓ The Cluster Report compiled by the Cluster Leader
- ✓ The Regional report compiled by the Curriculum Implementer responsible for coordinating cluster activities in the region.

The Head of Department – Mathematics and Natural Sciences shall submit three copies of summary report per activity conducted at the school. The principal shall keep one copy and the other two copies shall be submitted to the Cluster Leader and the Circuit Manager.

The school based inset report form shall cover the following aspects:

- ✓ Date on which the activity or INSET was conducted.
- ✓ The name of the facilitator of the activity.
- ✓ The venue where the activity was conducted.
- ✓ The content or topic that was treated.
- ✓ The Principal and Head of Department's signatures.

The Cluster Leader shall also in turn submit monthly reports summarizing all the cluster INSET activities to the Curriculum Implementer responsible for coordinating the monitoring of INSET in the region. Cluster reports must reach the coordinating Curriculum Implementer not later than the 5th day of the following month.

The Curriculum Implementer shall also summarize all the activities of the clusters within the region and submit a summary report of all cluster activities in the region to the Provincial Coordinating Committee. For samples of the various forms see annexure.

10.1.4 Workshop Materials

Workshop materials shall serve two purposes:

- ✓ They shall serve as an indication of the quality of the content of the INSET activity conducted.
- ✓ The collection of workshop materials shall promote the principle of collaboration. Workshop materials used by various schools or clusters during workshops or seminars shall be made available to other schools and/or clusters for use.

The Heads of Department – Natural Sciences and Mathematics shall keep copies of INSET materials used to conduct INSET at their schools; Cluster leaders will do the same at cluster level.

10.1.5 Evaluation forms

At the end of each workshop participants shall be requested to fill in evaluation forms. These forms shall be used to improve future activities of school based and cluster INSET activities.

10.1.6 Visits by Curriculum Implementers

Curriculum Implementers shall from time to time visit school-based and cluster INSET activities to give support as outlined in section 8.3 and 8.4. CIs shall be required to write reports about their impressions of the activities observed.

10.2 Evaluation

Evaluation is an ongoing process that entails:

- ✓ exploring the effectiveness of the activities of MSSI,
- ✓ improving the activities of the project
- ✓ justifying the need of in-service training in mathematics and natural science as envisaged in MSSI.

The question of what to evaluate, the purpose for such an evaluation as well as the sources used in evaluation are crucial factors in determining the course of action to be taken in improving the effectiveness of the project. The process of evaluation necessitates that different and interacting aspects of the project must be observed, studied recorded and analysed. Multiple sources of data are essential for the complete picture of the impact of the project in teaching and learning of mathematics and natural science as envisaged by the project.

The question of when to evaluate and who evaluates are also very crucial aspects if we want to form an objective view of the success or failure of the project.

The following principles shall guide the process of evaluation:

- ✓ Multiple data sources must be used in gathering information about the impact of the project.
- ✓ All the stakeholders involved in the project must understand the process of evaluation.
- ✓ The results of the evaluation process must be used to improve the activities of the project.
- ✓ Evaluation must be congruent with the goals set.
- ✓ The results of evaluation must be disseminated to all role-players in the project as well as other interested parties.
- ✓ Evaluation must be consistent and continuous (periodically)

11 Support from Japanese International Cooperation Agency (JICA) and volunteers, University of Pretoria (UP) and Mpumalanga Department of Education (MDoE)

11.1 JICA

Presently the Japanese government (through Japanese International Cooperation Agency JICA) provides:

- Financial and organizational support for CIs/CLs and Local Administration and management personnel to train in Japan
- Follow-up guidance for organizing workshops for HODs/Subject Heads
- Facilities – build schools
- Equipment – for teacher centers
- Project coordinator for MSSI
- Volunteers teachers for secondary mathematics and science.
- Support personnel during workshops

Japanese Overseas Cooperation Volunteers can be used as subject specialist at teacher centers to support mathematics and natural science educators. They can be invited to attend cluster and school-based INSET activities, conduct workshops, provide innovative advices and share experiences.

We feel that JICA can play a role in providing incentives to top participants of regional or provincial cluster activities like offering the opportunities to further academic studies in mathematics and natural science in Japan.

11.2 University of Pretoria

HODs/CLs should be proactive in utilizing the support and expertise of UP in all cluster activities. For example inviting UP experts to observe cluster or school-based INSET frequently. UP could offer educators the chance to be co-researchers in many research studies (educational research) they conduct. This may give educators the opportunity to obtain further accreditation. UP should continue to broaden its research studies on the project. Such ongoing evaluations of the project are necessary to establish relevance of INSET activities as well as measuring the impact on learners' achievements.

11.3 Mpumalanga Department of Education

MDoE is the initiator and owner of MSSI. For successful implementation and sustainability of the project all stakeholders (within the department) should be represented in the steering committee. The department should recognize circuits as the basic units of operation for cluster activities. This will imply that Circuit Managers and Principals must play a more active role.

Since complete ownership of the project solely lies with the department, it is crucial that the department should gradually phase in funding responsibilities and capacity building so that withdrawal of the other partners will not mean the demise of MSSI project.

12 Challenges facing stakeholders

CHALLENGES	RESPONSIBLE OFFICER (S)
Communication - Writing/fax/physical mobility/telephonically	Principal/CM/CI
Report writing and submission	Principal/CI
Time	Principal/educators
Reluctance and absenteeism of colleagues	Principal/SGB/Dept - Steering committee
Paradigm shift	Principal/CL/CI
Networking with other CLs	Principal/CI
Lack of support from stake holders	Steering committee
Transport.	Principal/Dept - Steering committee
TC not functioning, distant or not resourced)	Principal/CI/Dept - Steering committee
Bringing on board other stakeholders.	Principal/CL/CI/ Steering committee
Finance to run workshops	Principal/Steering committee
Ownership of project	All- Steering committee
Workload on HODs/CLs	Principal/educators
Subject specific Qualification	Dept/JICA/UP
Location of schools	Dept
Overtime, weekends and holidays	Dept/CL/educators
Registration of schools into cluster	Principal/CL/CI/DEPT
Conducting needs analysis	Principal/CL/CI
Plan of action for coordination of activities within the MSSI and with other projects	CL/CI/MDoE
Bringing grade 7, distant and disadvantaged schools on board the project	Principals/CL/CI/MDoE
What to do with schools that are not yet involved with the project	MdoE/ Principals/CL/CI

13 Workshops (proposed)

As per the cascading model (see page 4) the following workshops have been proposed.

Report back session (suggested time 2 days)	Meeting with the Local administration group Report back and clarification of roles

Science

1st workshop	Chemistry lesson study laboratory procedures classification and properties of household substances (chemsitry at home)
2nd workshop	Physics Light and electricity
3rd workshop	Earth and Beyond (Weathering and functions of rivers) Life and living (Observation and classification) (Cell division)

Mathematics

1st workshop	Grade
Mountaineering, lesson study	8 – 12
Congruency	8 – 12
Paper folding 3D	8 – 12

2nd workshop	
Similarity and paper size	8 – 12
Sharing meeting of CLs	
Tangrams	8 – 12
Teaching of functions (drawing	
And interpretation of graphs →	
Linear prorams	8 – 12

3rd workshop	
Trigonometry (Introduction)	10
Computer Training (number system)	

14 The Framework for the MSSI workshop for CIs /CLs/HODs 2003

The activities for MSSI would be informed by the cluster guideline that was drawn in Hiroshima (Japan), the interaction with all stakeholders in Nelspruit (Febuary 2003) and the needs analysis survey. The structure for the workshop would be as follows:

Report back session (Febuary 2003)

Report back session by CLs and CIs – Febuary 2003
Outcomes:
To report on the Japanes experiene and the accrued experiences by the CL cum CI team to Japan.
To discuss guideline document on cluster formation and implementation
Discuss MSSI implementation in phase II
Discuss monitoring and evaluation of the project
To interact with all stakeholders in the project and outline/clarify our roles and functions
Share workshop planes and implementaion scedule for 2003
Plan the logistics of implementation programs

Workshop 1
Theme: Material development and the use of available resources March 2003
Outcomes: A meaningful understanding and practice of lesson study, some laboratory skills and the use of household substances to teach chemistry

Workshop 2
Theme: Material development and the use of available resources May 2003
Outcomes: Designing and development of different teaching materials
Exploring of tne activities carried out in Japan
More on lesson study

Workshop 3
Theme: Material development for cluster and school-based activities September 2003

Outcomes: Fostering networking amongst, CLs, CIs and all other stakeholders
Strengthening of school-based activities
Emphasis on scientific approach to teaching and learning

15 Tentative Schedule for 2003 (Draft)

DATE	TIME	ACTIVITY	PARTICIPANTS	VENUE
27th Jan – 7th Feb	8H30-16H30	MSSI workshop	CLs/HODs and CIs	Former Districts
14th –15th Feb	8H30-16H30	Report back session	All CIs, CLs, UP, MDoE and JP	Nelspruit
20th –22nd Mar	8H30-16H30	CLs/HODs workshop	CLs/HODs and CIs	Regions
20th Apr	10H00-13H00	Reflection meeting	All CIs and CLs, UP, MDoE and JP	Middleburg
To be confirmed	10H00-13H00	Steering committee meeting	All stakeholders in the Department of education	Nelspruit
30th Jun- 4th Jul	8H30-16H30	CLs/ CIs 2nd round workshop	All CIs, CLs, UP, MDoE and JP	Ermelo
16th – 18th Jul	1330-16H30	Cluster support workshop	CLs and HODs	Regions
1st Aug	10H00-13H00	Reflection meeting	All CIs and CLs, UP,MDoE and JP	University of Pretoria
18th – 22nd Aug	8H30-16H30	CIs/CLs 3rd round workshop	All CIs, CLs UP, MDoE and JP	Volksrust
10th –12th Sep	8H30-16H30	CLs HODs support workshop	CLs and HODs	Regions
01st Oct	10H00-13H00	Reflection meeting	All CIs and CLs, UP, MDoE and JP	Nelspruit
To be confirmed	10H00-13H00	Steering committee meeting	All stakeholders in the Department of education	Nelspruit

Annexure A

MPUMALANGA DEPARTMENT OF EDUCATION

APPLICATION FOR CLUSTER REGISTRATION (MSSI)

Name of cluster ....

Name of school: ....

Name of Principal ....

Name of HOD/subject head ....

Contact number: ....

Fax: ....

Email ....

Postal Address:...

Pledge/commitment from school to:

- implement in our classes all instructional innovations and materials acquired in cluster activities and provide feedback
- submit reports as stipulated in the cluster policy
- attend all MSSI activities consistently
- agree to host cluster activities
- share resources and expertise

....	....	....
HOD	**PRINCIPAL**	**CIRCUIT MANAGER**
STAMP	**STAMP**	**STAMP**

Annexure B

MPUMALANGA DEPARTMENT OF EDUCATION

NEEDS ANALYSIS FORM: MATHEMATICS AND NATURAL SCIENCE EDUCATORS

Introduction

This needs analysis is not an instrument to be used against any educator. The purpose could be summarized as follows:

- To ensure that workshops that are held (school, regional or circuit) level are seen to address the actual needs of educators.
- That teacher center programs reflect what you require for your work at school
- To ensure ownership of cluster programs and hence full participation of all mathematics and science educators.

Finally we solemnly give the undertaking that the findings of this needs analysis will in no way be used against any educator but will help us in addressing teaching and learning challenges.

Name of school: ....

Contact number: ....

Name of cluster ....

Learning area: ....

Name of educator **(OPTIONAL)** ....

(a) Indicate your strong areas.

GRADE	SECTION/TOPIC	CONTENT/METHODOLOGY

(b) Indicate areas you are willing to share your knowledge, skills or expertise with other educators.

....

....

....

....

....

(c) Indicate areas that you need improvement in.

GRADE	SECTION/TOPIC	CONTENT/METHODOLOGY

(d) Please indicate resource person(s) whom you think could help address the above-identified challenges.

....

....

(e) Could you indicate other needs that you think should be addressed to make you more empowered? You could also identify resource person(s) to deal with these issues.

....
....
....
....
....
....
....
....
....

Thank you for taking time to complete this form.

Annexure C

MPUMALANGA DEPARTMENT OF EDUCATION

SUMMARY REPORT ON CLUSTER ACTIVITIES

1. NAME OF THE CLUSTER……… ……………………………………………………

2. NAME OF THE CLUSTER LEADER……………………………………………….

3. DATE:

YEAR				MONTH		DAY	
2	0						

4.

DATE	ACTIVITY/TOPIC	VENUE	FACILITATOR	M/NS M&NS	NUMBER OF PARTICIPANTS

5. ……………………………………..
CLUSTER LEADER'S SIGNATURE

6. ………………………………………
CIRCUIT MANAGER'S SIGNATURE

STAMP

Annexure D

MPUMALANGA DEPARTMENT OF EDUCATION

SUMMARY REPORT ON SCHOOL-BASED INSET ACTIVITIES

1 NAME OF THE SCHOOL……………………………………………………

2 NAME OF THE HOD……………………………………………………..

2	0		

3 DATE: YEAR MONTH DAY

4.

DATE	ACTIVITY/TOPIC	FACILITATOR	M/NS M&NS	NUMBER OF PARTICIPANTS

……………………………………… ……………………………………………

PRINCIPAL'S SIGNATURE H.O.D'S SIGNATURE

STAMP

Annexure E

MPUMALANGA DEPARTMENT OF EDUCATION

EVALUATION FORM: SCHOOL-BASED AND CLUSTER INSET

Date of workshop:................................

Venue:...

Facilitator:...

Please indicate by a tick or cross in the boxes below for example: [YES]

1. Did you get information on the objectives and content of the workshop before coming to the workshop? [YES] [NO]

2. How do you evaluate the workshop?

2.1 coverage of the subject/concept

[Too broad] [just right] [too narrow]

2.2 depth

[Too deep] [just right] [too shallow]

2.3 logical order of the workshop activities

[Good] [fair] [poor]

2.4 relevance of the workshop to your needs

[Good] [fair] [poor]

2.5 Where your expectations on the workshop met?

Fully met | somehow met | never met

3. Allocation time to different activities

3.1 facilitator's talk	too much	just right	too little
3.2 discussions	too much	just right	too little
3.3 exercises	too much	just right	too little
3.4 to reflect	too much	just right	too little

4 What was most beneficial?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

4. How can the workshop be improved?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

Thank you for taking time to complete this questionnaire.

Appendix 3

Executive Summary

The Mpumalanga Secondary Science initiative (MSSI) is a project of the Mpumalanga Department of Education (MDE) that aims at improving the teaching of mathematics and science in secondary schools through establishment of a province-wide system of in-service education and training (INSET) for teachers. The project was started in November 1999 with financial and technical support from the Japan International Cooperation Agency (JICA) and the University of Pretoria (UP). It is coming to its close at the end of March 2006 after two phases of work targeted at M & S teachers in all secondary schools (Grade 8 – 12) in the province.

The project has a number of characteristics, such as tripartite partnership involving a foreign donor and a local university, cascade model of INSET targeted at all teachers in all secondary schools (rather than selected teachers in pilot model schools), promotion of peer teacher collaboration and reflection, patterned after the corresponding Japanese practices (Please see the summary box). An external evaluation* conducted at the end of the first three-year phase of the project in September 2002 found that Phase 1 "has provided an excellent opportunity for the development of a unique INSET model that should be refined during the second phase of the initiative." The present evaluation has been organized by the three collaborative partners of the project as a 'joint reflection' of the achievements made and the challenges still lying ahead, as well as of the possible ways to further strengthen the department's effort to build the INSET system. As such, this is an internal evaluation of a formative nature.

The project intervention consisted of annual implementation of a material development exercise, followed by three rounds of cascade-based INSET targeted at leading teachers from schools, who, in turn, would implement INSET activities at their respective schools. The primary contribution to MSSI by JICA has been the annual organization of a training course for 10 MDE M & S educators, who learn about the Japanese experience in M & S education development and engage in material development and elaboration of INSET plans for the project. JICA has also organized another annual course for several senior managers of MDE to learn about the Japanese educational development and to develop plans to support MSSI. The total number of participants so far is 71 for the M & S educator course and 45 for the senior managers course. One important aspect of these training courses has been the exposure of these participants to different practices of Japanese educators, such as lesson study and other peer group exercises and the practice of group reflection, which have become the unique features of the project. The contribution of UP has been to provide technical backstopping for the project activities in the country, through the preparation of study guides and refinement of technical guidebooks, technical guidance for workshops and conducting of research on project implementation. UP researchers have conducted considerable amount of research on the Japanese educational development experiences and also accompanied the training for M & S educators in Japan, which facilitate their role as a technical guide in the partnership.

The MSSI project made a major change in its cascade training mechanism during its transition from Phase 1 to Phase 2. In 2002 MDE reorganized its structure of administration from 10 Districts to 3 Regions, and divided the Curriculum Section into

* "An Evaluation of the First Phase of the Mpumalanga Secondary Initiative (MSSI)" conducted by Dr. Zenda Ofir (Evalnet), Pretoria, September 2002.

GET Phase (Grades 1 – 9) and FET Phase (Grades 10 – 12). To cope with these changes, the focus of cascade training was shifted from school-based INSET promoted through District-level training workshops for M & S heads of department from schools in Phase 1, to cluster-based INSET organized by peer teachers from neighboring schools whose leaders (Cluster Leader/CL) will be convened for regional-level leader workshops. The structural change was also accompanied by shifting of assignments and posts for some of the leading CIs. These changes required major adjustments in the working of the cascade training mechanism. The altered mechanism based on clustering of schools began to take shape in 2003 and MDE decided in 2004 to make it an official policy of the department not only for M & S but also for other subject areas.

Given these developments and the consequent delay in reorganization of the INSET monitoring mechanism, it has not been possible to compile systematic data to permit a full and accurate assessment as to how far MDE has advanced in establishing an INSET system. This joint evaluation has conducted extensive interviews with many stakeholders at all levels and arrived at the following conclusions:

- Cascade model of training has been re-initiated with the focus on stimulating cluster-based INSET activities. M & S Curriculum Implementers are beginning to work with the Cluster Leaders, though their impact is still limited. Some of the newly recruited CIs are in need of training for contents enrichment and teaching skills improvement.

- Cluster activities by M & S teachers are taking place in all the circuits of the province, some more frequently and more actively than others. However, the mainstay of these activities are not INSET-related but for moderation of continuous assessment and other administrative work. The activity level seems to be particularly low for GET clusters.

- There are some clusters which have made some significant headway in developing cluster-based INSET activities. In these clusters there is observed both strong leadership and active participation by the participating schools. They also receive support from their schools, and call on CIs to seek technical support. However, inter-cluster sharing of their experiences so far has been limited to their case presentation at CL workshops.

- The link between cluster-based INSET and school-based INSET has not yet been established in most schools. However, some schools which have made substantial progress with school-based INSET during Phase 1 are maintaining their commitment to improvement of classroom teaching of M & S. Their teachers have not only improved content knowledge and teaching skills but also acquired positive attitudes and behavior. The key factor for these successful schools appear to be the principal's leadership.

- The senior management of MDE is aware of the positive impact the MSSI project has had on the department through the spreading the notion of peer teacher learning and the practice of group reflection, and is deeply committed to the pursuit of INSET system building work.

MDE realizes that the department is still a long way from establishing a province-wide system of INSET for the secondary M & S teachers, and has elaborated a sustainability strategy for further promotion of the system-building effort (Please see

Appendix 3). In support of this continued work, the joint evaluation makes the following recommendations to MDE:

1. Establishment of a Math and Science Coordinating Committee
2. Rebuilding of the monitoring mechanism for cluster-based and school-based INSET
3. Institution of a training program to strengthen the contents knowledge and teaching skills of the M & S Curriculum Implementers (CIs)
4. Improving the effectiveness of Cluster Leaders
5. Provision of regional office support for the cluster-based INSET activities
6. Improving the functional utility of the Education Development Centers
7. Development of a 'culture of continuous improvement' at schools through involvement of the school leaders
8. Integration of M & S INSET initiative with MDE systems through elaboration of an INSET policy
9. Holding of an annual provincial meeting to share exemplary practices in M & S education

The joint evaluation also recommends to the University of Pretoria the following: (i) Continuation of the collaborative partnership with MDE, (ii) cooperation in the preparation of guidebooks on lesson study approach, and (iii) establishment of a Research Unit on Lesson Study. It further recommends to the Japanese partners: (i) extension of the JICA Training Course for M & S Educators, (ii) alignment of the work of the JOCV volunteer teachers to the needs of MDE, (iii) continued dialogue between JICA and MDE on educational cooperation, and (iv) research commitment by the Japanese Universities.

Mpumalanga Secondary Science Initiative (MSSI)

Goal: Improved classroom teaching of secondary M & S for enhancement of learner understanding
Aim: Development of a province-wide system of in-service education and training (INSET) for secondary M & S teachers
Duration: November 1999 - March 2006
Partners: Mpumalanga Dept. of Education (MDE)
Japan International Cooperation Agency (JICA)
University of Pretoria (UP)
Target: M & S teachers in all secondary schools (Grades 8-12) in the province

Characteristic approaches:
- Promotion of INSET for teacher capacity improvement and curriculum reform
- Tripartite partnership approach for project planning, management and implementation
- Cascade model of training targeted at cluster- and school-based INSET
- Development of a peer teacher learning approach to improvement of classroom instruction, employing a 'lesson study' approach adopted from the Japanese practice
- Widespread use of the practice of reflection

Appendix 4

FACILITATORS' GUIDE FOR THE MSSI REGIONAL WORKSHOPS

Activities for day one

Workshop Presenters: Prof. Kita , Prof. Ono, Dr. Jita & T. Ndlalane.

9.30 - 945 What is MSSI and what are the aims and objectives of the project will be shared with the participants. A person who understands the goals and the aims of the project should do this task. Achievements in phase one will be shared and the weaknesses in phase one that led to phase two changes. Partnership and roles should be highlighted during this presentation.

9.45 – 10.00 Purposes of the session will be highlighted on the OHP transparency and the participants will be taken through.

10 – 10.30 The roles and the tasks of the clusters in changing classroom practice. This will be done through brainstorming and reflecting on the daily tasks of the cluster leaders. Input from cluster leaders is important.

11.00 – 12.00 Examples of cluster activities will be issued to the cluster leaders and the curriculum implementers are expected to do the following:

- Help cluster leaders to form groups as according to their specialization in the four themes of natural sciences and one group for mathematics.
- The curriculum implementer to issue a A4 paper to each cluster leader
- Ask each cluster leader to write the topic on discussion on the top of the paper, e.g. Energy, Seed, etc.
- Make sure that the cluster leader write his/her responses and submit the paper to the curriculum implementer, who will submit it to the presenters.
- The curriculum implementer will then issue a Koki pen and a flip chart paper to the group.
- The cluster leader to facilitate the discussion in a group and encourage all the leaders to participate.
- One of the leaders will be a scriber and one will report on behalf of the group.
- The curriculum Implementer will then collect the flip chart paper from his group and submit it to the presenters.

~~12.00 – 12.30 The cluster leaders will be taken through~~ the process of facilitation. The focus will be on the skills used at this workshop.

1.30 – 2.00 Lesson plan discussion (Framework)

Appendix 5

Programme for the 2nd MSSI provincial workshop 2004

Venues: Riverside Complex

Day	Date	Time	Session	Responsibility
1	21 June (Mon)	A.M.	Arrival at the Riverside Govt. Complex	
		09:30	**Tea**	
		10:30	Welcome + Purpose of the workshop **(Room 2/3, Whole day)**	V Mkhwanazi
		11:00	Feedback on Cluster Activities * Report from regions * Univ. of Pretoria	C. Mtetwa
		13:00	**Lunch**	
		14:00	Discussions on Cluster Activities (cont)	T Ndlalane
		15:30	Introduction of monitoring format	L. Mogoane
		16:30	Reflection (H/O, UP, JICA)	K Maremane
2	22June (Tue)	08:00	Review of progress Today' schedule	DCES
		08:15	Content enrichment (Introduction of study guides)	DCES / Experts
		10:00	**Tea**	
		10:30	Content enrichment (continued)	DCES / Experts
		13:00	**Lunch**	
		14:00	Content enrichment (continued)	DCES / Experts
		16:30	Reflection H/O, UP, JICA, 1 CI per sub-group	K Mohan
3	23June (Wed)	08:00	Review of progress Today's schedule.	DCES
		08:15	Content enrichment	DCES / Experts
		10:30	**Tea**	
		11:00	Planning for Cluster Leaders workshops	DCES / Experts
		13:00	**Lunch**	
		14:00	Planning continued	DCES / Experts
		15:00	Reflection (H/O, UP, JICA, ROC's) Departure **(Room 2/3)**	Dr. F Khumalo

Appendix 6

Post - Cluster Meeting Questionnaire

As part of providing support to the cluster activities of the Mpumalanga Department of Education (MDE), the University of Pretoria is collecting feedback on all cluster sessions and suggestions for improvement. Your responses to the following questions are therefore critical for the improvement of the cluster approach as a whole. Your names and schools are needed only for research purposes and will NOT be divulged in any correspondence with the MDE.

Name: ______________________________

School: ______________________________

Cluster Name: ______________________________

Question 1

How did you find out about today's meeting?

____

____

Question 2

What was/were your major reason(s) for attending today's meeting?

____

____

Question 3

What were your expectations for today's meeting? Please elaborate.

____

____

____

Question 4

Did today's session meet your expectations? Why/Why not? Please elaborate.

____

____

____

Question 5

What would you like to see done differently? Why/Why not?

____

____

Question 6

How will you use the information from today's session in your classroom? Please be specific about the topics, activities, materials/hand-outs, etc and how you will use these in your own classroom (please use the back of this page, if you need more space)

____

____

University of Pretoria: Joint Centre for SMTE

SECTION A

---

1. Which of the following activities related to the tasks and functions of curriculum implementers have you participated in during the past three months (i.e. April, May and June)? Indicate approximately how many times you engaged in each activity:

	4 times	**3 times**	**1 or 2 times**	**Not yet done**
a) Observe a cluster meeting in progress	☐	☐	☐	☐
b) Visit a school for classroom observation in my subject	☐	☐	☐	☐
c) Conduct a workshop/meeting with **all** Cluster leaders in my region........................	☐	☐	☐	☐
d) Delivery of LSM to schools……….	☐	☐	☐	☐
e) Conduct a workshop/meeting with **all** the teachers in the schools for which I am responsible…………….	☐	☐	☐	☐
f) Design and development of LSM at regional Or local level……………………….	☐	☐	☐	☐
g) Attend a class or course in science/maths as Part of my own personal development…….	☐	☐	☐	☐

---

2. If you have conducted a workshop or participated in a cluster meeting, which of the following best describes the <u>focus</u> and <u>frequency</u> of your engagement during these activities?

	4 times	**3 times**	**1 or 2**	**Not yet Done**
a) Help teachers with portfolios	☐	☐	☐	☐
b) Assist teachers in doing CASS....	☐	☐	☐	☐
c) Conduct OBE/RNCS training.......	☐	☐	☐	☐
d) Teach a demonstration/model lesson………………..	☐	☐	☐	☐
e) Discuss specific subject content ...	☐	☐	☐	☐

f) Please specify the **topic** and describe briefly what you **did/said** during the discussion in (e)

----

g) Discuss the MSSI study guides ...	☐	☐	☐	☐

h) Please specify the **actual topic(s)** and describe briefly what **activities** (from the guide) you did during the meetings described in (g)
