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. Loucks-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), Loucks-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.