Chapter three

RESEARCH METHODS

3.1 Introduction

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

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

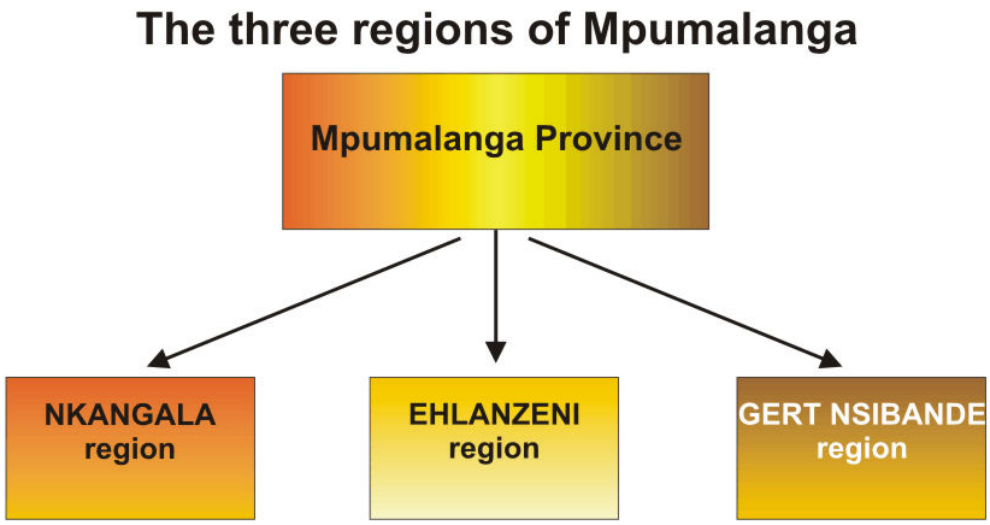
Qualitative techniques provided this study with descriptions that portrayed the richness and the complexity of events that occurred in natural settings of clusters from the participants' perspective. By triangulating the data collected from the various sources and through the various instruments, I was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

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

3.1 .1 Description of the Field

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

Fig. 2. Illustrates the three regions of Mpumalanga



Mpumalanga Province is divided into three regions, Nkangala which is semi rural and closer to Pretoria, Ehlanzeni which is rural and far from Pretoria and Gert Nsibande which is also rural and far from Pretoria. As one of UP's facilitators in science and mathematics workshops, I worked in the whole province (see fig. 2 on dominant MSSI clusters on this chapter). I had a fairly good understanding of the geographical areas of this province. For this study I chose to target all regions but sampled on specific areas and schools that would give me the best understanding of clusters' operation at their contexts.. Ehlanzeni was chosen for the Isibonelo cluster as a case

study because it has unique features that compared well with the other cluster - SIM. at Nkangala. The choice of these two different cluster structures was for a specific purpose for this study. Firstly, both clusters engaged teachers in constructing and reshaping their scientific content knowledge. Secondly, they are both under the leadership of cluster leaders but their leadership and operation differs. The one operates in a hierarchical fashion while the other operates in a voluntary way as discussed and defined in table one. Thirdly, the provincial policies and the implementation of MSSI activities affected both of them in a similar manner. By studying in detail their operation and functioning in reshaping science teachers CK and PCK would enable me to understand the concept of clustering better. I intended to bring the contrasts and similarities in the way in which the clusters operate in helping the teachers to learn from each other as peers. For example; if we take the case of Sibonelo cluster, it is the only cluster that engaged teachers in different types of cluster activities which it called, *cluster teaching* and yet was the most rural. Cluster teaching means teachers after attending a cluster meeting of collaborative planning of lessons, they will invite learners from all the cluster schools and teach them while the other teachers are observing. This is a unique feature that I had intended to explore and examine in detail by selecting and working with the schools that were participating in these clusters. The findings of my investigations are shared in chapter four of this study.

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

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

Fig. 3 Illustration of data collection points at Dominant Clusters

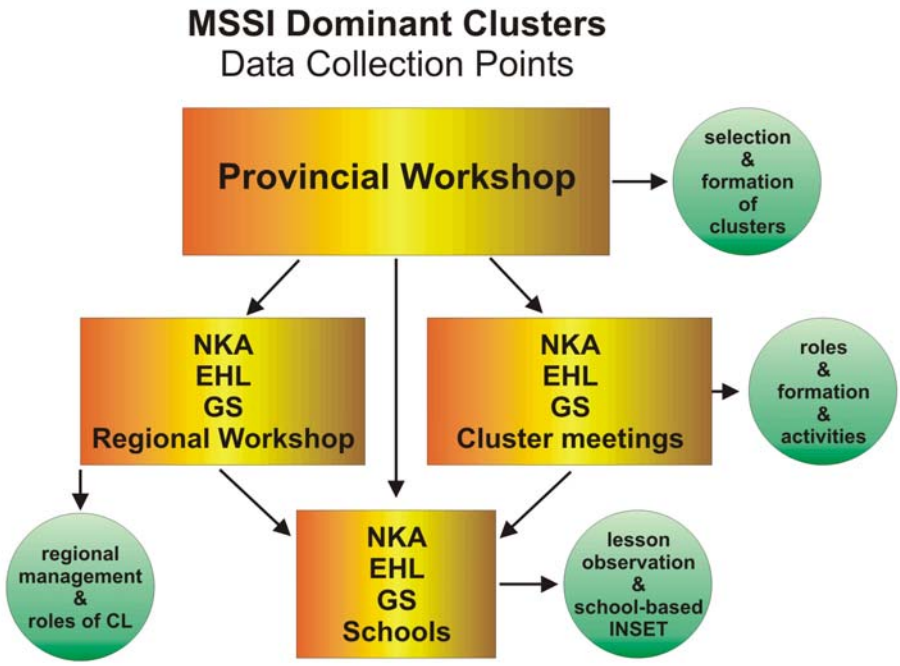


Fig. 4 Illustration of data collection points at SIM Cluster

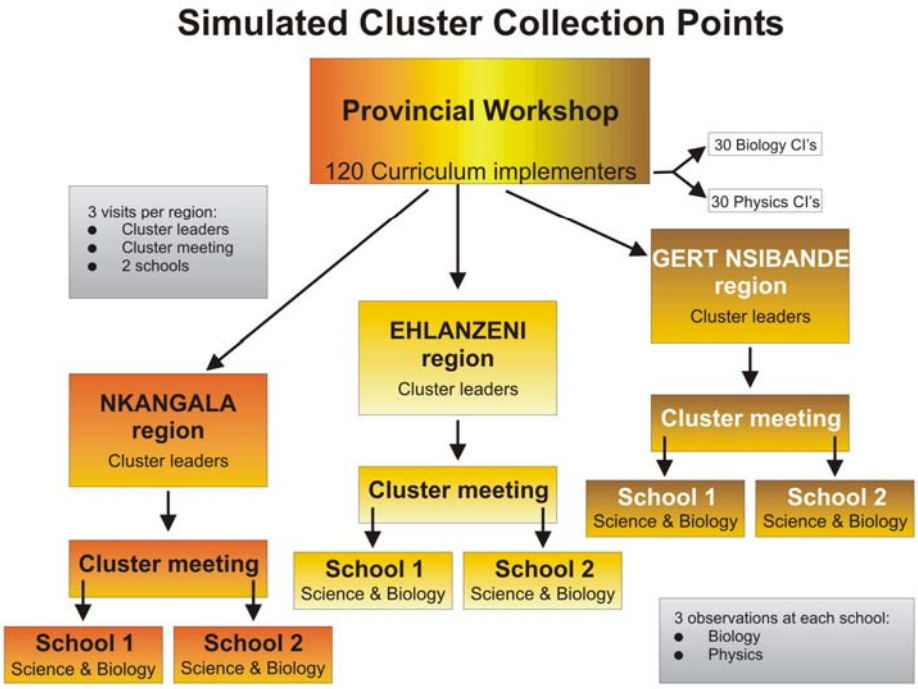
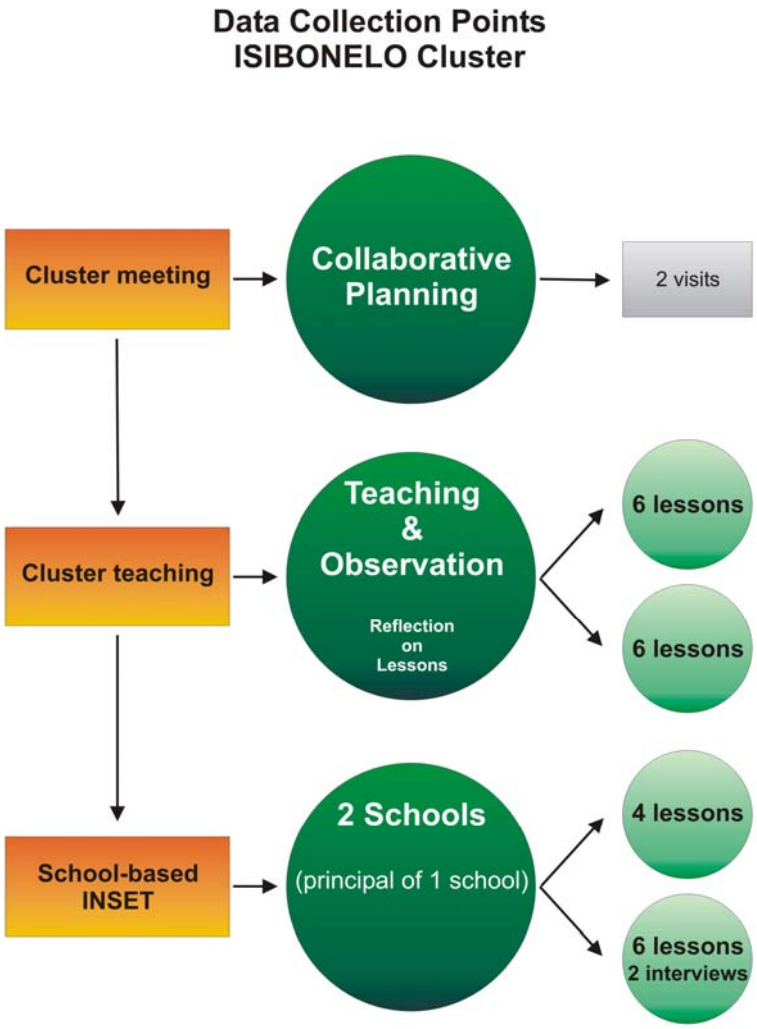


Fig.5. Illustrates data collection points at Sibonelo Cluster as an External cluster.



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

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

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

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

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

3.2 Research Design

3.2.1 Methodological approaches used:

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

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

This approach enabled me to describe the context and the social environment in which clusters operated. Multiple case studies are one of the most common ways to undertake qualitative inquiries because they enable interpretation within a context (Denzin and Lincoln, 2000). Case studies focus on a specific situation or phenomenon and as they are descriptive, they offer insights into the phenomenon that is being

studied (Merriam, 1988). In this study the phenomena under examination were the two unique clusters (the SIM and Sibonelo) that were deliberately chosen. One of these clusters is situated in a deep rural area of Mpumalanga and the other was a created cluster (simulated) in a central semi-urban area. An in-depth study of what the clusters leaders did as a group that challenged and reshaped their knowledge and practices in the classroom, was carried out. Malcolm's (2001) opinion is that case studies describe and analyse the people's individual and collective social beliefs, actions, thoughts and practice. This statement is in line with the findings of this study. Mpumalanga Province had 120 clusters registered in the MSSI project and to study all these clusters would complicate the focus in describing and understanding what clusters do in changing and shaping teachers' practice.

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

The cluster leaders from registered clusters were provided with training on support as instructional leaders by the University of Pretoria. In this setting the cluster leaders were themselves learners. At the other level they were expected to run workshops for other participants in their cluster as trainers. This study attempted to capture these processes of knowledge dissemination that impact on clustering at all the cascade levels. Guba and Lincoln (1989) argue that,' case studies provide detailed description of the cases, analyses of the themes and issues, and the researcher's interpretations or

assertions about the cases. The events and operations in clusters provided dynamics that could be best captured by describing those events that provided information on those issues which are key to teacher development. Yin, (1988) points out that, although case studies are narrower in scope, they are more thorough and more qualitative than surveys and are therefore more enlightening and reliable. The information gathered from MDE documents and reports had some limitations. It might look similar to the outline of the course or workshop proceedings but failed to bring the in-depth observations and descriptions of events that might lead to interpretations on clusters that appear similar but operated differently. These differences in the way they operated would enrich those interested in clusters as an approach to teacher development. Each case examined and explored the following activities:

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

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

The data collected from these case studies was analysed, and documented. Data from interviews was captured through note-taking and audio tapes. This data was categorised in order to identify common themes and patterns. The themes and patterns

that emerged were linked to the way in which opportunities that are created by clusters for teachers to explore and improve their pedagogical content knowledge. Examples of these themes are given in the results of the proceedings of the workshops, for both clusters, in chapter four. The case study participants were given pseudonyms in order that they remain anonymous.

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

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

Further, I had to review the programmes and the work plans of the clusters leaders in order to get an understanding of the cluster activities. The documents were reviewed and analysed in order to gather the data on the specific content knowledge that the clusters were handling. These documents attempted to give light to the nature of

activities that the teachers were struggling with in the classroom as well as the work that was demanded from the teachers by the provincial or regional offices.

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

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

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

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

3.2.2 Sampling

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

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

3.2.2.1 Sampling of documents

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

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

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

3.2.2.2 Sampling of Clusters

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

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

(ii) External Clusters

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

The second cluster was a sample of external clusters and how they operate on their own on voluntary basis. One cluster was selected on the basis of its activities and

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

3.2.2.3 Sampling of Schools

(i) Schools from registered clusters

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

(ii) Schools from external clusters

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

3.3 Research Instruments and Data Sources

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

3.3.1 Interviews

Using interviews as a tool for collecting data was an ongoing process in this study. Initial interviews were conducted as early as 2002 with MDE personnel. These interviews focussed on broad policies and practices of the MSSI project in the regions. The second set of interviews used in the study targeted focus groups during

the simulation workshop. Focus group interviews involved discussions with subject area cluster leaders and responses to a questionnaire after the activity. The purpose of the focus groups was to give the cluster leaders an opportunity to share their experiences and to modify their original perceptions about the clusters. Group interviews did not replace individual interviews but served to provide another level of data gathering. Four group interviews were organized for this purpose based on the four subjects. Open ended interviews were used in group interviews. The responses were recorded, grouped and then analysed in order to establish meanings.

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

3.3.2 Observations

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

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

3.3.3.1. Classroom case scenarios

In reviewing the literature on teacher development programmes, the issue of inadequate content knowledge has been a topic of research for many years (Fullan, 1993; Gunstone, 1994). The issue of teachers' PCK has always been a problem which

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

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

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

Themba and Thula are the best students in a science class at Zamokuhle Combined School. They are also very good friends and often talk about their subjects during their free time. On one occasion, the two friends engaged in a conversation about one of their weekend activities.
Themba says to Thula: After cycling all weekend, I have lost all my energy.
Yes, you have lost all your energy and your bicycle has gained it, responds Thula with a smile.
Nonsense, how can a bicycle gain energy? What has it got to do with energy anyway? Themba responds, a bit amused by his friend's argument. Well, we should ask Mr. Zikhali [their science teacher] about this, retorts Thula.
In class, the two students begin their conversation again, this time engaging Mr. Zikhali and the rest of their classmates in this discussion.

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

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

Put yourself in Mr. Zikhali's position……

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

Why do you think so?

What does this student understand?

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

Why do you think so?

What does this student understand?

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

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

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

[hint: plan an actual intervention lesson for Thula]

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

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

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

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

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

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

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

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

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

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

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

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

Why do you think so?

What does this student understand?

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

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

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

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

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

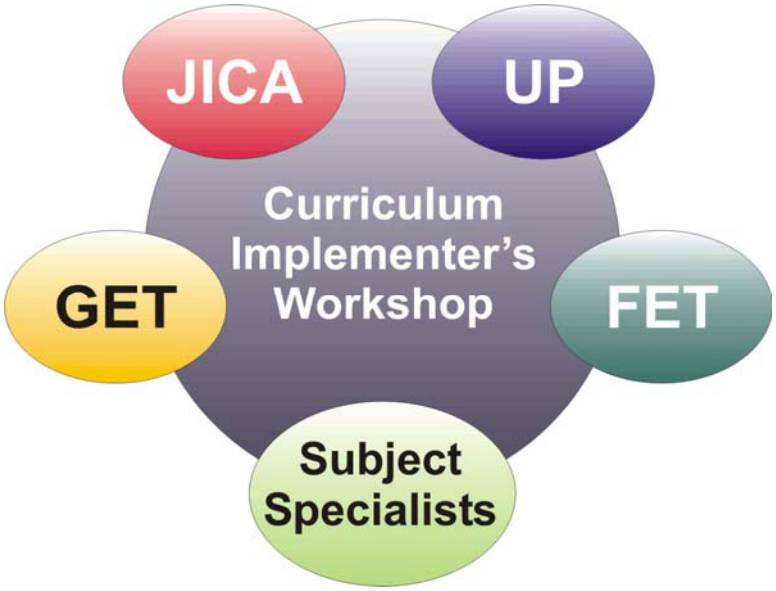
The purpose of using this type of instrument during cluster workshop was to simulate the process of uncovering, shaping and constructing new knowledge through sharing in clusters. The instrument also intended to assess the level of the teacher's content and pedagogical content knowledge before the cluster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

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

3.3.3.2 Cluster Simulation at the Curriculum Implementers' Workshop

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

Figure 6. Curriculum implementer's workshops

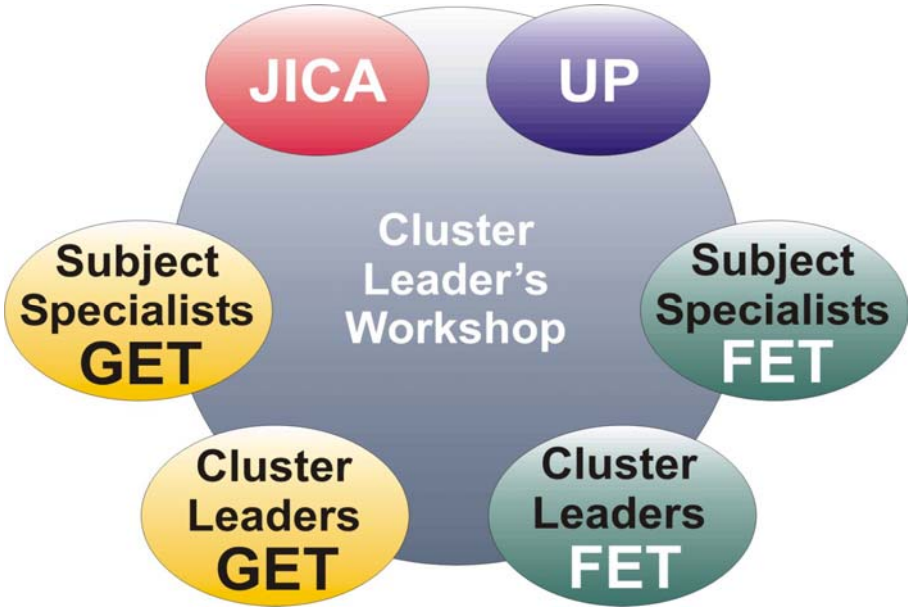


My role at this meeting was to train and develop curriculum implementers on content knowledge and the facilitation of workshops for cluster leaders. The data on the activities of the clusters from all three regions was shared and distributed in form of handouts, to all the participants. Each cluster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

3.3.3.3 The Regional Cluster Leaders' Workshop

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

Figure 7. Cluster Leaders' Workshop



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

3.4 The Process of data collection based on research questions

3.4.1 Research question 1

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

3.4.2 Clusters in Mpumalanga

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

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

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

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

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

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

"Focus groups generally range from six to twelve participants, the exception is where the topic needs to be explored in great depths and where people had great experiences related to it" (Anderson 1990:224). Focus group in this study was of a different nature as against the numbers recommended by researchers. However, while training a group

of 120 cluster leaders I was able to use this large group in order to collect data using a group brainstorming technique and the consolidation of the responses for agreement and disagreement on the spot. The purpose of using this technique of data collection was to get the groups' perspectives on their roles as Cluster Leaders and be in better position to compare and contrast it with the one reviewed from the MDE documents. The question that was put on the overhead projector was:

What do you perceive as your roles as Cluster Leaders?

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

3. 4.3 Research question 2

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

3.4. 3.1 Challenging teachers' PCK in clusters

In order to understand the complexity and dynamics of clusters in improving teachers' pedagogical content knowledge, the cluster workshops were used to simulate teachers 'cluster meetings. This approach to data collection has been chosen in order to be in line with fieldwork on science teacher development and the nature of science and science learning. My data collection adopted this technique and extended it further by

designing classroom case scenarios based on the two topics in science. One topic is a physics topic on *Energy* and other one is on a biology topic on *Seeds and Growth*. Specifically, UP team of facilitators created classroom scenarios as responses from learners. These scenarios were used as instruments to asses the content and pedagogical content knowledge that teachers, as learners, bring to the cluster workshops. These instruments were used at two levels; provincial MSSI workshop and at regional MSSI workshops. The qualitative data that was collected at both levels, enabled me to take into account the importance of both human resources beliefs and practices in terms of CK and PCK in influencing the classroom practices.

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

3.4.3.1 Simulation as a tool in clusters to determine PCK

(i) Proceedings during the simulation

Step one: Curriculum implementers were divided into four groups as according to the learning areas in MSSI. Each person was given the task on a piece of paper as an individual. They were given 30 minutes to respond to the task as individuals. They were expected to write their responses on the paper and submit the paper after completion. They were not expected to write their names on their responses nor to

discuss their responses with others. Monitoring and supervision of the participants was strictly carried by the UP staff. There were 22 participants in the physical science group and only eight that opted for biology. While all the subjects were considered for this activity, this research focused only at the two groups; science and the biology. The individual responses were captured and presented into each group for sharing purposes.

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

Step three: Cluster leaders' workshops

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

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

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

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

3.4.4 Research Question 3

What is the nature of resulting knowledge and classroom practices?

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

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

3.4.4.1. Observation and field notes

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

3.4.4.2 Interviews and classroom observation

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

3.5 Reliability and Validity of Data

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

3.6 Problems and resulting limitations

My plan was to collect data on the activities in cluster leaders' workshops twice a week in three schools per month. Such data collection process would enable me to

study the patterns of knowledge that teachers bring in the cluster and how it was shared within the cluster. However, one of the most frequent problems encountered in the study is that although the dates were arranged before hand, these were not always adhered to by the teachers in the schools. Some of the reasons were:

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

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

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

cluster members of the SIM cluster, that participated as cluster leaders were promoted to senior positions of being implementers; it became difficult to follow them for feedback on how they taught the sessions on Energy and Growth in their own classrooms.

3.7 Research Ethics in my role as a researcher

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

As the SIM cluster was operating under the jurisdiction of the MDE and UP as partners, I managed to collect data at all entry points. Permission that allow UP to do research was part of the contract for working and supporting clusters as indicated earlier on my wearing of two caps in the MSSI project. Access to entry was negotiated with the parties concern. For example, if I had to go to school to talk to the cluster leaders, permission was obtained from the school principal. Individual requests were made to cluster leaders that were to be interviewed and detailed explanations were given on why the information was needed and how it was to be used. The collection of data from the regional managers was also negotiated with the individuals. Explanation on the use of data was clarified to all the people that participated in this study. In order to balance my contradictory roles as a researcher

and a trainer, I made use of the team from UP in data collection. For example, in interviewing the regional managers my colleague led the interviews and in collecting data on uncovering the content knowledge we also worked as a team of three people (experts); science, maths and biology. My dilemma being in this situation was to wear the two caps. Being a participant observer, working with the team and using a variety of research techniques helped my situation.

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

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

subjects in data collection. Their involvement in the cluster (SIM) reduced the biases on the data collected.

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

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

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

3.8. Data Analysis

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

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

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

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

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

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

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

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

3.9 Summary

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

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