Chapter One

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

1.1 Study Overview

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

The idea behind our science cluster was to engage ourselves as teachers in discussions on real classroom issues that challenged the way science was taught at schools. Like many of my colleagues in our cluster, I was familiar with, and had used the excuses of not having enough science equipment, not enough time for practical work; and no running water at our schools to explain the poor teaching practices in my science classes. Fortunately for us, our collaborations and the supportive guidance from the university lecturer helped us

to challenge and rethink our excuses and thereby our teaching practices in general. Upon reflection, I can still see how, many of the teachers in this cluster became active participants because of this guidance and support from Mr. Knowles, the university lecturer. Over time, we also came much closer together in our thinking and in our beliefs about teaching science. As time went on, and discussions continued, we began to see the importance and value of practical work in the teaching of science. The teachers from schools that had science equipment, among the cluster members, also became more and more willing to share their resources with the rest of their colleagues in the cluster.

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

The major goal of the cluster was to encourage us to challenge and re-examine our knowledge and practices of science teaching. We were then expected to use the knowledge gained in these sessions to improve our teaching in our own schools and classrooms and then to come back and share the classroom experiences in the subsequent cluster workshops. As I reflect back on my teaching career, I can still argue with myself that this is where my teaching of science changed significantly, from a focus on teaching only the topics that I understood with no use of practical work or experiments to progressively incorporating practical work and investigations in almost every science lesson I taught. I moved from a practice of just reading the experiments from the book with the expected results as written out by the authors, to a practice of using the investigations to explore and facilitate conceptual understanding of science concepts for

the learners. I know that this was the case for most, if not all of the teachers in our cluster, because two years after the cluster had been initiated, four teachers were awarded a British Council Scholarship to further their studies in science education in England. Three out of the five schools from where the cluster teachers came, became best performing science schools in KwaZulu-Natal. Indeed, I am still convinced that something interesting and worth investigating happened in that cluster to result in the kinds of outcomes and professional growth that I have just described.

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

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

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

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

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

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

1.1.1 Personal Drivers

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

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

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

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

1.1.1a Teacher Development

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

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

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

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

In this study, I have explored and tried to understand how clusters in the Mpumalanga province of South Africa assisted teachers in changing their knowledge and practices in the science education. Furthermore, I examined how the learning opportunities and

approaches that were created, all functioned to enhance learning and change in the cluster sessions. On the basis of my own experiences as a science teacher and a teacher developer, I postulate that clustering of schools based on teachers' voluntary participation, interaction and collaboration based on real classroom activities, has the potential to challenge and change the classroom practices of science teachers. This study is a contribution to the literature on teacher development and should be an aid to policymakers and providers of INSET generally.

1.1.2 Theoretical Drivers

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

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

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

1.2. Clusters as aid to teacher development

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

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

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

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

the most commonly used word is clusters rather than networks and for the purposes of this study I will adopt the word clusters to describe such networks.

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

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

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

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

1.2 Mpumalanga Secondary Science Initiative

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

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

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

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

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

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

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

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

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

This study uses the experiences of the Mpumalanga teachers as an aid in attempting to understand the concept of clustering and the influence of clustering on teachers' classroom practices. The cluster leaders, who are selected for each cluster, are the major players in the organization and leading of the clusters of peers. They are teachers themselves, who have been given this extra responsibility. Their role is to support other teachers by facilitating all the cluster activities in their locality. The Curriculum Implementers, previously known as subject advisers, have been included in Phase 2 of MSSI project, mainly to play a support and monitoring role in activities of the various

clusters. While the MSSI project focuses on both science and mathematics, this study focused only on the sciences because of my personal interest and experience in the teaching of the sciences. In undertaking this study I was keen to understand the processes behind the changes in the knowledge and practices of the cluster members and, furthermore, how this change gets transferred, if at all, into the classroom.

1.4 Statement of the problem

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

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

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

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

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

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

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

1.5 The organisation of the study

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

As a point of departure, chapter one has described the concept of teacher clusters as a case of teacher development and the implications it may have on changing teachers' classroom practices. I also reflected on my own experiences as a teacher and as a leader

of a cluster in order to contextualize and locate my present research and scholarly interests on teacher clusters and teacher development generally. It has also aided in explaining and exploring the visions and intentions relating to teacher development, innovation and change in science education.

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

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

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

The fifth chapter gives further detailed descriptions and analysis of the two case studies and explores how teachers in these clusters used the opportunities created for their own development in changing classroom practices. These two cases highlight the stories and experiences of the teachers who participated in the selected clusters. The discussion focuses on the cross-case analysis and highlights the similarities and the differences in the formation, operation and the potentialities of the different cluster approaches to changing

and challenging CK and PCK. This chapter further gives a brief summary of the entire study and gives pointers and the important themes and new knowledge coming out of the study. It also highlights the importance of this research and opportunities for further research in this field.