Teacher clusters in South Africa: opportunities and constraints for teacher development and change[1]

LOYISO C. JITA AND TEMBI C. NDLALANE

jitalc@unisa.ac.za

Teacher clusters represent a recent experiment in the field of teacher professional development in South Africa. Increasingly, teacher clusters are being used as a substitute for the traditional approaches to professional development in helping teachers reshape their professional knowledge and change their classroom practices. What underlies this renewed confidence in teacher clusters as a vehicle for professional development? In this paper, we use a qualitative case study approach to examine the efficacy of clustering as an approach to teacher development. Using interview and observation data from a cluster of 120 science and mathematics teachers in Mpumalanga, we discuss how structure and function in the cluster interacted to provide the participating science teachers with a rich set of 'opportunities to learn'. We argue that it is not merely the existence of the structure, namely, the cluster, that provides the opportunity for effective professional development, but that it is the interactions among teachers, together with relationships of trust and identity, that make clusters an attractive vehicle for challenging and (possibly) changing teachers' professional knowledge and practice.

Introduction

The answer to the question of what it will take to change teachers' classroom practices remains as elusive today as it has always been. For this reason, the search for more effective strategies for the professional development of teachers continues in many countries around the world. South Africa has over the past few years been engaged in various approaches to teacher development, and the development of science teachers in particular. Nevertheless, despite all the efforts and enthusiasm, very little appears to have changed in the teachers' practices (Kahn, 1995; Jansen, 1999).

As a consequence of the lack of effective classroom practices and related theoretical debates, especially in South Africa, many new approaches to professional development have begun to emerge. Most of these are aimed at science and mathematics teachers (Grayson & Ngoepe, 2003; Southwood, 2002). This is in part because the majority of science teachers in South Africa are either underqualified or not qualified at all to teach the subject (Kahn, 1995; Taylor & Vinjevold, 1999). Teacher clusters represent one such recent experimental approach to the professional development of teachers in South Africa. In other countries and contexts, clusters are also referred to as 'teacher communities of learning' or 'teacher networks,' and have a relatively longer history (Adams, 2000; Lieberman & Grolnick, 1996; Lieberman & Mclaughlin, 1992). Although the teacher network approach has gained popularity in countries such as the United States of America (USA) and the United Kingdom (UK), research on its usefulness in changing teachers' knowledge and practices is not conclusive. In fact, as Lieberman and Grolnick (1996) contend, little is known about how such networks are formed, what they focus on, and how they develop teachers. Even less research on clusters has been done in Africa and other developing countries. This also applies to South Africa, in spite of the fairly rich history of clustering in the 1980s and early 1990s among a number of non-governmental organisations (NGOs) and teacher organisations, including the Transvaalse Onderwysersvereniging (TO), the Transvaal Teachers' Association (TTA), the Suid-Afrikaanse Onderwysersunie (SAOU), and the South African Democratic Teachers' Union (SADTU).

Using a research and development project funded by the Japanese International Cooperation Agency (JICA) in the province of Mpumalanga in South Africa as our context for investigation, we set out to explore the utility of teacher clusters or networks in helping to challenge and change science teachers' knowledge and classroom practices. We were interested primarily in the question

of whether and how clusters are able to create better opportunities for science teachers to challenge and change their subject content knowledge (CK) and pedagogical content knowledge (PCK) within the South African context, specifically.

In this paper, we present findings from a multi-year research project on teacher clusters, involving 120 science and mathematics secondary school teachers in Mpumalanga. We discuss a case study of a cluster activity to develop insights concerning the way in which structure and function in teacher clusters interact to provide different sets of 'opportunities to learn' (OTL) for the participating teachers. We argue that it is not simply the existence of the structure, namely, the cluster or network, but more importantly the nature and quality of the teacher-led interactions within the cluster itself, plus the construction of relationships of trust and identity by those participating in the cluster, that provide the opportunities for the effective professional development of teachers.

Theoretical framework

Numerous studies have already established that many of the approaches used to develop teachers have had minimal results in influencing and changing teachers' knowledge and classroom practice (Fullan, 2001; Gottesman, 2002; Jansen, 1999). Unfortunately, much of the evaluation of staff development programmes begins and ends with the assessment of the individual's reactions to workshops and courses. In such cases, little is revealed about the acquisition of new knowledge and skills and how that learning affects teachers' daily practice (Guskey, 2000).

Teacher clusters are a "form of professional community that provides a context within which members can come together and understand their practices" (Secada & Adajian, 1997, 193). Lieberman and Grolnick (1996) have stressed that, although there is no single definition of clusters or networks, the group of clusters that they studied engaged in similar activities, such as sharing content knowledge, reflecting on their teaching experiences, giving feedback, collaboration and negotiation. Collaboration and sharing of knowledge among peers helps teachers to reflect on their practices as equals through meaningful social interaction. Prawat (1992) uses the term "negotiation" to describe this social interaction because it involves learning and unlearning new information. The cluster approach to teacher development therefore seems to promote collaboration, construction and sharing of CK and PCK in a meaningful way (Guskey, 1986). Although clusters are not a new phenomenon in other countries, in North America and Europe, research on their successes and failures remains scant, a gap that our study sought to fill.

In our study we adopted a conceptual framework based on the work of Cochran-Smith and Lytle (1999) and Shulman (1986). Cochran-Smith and Lytle (1999) provide an analytical framework for theorising teacher learning on the basis of fundamental ideas about how knowledge and practice are related and how teachers learn within communities and other contexts. Their views are based on a scheme that explores the knowledge that teachers have acquired through formal training (*knowledge of practice*), the knowledge they acquire during their teaching experiences (*knowledge in practice*), and the combination of both types to form knowledge for professional practice (*knowledge for practice*).

While these concepts that explore teacher learning on the basis of the relationship between knowledge and practice are important, they still fall short of articulating the broader spectrum of possible knowledge that is required for teaching. We therefore blended Cochran-Smith and Lytle's scheme with the 'knowledge for teaching' framework of Shulman (1986), which, among other things, identifies PCK as a critical component of the teacher's knowledge for teaching. Linking the two conceptual frameworks concerning teachers' knowledge made sense, especially for examining the relationships between teachers' CK/PCK and the resulting changes in classroom practice. This combination of perspectives on teachers' knowledge in our conceptual framework helped to overcome what we viewed as the limitations of past research that sought to understand only what teachers need to know and how they learn to teach, instead of what they know and how they teach what they know (Lieberman & Miller, 1991).

Mode of inquiry

The study used qualitative research approaches to investigate and explain changes in the teachers' CK and PCK through the cluster experiences. Qualitative methods allow for verbal descriptions, analysis, and the interpretation of the phenomenon of clustering (Denzin & Lincoln, 1994). Qualitative interviews and observations allowed us to provide descriptions conveying the richness and complexity of events that occurred in the clustering process from the participants' perspectives. In order to obtain in-depth knowledge and information about cluster activities and their influence on teachers' professional knowledge and practice, we developed a series of case studies of some teacher cluster activities. The case studies clearly revealed widespread diversity on a variety of issues, which could not have been explored as thoroughly using other research approaches. This widespread diversity of information on clusters provided greater understanding of the dynamics in clusters.

A particular methodological innovation in this study is its attempt to offer a detailed investigation of how teachers share and exchange CK and PCK in these cluster meetings, thereby making clusters a fertile site for teacher development and change. Methodological difficulties have so far conspired to restrict the exploration of teachers' professional knowledge to a limited pool of small-scale studies at best (Loughran, Mulhall & Berry, 2004). As Loughran *et al.* (2004, 370) observe, "teachers' professional knowledge is difficult to categorise and therefore exceptionally difficult to articulate and document". This is in part because in the case of many teachers, practice and the knowledge or ideas that influence it are often tacit. A handful of researchers in science education have tried, over the past two decades or so, to uncover teachers' subject matter (content) knowledge of specific topics such as light and shadows (Smith & Neale, 1991), and forces (Kruger, Palacio & Summers, 1992). However, not many studies of this nature have examined the knowledge and understanding of science teachers in developing countries, as work in developing countries has tended to focus rather on children's knowledge and dispositions in science. This, we believe, is a critical omission in the research on science education, in South Africa especially, given the emphasis on subject matter (content) knowledge and conceptual development in the latest curriculum reforms nationally.

Our study contributes to the literature on teachers' professional knowledge generally, and more specifically to the literature on science teachers' subject matter (content) knowledge. Simultaneously, we also want to make a methodological contribution through our development of an approach used to capture and categorise teachers' knowledge of science content.

Data collection

We sampled a group of science teacher-leaders, whom we refer to as cluster leaders. The cluster leaders constitute a group of senior and/or exemplary teachers who have been given the responsibility of co-ordinating the activities of groups of local teachers (the clusters) who come together periodically for sharing their experience of the professional development activities in their school settings. In this case, we purposively sampled a total of 120 cluster leaders from three regions of Mpumalanga who had attended the Mpumalanga Secondary Science Initiative (MSSI) professional development workshops between 2003 and 2006.[2] The MSSI used the concept of teacher clusters (or networks) to pursue its professional development activities. The cluster leaders, although similar to other science teachers in the clusters across the province, should by definition constitute the leadership core of this group of teachers. They can thus be assumed to be relatively more knowledgeable and skilled than their counterparts who are not cluster leaders. While this possible over-estimation in terms of knowledge and skills in our sample is useful to bear in mind, it is not critical for the present study, given that our focus is on the phenomenon of clustering as an approach to professional development rather than on seeking to generalise teacher characteristics to a population of individuals.

As we mention earlier, many researchers have found it difficult to study the notion of teachers' professional knowledge empirically, because it is often tacit and contextual and not easy to verbalise. On the other hand, there is also uneasiness concerning the ethics of 'testing' teachers on their knowledge. In the South African context, where teacher unions are fairly strong, such 'testing' of teachers' knowledge is at best likely to be viewed with suspicion. Consequently, we developed an instrument that would help us uncover aspects of the teachers' professional knowledge in a way that would not be offensive to the group of teachers we worked with in the MSSI. The instrument consisted of a hypothetical case study involving two or more learners engaged in a discourse about a key topic in the subject (such as energy and work in Physical Sciences). The cluster leaders were requested to assess and give an opinion on each of the learners' statements and responses. Through the teachers' comments, we hoped to uncover aspects of their CK and PCK, and thus describe how the subsequent collaboration in the cluster meeting had helped to challenge and (possibly) change these components of their professional knowledge. The four groups of 30 cluster (teacher) leaders (teaching Mathematics, Biology, Physical Sciences and Agriculture, respectively) were each given a subject-specific case study to work with. Each group had two or more facilitators (the subject advisors from the Mpumalanga Department of Education (MDE), often called curriculum implementers or CIs). Part of the day-to-day role of the CIs includes helping teachers with CK and PCK issues in their schools.

The teachers were given 60 minutes to work individually, and then gathered for a simulated cluster meeting where they compared their individual responses, debated them, and collaboratively constructed a negotiated group response to the task. The research team collected both the individual and the collective responses for analysis and sharing with the cluster leaders at their next professional development session.

In the next section, we discuss the findings from the Physical Sciences and Biology cluster meetings, to illuminate the issue of how the Mpumalanga teacher clusters functioned to challenge (and possibly change) teachers' CK and PCK.

Findings

The study of teacher clusters was motivated by our desire to explore and understand what underlies the trust that many researchers have placed in clusters as an approach for the professional development of teachers. In this section, we discuss precisely what the Mpumalanga clusters did to challenge the teachers' CK and PCK, and how they did so.

Uncovering cluster leaders' CK and PCK

An interesting finding based on the responses of the cluster leaders was that their responses reflected a pattern similar to that noted by researchers who study learners' misconceptions (Driver & Bell, 1986). Most responses reflected misconceptions and insufficient content knowledge of the specific topics. For example, in the Physical Sciences cluster group, there was some confusion between the concepts of energy, force, friction and work. The confusion related mainly to the observable consequences of energy flow, for example, sweating and tiredness. As the cluster leaders' responses were analysed, four major themes emerged. These four themes were not mutually exclusive, however, and in some cases could all be found exhibited in one person's responses simultaneously: poor organisation of knowledge about energy and work; rote learning or recitation of facts about energy and work; confusion about the law of conservation of energy; and, lastly, an anthropocentric view of energy. Similarly, in the Biology cluster group, we found the following three major themes: poor organisation of facts; misconceptions relating to the concept of photosynthesis; and a general lack of appropriate content knowledge about the topics under discussion. Overall, our data suggest that on the topics of energy and plant growth as discussed here, there were serious gaps in the teachers' conceptual understandings of the subject (see Jita, Ndlalane & Maree, 2008, for a detailed discussion of the findings regarding the CK of the cluster leaders in this study).

WORK AND ENERGY CASE STUDY³

Themba and Thula are the best students in a science class at Zamokuhle Combined School. Before class, the two friends are 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 her friend's argument ...

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 lose some of your energy and half of it goes somewhere, for example, in my case it went to my 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's) response? Why do you think so? What does this student understand?*

B] *What do you think of the second student's (Themba's) response? Why do you think so? What does this student understand?*

C] *If you could imagine the ideal student response to the 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 a list of topics).*

E1] *How might you go about teaching Thula to bring her to the ideal student response level?*

E2] *How might you go about teaching Themba to bring him to the ideal student response?*

In both cases (E1 & E2), be specific about the pedagogical strategies you will use and exactly how to use them with the content you've identified. (Hint: plan an actual intervention lesson each for Thula and Themba.)

We were somewhat surprised by the teacher leaders' responses, in part because we had expected these experienced teachers to have a better grasp of the concepts under discussion. Our next focus was then on trying to understand how the cluster workshop would be able to help these teachers confront and change their conceptions and articulation of the content relating to energy and plant growth. The support generated by the collaboration between the teachers seems to play a key role in that process of change, by breaking down the barriers to sharing among the teachers and allowing them to overcome the fear of confronting the inadequacies in their CK and PCK.

Overcoming the barriers to sharing

In most cases, teachers work in isolation in their schools and classrooms. There are relatively few opportunities for them to talk about their classroom practices with one another. This became clear when the teachers in our study were asked to respond individually to the learners' responses in the research instrument. When interviewed about their individual responses, one of the cluster leaders alluded to the difficulties associated with working alone, and the helplessness that seems to be experienced:

> *I took some time to respond to the learners' work, as it made me to think and come with the best answer. I thought that I was familiar with the topic energy but the students' answers complicated and confused my thinking. I then wrote what I thought was the best answer, but it was rated very low by the group. At first I was disappointed and ashamed of myself but as many of us were wrong I became confident, especially because the FET* (Further Education and Training or Grades 10–12) *cluster leaders were also wrong.*

Although initially apprehensive about sharing his ideas with the group, this cluster leader's comments draw attention to how he finally managed to overcome that barrier. His comments suggest that he drew strength from seeing other teachers in the group, especially the 'senior' teachers (or FET teachers) who would normally be better qualified than the primary school teachers of science, also giving 'wrong' responses. The idea of sharing among peers in an equal relationship in terms of their knowledge was comforting to this cluster leader. Similarly, another cluster leader drew strength from the peer support and the sense of common identity in the cluster. She described her experiences of the cluster as follows:

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

It became clear to us, from these cluster leaders' responses and those of others, that within the cluster workshops possibilities exist for breaking down the barriers to teacher collaboration and sharing with regard to issues of CK and PCK. Some of these barriers, which include physical isolation in one's school or classroom, absence of a strong identity as a result of isolation from other subject peers, and the lack of trust and suspicion displayed by other colleagues who may be better educated than oneself, were effectively exposed and reasonably successfully challenged by means of the clustering activity. Overcoming the barriers to sharing and exchange is an important first step in using clusters as a vehicle for professional development of the science teachers. However, what would be even more critical is to understand how the clusters, once formed and operational, then assume the function of challenging and changing teachers' CK and PCK.

Challenging and changing teachers' CK and PCK

Generally, teachers tend to feel uncomfortable with being assessed by means of testing and/or classroom observations. Using a case study instrument incorporating some hypothetical questions and responses from students allowed the research team to gain a sense of the teachers' CK and PCK

without fuelling such fears among the cluster leaders. The demands of the cluster meeting promoted a feeling of empowerment among the teachers as they interacted and shared their own individual experiences to create a collective understanding through the combined resources of CK and PCK in the group. For example, one cluster leader's response helps to uncover some of these critical cluster processes that lead to new knowledge for the teachers:

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

A sense of collegiality began to develop among this group of cluster leaders. It is this collegiality that seems to have been critical to the successful functioning of the cluster in this particular case. Our interviews with the teachers confirmed the importance of this sense of collegiality in breaking the isolation and overcoming the fear among this group of teachers. For example, when the cluster leaders were asked to comment on what factors might have contributed to the changes in their responses (as an indicator of the changes in their conceptions and knowledge), they mentioned factors such as the following:

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

The importance of teacher ownership of the sharing process and participation as peers, with each colleague making a contribution to the collective resources of the cluster, again come through as critical factors in creating a successful clustering process for this teacher leader. Similarly, another cluster leader emphasised the need for each member to open up and contribute their own experiences and resources to the group:

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

It is clear, therefore, that the cluster members felt that they had adequate resources among themselves to enhance one another's strength and competence with regard to CK and PCK; those whose CK and PCK were at a higher level tended to offer assistance to the rest of their colleagues through discussion and debate of the concepts and learners' responses. These interactions within the cluster promoted the co-construction of new knowledge by some of the members of the group. For this reason, we argue that there is some evidence of learning and growth resulting from the interactions within the cluster. We further explored the idea of teachers' learning during our observation of the cluster processes. In the next segment, we capture a discussion among the Biology cluster leaders to exemplify the processes of teachers' learning in the group:

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

The interesting point about this Biology cluster group is that they realised that one of the students in the research instrument had thought of soil as "food for plant growth". The group wanted to help the student by re-teaching the concept of photosynthesis to the class. The cluster leaders debated the various concepts required for teaching photosynthesis successfully, and all helped to construct this

new collective understanding of the process of photosynthesis. It is this unique construction of new knowledge resulting from the collective experience of the sharing of professional knowledge in the cluster that all of the cluster leaders took back with them to their schools and classrooms. As we visited the cluster leaders back in their cluster meetings and interviewed them on their experiences of the cluster workshop, their responses confirmed two significant issues: their recognition of the inadequacy of their content knowledge and the value of opportunities for teachers to meet and share their classroom practices. A comment from one cluster leader captured these sentiments:

> *I fumbled alone and as a result I failed to recall CK that I did a long time. I only remembered the definitions on photosynthesis as it appears in our Grade 10 textbook. I could not think about the learners' response, as a result our own response did not make any sense to the group. Fortunately I had members of the group to make sense of the learners' response and I learnt from them.*

From these responses and the foregoing analyses of the processes at the cluster workshop, it is reasonable to suggest that the teachers' CK and PCK were indeed challenged during the cluster workshop, and that some possibilities for change in their professional knowledge also existed. As a result of the removal of the barriers to sharing and collaboration through the establishment of the cluster, the cluster leaders were offered a unique opportunity to work with peers on issues of content knowledge and classroom practice. The evidence presented seems to suggest that for most of the cluster leaders, removing the barriers to collaboration was an important and necessary step in achieving effective peer learning and development. Removing the barriers, however, is more of a structural change that seems necessary for clusters to create the kinds of opportunities for teacher learning and change that are often anticipated.

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

Finally, the co-construction of new knowledge, as discussed by several of the cluster leaders we interviewed, seems to be the critical stage in the functioning of a cluster. Many, if not all, the cluster leaders who participated in the cluster workshop stated that the group discussions and debates enabled them to learn more, know more and better organise their CK and PCK relating to the topics under discussion. It is this clear link between CK and PCK that is more likely to help teachers to change their classroom practices. The evidence further suggests that the cluster workshop was able to provide enhanced opportunities for the teachers to make this link more explicit.

The foregoing discussion on the structure and function of the clusters begins to provide some empirical evidence regarding how teachers' knowledge and practice are related, and how teachers learn within communities and other contexts, as suggested by Cochran-Smith and Lytle (1999). The cluster workshop experience seems to indicate that cluster leaders needed to challenge and change their CK and PCK as a minimum condition for shifting their classroom practices. Although we did not observe these teacher leaders' classroom practice as part of this study to establish whether there were any changes in practice, the suggested lesson plans they developed collaboratively as part of the activities of the cluster workshop did provide evidence of the shifts they were making in at least what they considered important to teach, and in how they themselves now understood the concepts and content topics they were dealing with.

Summary

One of the most critical contributions of this study is its ability to shed light on the structuring and

operation of teacher clusters as opportunities for teachers to improve their CK and PCK, and thereby begin to reshape their classroom practices. While it was evident from the case study discussed here that teacher clusters do begin to provide teachers with the opportunities to meet and discuss classroom practice as peers, it is important to note that not all teachers will participate with the same eagerness and learn in the same way from the cluster meetings. This therefore dispels the assumption that clusters are monolithic and offer identical benefits to all participating teachers. The differential benefits of the cluster to the participating teachers are very important for considering whether clusters or networks are to be considered for a large-scale programme of professional development for science teachers in South Africa and elsewhere. A certain level of personal investment and opening up seems to be the one element required of participating teachers. This would avoid the danger of what Hargreaves and Dawe (1990) term 'contrived collegiality', where teachers come together as a bureaucratic requirement rather than for their own benefit and growth.

The main issue in this study was not simply whether the teachers came together in clusters during the professional development interventions, but also how such opportunities were created for teachers to uncover and share their CK and PCK with the aim of improving classroom practices. Discussions and dialogue leading to sharing, challenging and reflecting on classroom practices seem to provide better opportunities to challenge and change teachers' CK and PCK. As discussed earlier, the success of the teacher clusters in uncovering CK and PCK depends entirely on teachers' strong sense of commitment to their collaborative learning and support in the cluster meetings as peers. This commitment is based on trust, giving teachers the confidence to share what happens in the classroom, with the aim of improving and changing their classroom practices. This study has provided us with a window on why and how teacher clusters make it possible for teachers of science to challenge and change their CK and PCK, and thereby their classroom practice. In short, the major thesis can be restated as follows: by focusing specifically on the participating science teachers' CK and PCK, and especially on the interactions through collaborative discourse and practice, the clusters or networks were able to overcome the limitations of many professional development programmes that have failed to reshape classroom practice.

Conclusion

In conclusion, although we now have a better idea of what makes for successful clustering among science teachers, and how to account for the resulting changes in their CK and PCK, we still know too little about how other groups of individual teachers may respond to clustering and the various opportunities that clustering presents, i.e. while we have begun to outline a theory of what contributes to the efficacy of clusters, we still have scant knowledge of how such a theory may interact with say identity theories, in order to maximise benefits to individual teachers of science. Individuals make sense of every new experience and every new piece of information actively, in terms of their individual existing needs. As argued by Adams (2000), the codes and concepts available for interpreting the information are based on each individual's past experiences, which may be similar, but never identical, to that of another individual.

Finally, it is important to contextualise these teacher networks within Mpumalanga (or South Africa in general) and to consider how they are situated within a web of structural and organisational relationships existing within the education system. We are still not clear, however, about what sort of relationships need to be encouraged between the existing structures and organisational arrangements with the new emerging clusters. A restructuring of sorts will be necessary to accommodate and support the formation and operation of effective teacher clusters in South Africa. Further work is needed to explore the possibilities and arrangements that are likely to support and sustain the formation and operation of such effective clusters. In the same vein, more work is needed to redevelop, refine and test our instruments for uncovering teachers' professional knowledge with different groups of science teachers.

Notes

1. An earlier version of this paper was presented at the 2007 annual meeting of the American Educational Research Association (AERA) in Chicago, USA.
2. The MSSI was formed through a partnership between the Mpumalanga Department of Education (MDE), JICA, and a local university to offer professional development to science and mathematics teachers in Mpumalanga between 2000 and 2006.
3. A similar case study was given to the Biology cluster leaders, focusing on photosynthesis and plant growth, and another to the Mathematics group, focusing on ratio and proportion.

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Loyiso C. Jita is a Professor in the Department of Further Teacher Education at the University of South Africa, Pretoria.

Tembi C. Ndlalane is a Lecturer in the Joint Centre for Science, Mathematics and Technology Education at the University of Pretoria.