

Chapter 6

6 DISCUSSIONS AND CONCLUSION

6.1 Introduction

In this chapter discussion and reflections of the study will be given. This will include discussion and reflection of the study, main findings. Towards the end, this chapter will close by stating and answering research questions of this study.

6.2 Main findings of the study

This study has tried to investigate the practice of two teachers in the area of the mole as well as their content knowledge. It studied the practice of Ms Simelane and Mr. Xaba who are both teachers in East Rand Township, an area east of Johannesburg (Gauteng).

These teachers were interviewed and subsequently workshopped on the mole. The workshop was followed by observing two lessons of each teacher at their respective schools. A series of issues arose from the findings of this study. These issues will be discussed in the following paragraphs.

6.2.1 Content Knowledge of the Teachers

One of the issues that arose from the findings of the study was the content knowledge of the teachers with regard to the mole. It was found to be at a

similar level. Ms Simelane described the mole as a counting unit. She further expanded her description where she indicated that the mole is just a number and she also explained the mole as a quantity of matter containing exactly the same number of elementary particles, a definition from one of the prescribed grade 11 textbooks.

On the other hand, Mr Xaba thought students should understand that a mole is the amount of atoms or anything in a substance and these substances are small particle like for example C is made up of small particles.

Thus both teachers considered a mole to be a number, one of the categories of description identified by Strohm Dahl et al. (1994) (that is, category F₂ which was explained in chapter 5 though Mr. Xaba's definition appears inaccurate at face value. In fact in his teaching of the mole, Mr Xaba made no mention of Avogadro's number at all, describing the mole to his students as a heap or pile of something. His conception of the mole moved from category F₂ to category F₁ (which is the lowest form of explaining the mole) as the lesson progressed which suggests that he was getting confused as the lesson progressed and his understanding of what he was teaching became more and more unstable.

Both teachers considered memorisation of definitions and the procedural aspects of the mole to be the most important skill. For example, Ms Simelane said that the kinds of activities that she gives to learners to create understanding are mainly calculations and she wanted them to master calculation on the mole because they will use such information when they

equilibrium rates and K_c . On the other hand, Mr Xaba considered memorisation of the concept important for the purpose of passing of examinations and not for conceptual understanding.

Ms Simelane, likewise had to return to her textbooks as she had interpreted the definition peculiarly. It is obvious that she was dissatisfied with the development of her PCK. She felt that her conceptualization of the mole was still lacking and the bridging of the concept to algorithms was unsatisfactory.

It is possible that her PCK could improve further over time as a result of experience in many classroom settings. In her reflection, after lesson presentation she indicated that it took her a very long time to be confident with the mole, the difficulties she encountered in understanding the mole and that she was then not sure if she understood it so well.

During the interview and at the beginning of her lesson she defined the mole as the number and also used the word 'dozen' to explain the concept, a word which is said to be comparable to a number according to Stromdahl. However there are also traces of F_1 characteristics in her explanation because she also used the concept of weighing the 12 items by using the mass scale and spent most time on calculation exercises like Mr. Xaba. But interesting to note is that as the lesson progressed she referred to the mole as the amount of a substance which suggests that her conception of the mole is in line with the F_3 description of the mole, a higher level of conception of mole.

It is not unusual that she incorporated the properties belonging onto other fundamentals and this idea reveals an important aspect of PCK of an educator, that is, CK. Stromdahl et al. (1994) and Tullberg et al. (1994) also encountered the same situation of properties of one fundamental being included into another. However, the result of doing that is that is individual brings about the logically inconsistent reasoning which they are usually not aware of.

Although there were differences noted in their conception of the mole, they both consider a mole to be some kind of a number and they both used this conception to use the algorithmic approach. This point leads to the next issue that arose in this study.

6.2.2 Practices of the Teachers

Although there were variations in the teaching approaches adopted, there was a surprising level of commonality. Both teachers held similar personal conceptions of the mole, considering a mole to be equivalent to Avogadro's number, yet in none of their classes did this belief emerge as an important strategy for teaching the mole. The key to this question may lie in their belief in the importance of the mole.

In many aspects, the CoRes of the two teachers show similarities, as shown by the points attributed to both teachers. Both teachers' lessons are intended to achieve the goal of preparing learners for the external examination. Both teachers placed emphasis on knowing definitions of the

mole and being able to do related calculations, a theme which emerged strongly in their teaching.

There also seems to be commonality in their understanding of their students' background. In both cases, it is the first encounter with learners and they have not taught learners in previous classes. Furthermore learners seem to have acquired insufficient chemistry background in earlier classes and have struggled with earlier tasks assigned to them. This suggests a reason which probably leads to one teacher makes use of students' home language to clarify concepts, a strategy also used elsewhere by most teachers in the townships.

But there are also noticeable differences. Ms Simelane also identified conceptual issues with regard to the importance of the topic and her consideration of the students' background which carried through into her suggested teaching strategies. On the other hand, enforcement of calculations dominated in Mr. Xaba's lesson which support his belief in mastering mole calculations, a base he considered to be important for questions such reduction/ oxidation in examination.

Several issues arose about their practice. Firstly, both teachers considered memorisation of definitions and the procedural aspects of the mole to be most important skill to place in the hands of their learners. For example student difficulties identified by Xaba related directly to the calculation aspects rather than the understanding of the mole. Issues highlighted included difficulties in calculating molar mass, changing the subject of the

formula, knowing the difference between atomic mass and atomic number and knowing the symbols of the elements, amongst others. The statements which attempts to give answer to prompt 1 in the CoRe in chapter 4 support the claim made concerning memorisation of definition.

Secondly, both teachers used analogies to enhance understanding of the definition of the mole, but they did not try to link these analogies to the calculation aspects of the lesson. They both initially explored the concept in the lesson, but the teachers were quick to jump to the use of a formula rather than developing the proportional concepts, making it difficult for students to grasp the full meaning of the mole. One of the teachers felt that her conceptualisation of the mole was still lacking and the bridging of the concept to algorithms was unsatisfactory. In fact from the observation, the other teacher spent very little time to explaining content devoting most time to algorithmic aspects.

The discussion above indicates that teachers are mostly using an algorithmic rather than a conceptual approach. This approach may be employed consciously to avoid difficulties that one may encounter when teaching for conceptual understanding probably because teachers are not confident with the content themselves or alternatively due to the constraints brought upon by the external examination demands on the teacher.

6.3 Reflections on Methodology

There are many issues that were good when conducting this study and the discussion above may give an indication of that. However there were also

weaknesses. The following paragraphs will highlight difficulties and weaknesses associated with this study.

To find out about teachers content on the mole, inferences were made from the interview. Probably it may have been better if a diagnostic test was conducted. However I thought finding out about their content knowledge was out of the scope of this study because I was not well versed with PCK at the time the data were collected. Only after I had an in depth interaction with appropriate literature and researchers of PCK I realized that a diagnostic test would have been appropriate. However it was too late for me to consult with participants because they were engaged with issues related to their respective jobs and could no longer accommodate me because I needed to consult them to confirm or deny issues related to the analysis of data for this study which they thought it was taking most of their time.

The method used had its weaknesses which may have had negative effects on the study. One particular issue was that one of the original participants of the study withdrew due to school examination demands and the other one decided to conduct lessons on the mole without informing me. Thus I could not collect data. I had to find other teachers who were interested in being part of the study. This process delayed the data gathering process.

It is also important to note the tape recorder that was used had its flaws on the day of observation of one of the teachers. I had to rely on the notes that I have taken on that day. I went through them with the teacher

immediately to check and confirm that I had captured the issues correctly. Because that teacher was in a hurry to prepare for the next class, that teacher may have misled me by quickly agreeing on issues I was raising so that he does not get late for the next class.

Secondly, coding or analysis of data took longer than expected because I did not have a way of analyzing up the information at hand. However one good aspect is that appropriate frameworks for the study were eventually found. Loughran et al. (2004); Stromdahl et al. (1994). If Loughran et al.'s framework had been discussed earlier, I might have decided to use the prompts from the CoRe as interview questions because teachers may have been given more direct questions for answers instead of the questions that I created.

Teachers' knowledge is tacit so not much emerged from the interviews. The bulk of the knowledge was revealed in practice. For example, one of the teachers tried to teach for conceptual understanding by employing the analogy of a dozen and weighing objects to explain the mole to learners. In addition, the kinds of activities that were selected by one of the teacher were meant to create an understanding of the concept even though this teacher failed to link it to the conceptual aspects of the mole. Perhaps if I had used the prompts during interview I might have heard about this strategy in advance. According to Rollnick et al.'s model (in press), the teachers has displayed evidence of highly developed PCK in terms of what could be observed in his teaching (upper part of fig. 2.1 chapter 2) yet her articulation of the strategy in the interview did not the reveal the

underlying domains of knowledge which can be read into such an approach. This raises a question about the extent to which teacher knowledge is explicitly articulated and leads to the belief that the knowledge is tacit.

The CoRes and PaPeRs were very useful for this study in that they provided a tool for capturing and portraying the data I had. My views of PCK in this study suited well with Loughran et al. (2006). PaPeRs that were created acted like a window into teachers' class and practices of PCK.

6.4 Reflection on a Tailored Model for PCK

In chapter 2, a model that is tailored for PCK was discussed (Rollnick et al. (in press). this model identifies the difference between domains of teacher knowledge and their manifestation in the classroom.

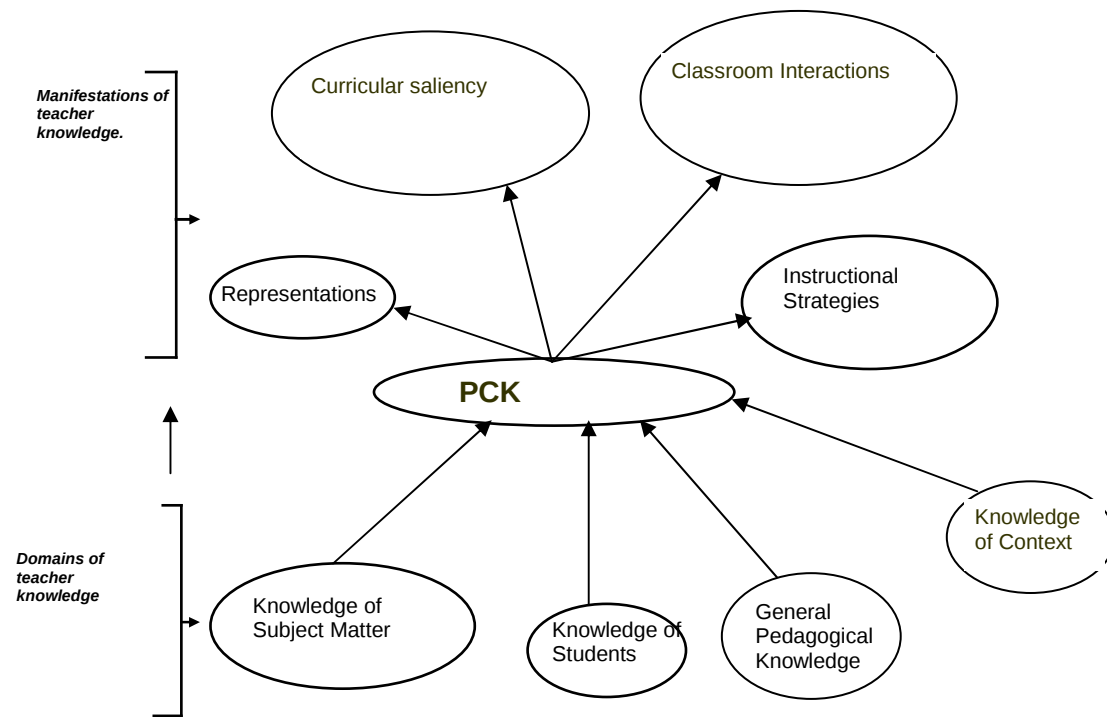


Fig 6. 1: Consolidated model for PCK (Rollnick et al., 2008)

The visible parts of the teachers' practice analyzed above, together with the observations provide information about their own content knowledge, allow me to use Rollnick et al.'s (2008) model to provide insight into their PCK. As mentioned in chapter 2, the upper part of figure 1 - their selection of learning strategies show how their general pedagogical knowledge is in place, as well as their understanding of their learners. Two factors appear to dominate their choice of teaching approaches used in the classroom - their content knowledge and their understanding of the teaching context. The latter causes them to look towards the importance of teaching for assessment - the common external examination does not directly examine the mole concept but only requires learners to use the idea of the amount of substance in calculations. According to the model mentioned above, we can

infer that the component that teachers used to produce analogies and representations is the subject matter knowledge of the teachers.

Literature (Shulman, 1986; Loughran et al., 2004; Chen & Ennis, 1995; van Driel *et al.*, 2000; Peterson & Treagust, 1995; Cochran et al., 1993) also indicates that there are very few articles that have captured the practice of teachers in their classrooms. Because it is difficult to get practice of teachers' I was able to at least capture and portray teachers practice and by so doing being able to identify some of the elements of their practice. Another issue is that, I was able to use Loughran et al.'s model to put my study into the context of PCK. Furthermore Stromdahl et al's model gave me a way of categorizing the CK of teachers. I was able to classify teachers CK of mole using his categories hence I was able to use teachers' conception of the content to come to an understanding of the strategies they employed when teaching mole.

The positive aspect about this study is that my direct interaction with researchers that are interested and involved in similar studies had a positive influence on the framework used to analyze data. For example, I was able to seek clarity on issues that were confusing and check if my results in accordance to the relevant framework.

Another point to reflect on is the workshop given to educators by myself. Teachers were workshopped to use the package that was designed for

teaching conceptual understanding of the mole. But the use of workshop was problematic. Teachers were exposed to a short period of workshop which was about 3 hours in afternoon where they were expected to understand all issues presented by the researcher. They had to read and internalize the package of workshop on their own within that short period and implement in their practice for observation. From the finding, it seems that the package was used to extract exercises for algorithmic purpose. Interesting to note is that one of the teachers did not use conceptual aspects of the package from the workshop but only used for compiling exercises. On the other hand the one teacher who used the conceptual aspects was not confident with the content of the package (as discussed in her reflection) coupled with the unstable content knowledge disadvantaged her and she could not come up with the strategy that would link conceptual understanding on the mole to calculation approach.

Lastly, there is a need to reflect on triangulation of data. Triangulation of analyzed data was done extensively. Teachers were engaged in all stages of analysis. They were consulted to check and confirm the truth of analysis. In addition researchers with similar interests met regularly to discuss the results of the study and that enabled the production of comprehensive CoRe and PaPe-Rs which were informed by extensive communication.

6.5 Answering Research Questions

Here I attempt to answer questions which led to the study. From chapter 1 the research questions are:

1. What resource materials do teachers normally use to teach the mole?
2. What is their personal understanding of the mole?
3. What practices do teachers normally employ when teaching the mole?
4. How is the practice of science teachers affected by exposure to a teaching package on the mole?
5. How can these practices be captured and portrayed?

6.5.1 What resource materials do teachers use to teach the mole?

It seems participants of this study are able to use pedagogical content reasoning in terms of ensuring that learners gain knowledge of the mole as intended by teachers. It is clear that teachers needed learners to use extensive algorithmic procedures to calculate the number of moles. The use of resources, such as school textbooks, notes, tests, and past examinations papers, that promote algorithmic approach was common in both teachers. These materials were more examination oriented.

I sympathize with participants because the pressure that is put to teachers by the examination is very immense and the performance of learners is measured at grade 12 level by an external examination. External examination demands place the need for using the application of mole in related concepts

(such as stoichiometry acids and bases calculations, reduction and oxidation) rather than conceptual understanding of the mole.

This practice is not only common in high schools. Malefane (1996) interacted with Vista university pre-service teachers and resources they are prescribed to use for teaching and learning of mole. The results indicated that study manuals are the core teaching and learning materials and they do not put sufficient emphasis on conceptual understanding of mole. They promote algorithmic approaches to the teaching of the mole. The results also indicate that students were more comfortable with one step exercises involving mole -mass relations. This brings us to the next question.

6.5.2 What is their personal understanding of the mole?

The content knowledge of the two teachers with respect to the mole was found to be at a similar level. Both teachers described the mole as number. This description of mole undermines the great deal of difficulties experienced by both teachers and learners alike with this topic (e.g. Gabel & Sherwood, 1984; Krishan, 1994; Furio et al., 2000; Petoagae, 2001; Lazonby, 1982; Novick, 1976; Stromdahl, 1996; Tullberg et al., 1994. Perceiving the mole as a number fits the F₂ category (Stromdahl et al. (1994), category that the authors describe as the lowest category of perception of this concept because it does not consider the historical development associated with the concept.

6.5.3 What practices do teachers employ when teaching the mole?

Both teachers utilized methods which promote memorisation of definitions and procedural aspects of the mole. To explain the concept of the mole, they generally used brief definitions. Because of contextual problems which include teaching to achieve a pass in external examinations, teachers used drill and practice methods to rehearse calculation of the mole. Where conceptual approaches were tried, they were not linked to appropriately calculations.

Algorithmic approaches to the teaching of chemistry abound in South African schools. Moves to conceptual approaches will involve far more than short presentation of packages using conceptual approaches. Teachers need to come to understand the importance of conceptual approaches to a meaningful understanding of chemistry and this can be achieved by long term exposure of teachers to such practices

6.5.4 How can these practices be captured and portrayed?

If we go back to the literature review of the concept of PCK in chapter 2, there has been extensive work on PCK. Some of these studies have extended the concept of PCK from Schulman's original understanding without changing the meaning. However, very few articles deal with the capturing and portraying elements of PCK.

Padilla et al. (2008) also proposed that Mortimer's CP model is one way of gaining access to the tacit knowledge of practice. However this study was not yet publicized at the time when I was analyzing my data.

Loughran et al.'s (2004) model of PaPe-Rs and CoRes is about narrating practice in classroom and representing the educators' understanding of PCK, that is, the different knowledge (aspects) that educators consider when preparing and presenting a particular content in their field of teaching. The knowledge includes excluding certain knowledge which is associated with the content; the reasons behind including the knowledge that "expert" educators think is important to be presented in conjunction with the particular knowledge; the misconceptions or alternative ideas associated with the concept; the idea in which the knowledge will be presented to learners; innovative ideas of testing for understanding the content; the explanations use and the framing of sentences or ideas to suit the age and the background of learners.

Loughran et al.'s (2004) use of CoRe and PaPe-Rs was found to be the best way that this study has seen fit and used to capture and process data which was collected for this study. I am not prescribing this model as super model for all related studies but there is a need in South Africa for collecting and gathering pool information that can be accessed and used by both pre-service and in-service teachers. Guided by the purpose of the study and the prompts in the CoRe, the prompts were rephrased differently and the order of the prompts was changed to suit context of the teachers I interviewed.

However the prompts were used as in the Loughran et al.'s model to develop the CoRe in this study.

6.5.5 How is the practice of science teachers affected by exposure to a teaching package on the mole?

Both teachers used approaches that used analogies to explain the mole. Only one of the two participants went further to employ strategies that were suggested in the workshop. This educator was however frustrated by the workshop ideas probably because of time frame and the examination demands that are set by DoE. This teacher intended to teach for conceptual understanding and used the suggested teaching approach package fully. However, her reflection indicates that she was disappointed by the fact that she had had to rush things and thus leave aspects that she though were important to highlight to learners and also she had not yet mastered the technique of linking analogy to calculation procedure. Part of this problem was due to the fact that she did not have sufficient time to internalize the ideas. Thus there is a need to for time frame of workshop intervention to be extended to allow time for teachers to interact longer with ideas of the workshop. This finding is not different from what van Driel et al. (2000) obtained even though teachers were exposed to intervention strategy for a period of one year.

6.6 Limitation of the Study

Not all schools and science teachers in Gauteng were targeted. The study has made inferences based on interviewing and observing two township

teachers, a very small number. However this study intended to obtain a detailed insight into teachers' practices. The study has achieved its aim in that I have an in-depth of teachers' practice of the mole, that is, their subject matter knowledge with regard to the mole is lacking and it affects their teaching of this idea conceptually in their classroom. However, I cannot generalize the finding of this study to all township high school science teachers because of the nature of the study and the time constraints put on the study.

6.7 Recommendations

The finding of this study reveals that the two teachers' content knowledge of mole is limited and that they prefer to use algorithmic rather than conceptual approach when teaching this subject. It is recommend that officials of DoE must find a way of dealing with this issue and avoid over pressing examination demands on teachers. But give support which will enable teachers to teach for conceptual understanding of basic concepts in order to achieve the goal of producing learners that are highly competent academically.

I also recommend that Physical Science facilitators within the districts establish a relationship with researchers of PCK and obtain knowledge about such issue and its role in teaching and learning field. Thus find a way of engaging, reflecting and developing their teachers in such issues and probably assist (probably using Loughran et al.'s (2004) model) in compiling a pool where good content teaching practice is portrayed and captured were it

can be accessible. I think this information can be shared in gathering such as physical science teachers' forums, organizations, workshop or clusters meetings and help to produce learners with high level of concept understanding and be able to explain the world around them.

6.8 Further Studies

Because this study could not access teachers' content knowledge, a further study where a diagnostic test is given to teachers prior and after observation to check on their CK and that a similar study be conducted on a larger scale which will allow generalization of results. I also recommend that Padilla et al.'s (2008) five PC zones used to categorize thoughts that are behind teachers' understanding of the mole