

https://dspace.org/

A case study of South African township teachers' use of pedagogical content knowledge.

Ndlovu, Thandi Brenda

2009-03-24T07:57:01Z
http://hdl.handle.net/10539/6779

Downloaded from a DSpace repository. https://dspace.org/

Chapter 2

2 LITERATURE REVIEW

2.1 Introduction

The chapter will reflect on the literature that was consulted during this study and the theoretical position taken in this research. To understand the context of the mole concept, literature will reflect on the history of the mole and the educators' perceptions of the mole. Later in this chapter Pedagogical Content Knowledge (PCK) and the implications of PCK in teaching and learning science and students misunderstanding of the mole are considered. In conclusion the literature that has an impact of the methods used in this study will also be considered.

2.2 History of and Research into the Mole

The aim of this study is to find out how educators teach this mole concept which is regarded as difficult in chemistry education. A brief account of the history of the mole will be given because historical development of the mole plays a major role in understanding current conceptions held by both learners and educators with regard to the mole.

According to Stromdahl et al. (1994), the term "mole" (denoted by 1Mol) was created by Ostwald in the late 1888's as an abbreviation of '*Molekel*' or '*Molekül*' and it was perceived as a chemical mass quantity. Each type of element or chemical compound had its own individual "amount of mass" for example 1 mol gold =196, 97 grams gold, and 1 mol water =18, 02 grams water.

Hawthorner (1973) in Stromdahl et al. (1994) further highlights that during the development of atomic theory a shift occurred from Ostwalds's conception of the mole to a view of defining one mole as a fixed number of atoms, molecules, ions or formula units. Although the number was not determined by Avogadro it was called Avogadro's number of elementary entities and this idea of associating one mole with a number became a common understanding. According to Furio et al. (2000) the Avogadro concept was used because he postulated that under the same condition equal volumes of gases would have an equal number of molecules.

However later on a new physical quantity called 'amount of substance' which emerged was associated with one mol (1mol). In 1971 during the 14th meeting of the General Conference of Weights and Measurements 1 mol was adopted as the SI unit for the new physical quantity called "amount of substance". Since then 1 mol has had a status that is comparable to that of the standard units, for example 1m, 1A, and 1K, 1kg. But the label "the mole concept" seems to be the connotation that is accepted of comprehending the mole and this label is frequently used and is more aligned with the idea of the mole as Avogadro's number. However, Stromdahl et al. (1994) warns that the use of this label may be a conceptual trap that prevent a proper comprehension of the mole in accordance with the prevailing scientific view, because nobody refers to the metre concept, the kilogram concept or the Kelvin concept.

Clearly, history of the development for the explanation of the "mole concept" indicates that mole has both quantitative and qualitative dimensions and this bring about confusion in teaching and learning of this concept. If chemistry educators are to be effective in making learners to understand the deeper meaning of the mole concept they need to be aware of the dilemma that is associated with the past and current definitions of

the mole. Historically, the concept of "the mole" was introduced before the quantity "amount of substance" for which it is the unit (Furio et al., 2000). The study will use the word "mole concept" because most teachers use the mole to mean "the amount of substance".
High school learners in South Africa encounter formal teaching about the mole in grade 10. By this time, they are expected to have learnt about chemical reactions and equations, balancing of chemical equations.

However, there are difficulties associated with the teaching and learning of the mole. In his personal communication, Bradley (2001) said that the introduction of the mole concept at school is delayed until late. When it is introduced, the mole is coupled with stochiometry and this adds to another layer of complexity. Novick and Menis (1976) recommend that a simpler and less involved development of the mole concept in the early part of a chemistry course would at least be less confusing to most students.

Peloagae (2001) identified misconceptions that grade 11 township learners have with respect to how teachers and textbooks in South Africa define the mole. He also identified subsequent ideas that learners create in their minds as a result of misconception. Peloagae (2001) found that some grade 11 learners in his study have an inadequate conception of the mole. Those who were regarded as knowing the mole concept did not regard the mole as a unit of amount of substance but rather as a quantity of matter. They had poor understanding of Avogadro's hypothesis because educators (who are presumed not to know the history of the mole) introduce rote learning procedures and application of algorithmic procedures when explaining the mole.

Language problems, lack of facilities and poor socio background compounded difficulties of South Africa's township learners.

Empirical studies on learners' alternative conceptions have shown that students often make mistakes as they are misled by alternative conceptions, for instance there has been a shift of meaning of some chemical terms in the course of time. Such terms are ambiguous since they may contain an old and a new aspect. The mole has shifted from having both qualitative and quantitative dimension to a purely quantitative one when it is thought as a unit (Stromdahl, 1996). Stromdahl et al. (1994) indicates that to understand the ambiguity of the mole concept proved to be quite a challenge for many students. Some students understand it, others do not. However, the majority try understanding it but fail. Schmidt (2000) suggests that to make chemistry lessons more attractive requires more intellectually demanding courses and a new teaching culture in which teachers are interested in what students think and from that basis to help them to develop their understanding of chemistry.

Many science teachers use the algorithmic approach where learners are expected to perform and master skills of solving certain mathematical problems in an attempt to teach the mole. Frequently such learners obtain correct answers (Gabel, 2003). However Gabel (2003) warns that correct answers do not necessarily mean that students understand the concept.

Gabel (2003) further indicates that algorithmic approach should be used consciously by ensuring that learners understand the underlying concepts before introducing the formula. Some teachers argue that using algorithmic approach leads eventually to understanding the concept but many learners do not reach that point (Gabel, 2003).

2.3 Research on Teaching and Learning of the Mole

Since the inception of the mole in science and thus in science education, a number of studies have been conducted. Certain studies were carried out

to identify difficulties experienced by students when they solve problems involving the mole concept (e.g. Hankinson et al., 1977; Morikana and Newbold, 2003; Steiner, 1986; Krishnan, 1994). Other studies focused on teachers' understanding of the mole (e.g. Beall and Prescott, 1994; Stromdahl et al., 1994; Padilla et al., 2004.

Other studies were conducted to identify misconceptions that are held by learners (e.g. Hakinson et al., 1977; Gabel & Sherwood, 1984; Krishnan, 1994; Furio et al., 2000; Peloagae, 2001).

Hakinson et al. (1977) and Lazonby et al. (1982) carried out investigations to identify difficulties experienced by students using the mole in stoichiometric calculations. The findings reveal that students generally did not find it difficult to solve the problems because they seemed to understand and use the mole as a unit of quantity. However students failed to form a strategy for solving other problem.

Krishnan (1994) diagnosed students' conceptual understanding of the mole and developed a pen and paper instrument that will enable the teachers to plan and design their instruction in order to address the inconsistencies in students' conception of the mole.

Furio et al. (2000) investigated why the mole concept is poorly understood by the students. Their findings indicate that poor conception of the mole is due to the lack of knowledge by teachers of the social-historical context of the mole and of the evolution of its meaning. Thus Furio et al. (2000)

indicate that lack of knowledge by teachers led to incorrect transmission of conceptions of the mole.

When explaining the mole, the strategies used by teachers were rote learning and algorithmic procedures. Earlier in this chapter I indicated that Peloagae (2001) not only found that learners had misconceptions on the mole but also those misconceptions were accelerated by strategies that were used by teachers when introducing the mole.

Other studies focused on how learners understand the mole (e.g. Novick and Menis, 1976; Gorin, 1994; Staver, 1995; Case and Fraser, 1999). Novick and Menis' (1976) main findings revealed three main conceptions that are held by groups of pupils. Firstly, the mole is perceived as a certain mass and not a certain number. Secondly, the mole is thought as a certain number of particles of gas and lastly, the mole is thought as a property of a molecule. From their study, Novick and Menis (1976) claim that it seemed that Israel pupils were not functioning at the cognitive level that is necessary to acquire the mole concept. They further indicate that the mole concept is introduced at high school level. At that level learners do not have a coherent understanding of the mole and its significance in interpreting chemical phenomena.

Novick and Menis (1976) further claim that there is a need to introduce the development of the mole that would attempt to make minimum conceptual demands consistent with a basic understanding of the mole as a counting unit. Novick and Menis (1976) suggest that a simple and less

involved development of the mole concept in the early part of a chemistry course would be less confusing to most students.

On the other hand, Gorin (1994) differs with Novick and Menis and postulates that it is not difficult for learners to understand the mole as a measuring unit. Gorin (1994) claims that the actual problem a mole as a measuring unit but is that in most cases measuring units (where a qualitative understanding of what is being measured) can be provided and then a more precise measurement can be obtained with the help of appropriate instrument. In the case of the mole, Gorin claim that this sensation is lacking. They say that the unit measures relative number of atoms or of particles derived from atoms in comparison with those present in a standard. It is not possible to count atoms experimentally and hence the mole is always encountered in the context of calculations.

Stromdahl et al. (1994) and Tullberg et al. (1994) conducted studies on how teachers comprehend the mole and approaches that can be used to teach for conceptual understanding of the mole. Stromdahl et al.'s (1994) study aimed to reveal conceptions of the mole held by students, trainee teachers and teachers in order to comprehend why the mole is regarded as difficult in chemistry education. Their findings indicated that teachers have different connotation of the mole. Four separate fundamental meanings of the mole were also revealed and Stromdahl et al. (1994) claims that the fundamentals can be used as a tool to make conceptual ambiguities about the mole and can be used as a starting point for descriptions of different teaching models concerning the mole.

Tulberg et al. (1994) is a continuation of the study conducted by Stromdahl et al. (1994) where authors aimed to find out the impact that the teachers' conception of the mole have in their teaching approach. Their findings showed that many teachers had a conception of the mole that was very different from the conception expressed in 1971 SI definition of 1 mol. Teachers taught the mole and its relations by means of reasoning methods and algorithmic approach was rarely mentioned by teachers.

Padilla et al. (2008) conducted a study which attempted to ascertain the knowledge base of each of four professors from Mexico and Argentina related to the topic 'amount of substance'. The authors were able to show that there are differences between some experienced chemistry professors uses of language and way if thinking whilst teaching. Unlike Stromdahl et al. (1994), Padilla used Mortimer's Conceptual profile model (CPM). Mortimer (1995) in Padilla et al. (2008) describes CPM as a 'superindividual system of forms of thought which describes different thinking routes to one topic. Based on four professors' thought about the amount of substance five CP zones were constructed. Although Padilla et al.'s (2008) is similar to my study in terms of topic of focus and researching teachers practices, the difference is that their participants are proffers and they have used CPM to evaluate the participants' conception of the mole whereas in this study Stromdahl's model of categorising teachers' conception of the mole will be used.

Some researchers conducted studies which were intended to identify different approaches of teaching the mole (e.g. Lazonby et al., 1982; Steiner, 1986; Krieger, 1997; Poole, 1989; Borrows et al., 1998). In Krieger (1997), an analogy called "Moe's Mall" was used to help learners understand the mole concept. Steiner (1986) suggested that the mole could be taught more easily by presenting it using concepts that students are familiar with. He constructed a stoichiometric problem using terms such as 'pounds' and 'dozen' for his seven-year-old daughter. He argued that usage of concepts that learners are familiar with, to explain an abstract science concept, make comprehension of those science concepts easier. However, he also warns against misconceptions that may develop as a result of using such analogies. However these studies include an algorithmic approach that includes the use of certain formulae which can cause learning problems.
Some research indicates that one of the factors that contribute to students' difficulties in learning science concepts is the teachers' lack of knowledge regarding students' prior understanding of concepts (Gorin, 1994; Krieger, 1997; Furio et al., 2000; Padilla-Martínez, 2005).

Dilley et al. (1991) suggested an approach which aims to teach for conceptual understanding of the mole. Authors of this book perceive the mole as a unit of measurement of amount of substance. They also give a clear explanation of the word "unit" and why the mole is a unit to measure the amount of substance. Furthermore a connection between the mole and mass is made. Lastly, Dilley et al. (1991) use what they called "kitchen demonstrations" to illustrate the concept of the amount of a substance. Studies conducted by Case and Fraser (1999) on investigation of chemical

engineering students' understanding of the mole suggested that an emphasis on physical referents is likely to have more success in promoting conceptual change towards more sophisticated and scientifically correct understanding. This study is similar to the one conducted by Krishnan (1994) where an instrument to assess conceptual understanding of mole was developed. The author developed a concept map tool that he refers to as a "mole concept test". This tool assesses conceptual understanding and full details are given. I think these two books can be used to teach for conceptual understanding because they are user friendly; use simple English language; and mathematical examples which are intended to assess conceptual understanding of the mole. Therefore if educators carefully use books such as these they will at least have an understanding of mole and some of the difficulties that are associated with its teaching and a means to address such issues.

With the inception of Outcomes Based Education in South Africa, currently, one of the focuses in science education is a shift to teaching for conceptual understanding of science concepts. I have indicated above that many studies that have been carried out on the mole but little or nothing has been done on pedagogical content knowledge (PCK) of the mole in South Africa. It seems in South Africa PCK is a new concept although the European Science Education Research Association (ESERA) conference 2005 indicates that in the UK and Europe there are extensive studies in progress. The term is expanded below.

2.4 Pedagogical Content Knowledge (PCK)

It is now understood that expert teachers employ more than subject matter knowledge in their classroom in an effort to simplify scientific concepts and procedures that learners find difficult. The knowledge that is used by teachers to make learning concepts easier is termed pedagogical content knowledge (PCK) (Shulman, 1986). According to Shulman (1986, 9) pedagogical content knowledge is the knowledge of content which "*embodies the aspects of content most germane to its teacheability".* Teachers transform difficult content knowledge to make it accessible to learners where subject matter knowledge, knowledge of students, knowledge of the pedagogy and the contextual knowledge are integrated. Transformation of knowledge includes strategies employed by teachers when blending or simplifying the concept in an attempt to reach out to the learners. PCK includes

> *" the most useful forms of representations of those idea, the most powerful analogies, illustrations examples, explanations and demonstrations in a word, the ways of representing and formulating the subject that make it comprehensible to others" for the most taught topics in one's subject area… PCK also includes an understanding of what makes the learning of specific concepts easy or difficult, the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons."* (Shulman, 1986, p 9)

In science education teaching does not only mean transmission of pure science content and skills. An important aspect of teaching for understanding and comprehension requires that teachers consider factors that will enhance or retard learning of such concepts amongst other

generic issues. In order to facilitate learning, teachers have to possess and employ a repertoire of topic-specific representations, that is, more than one method of representing knowledge in a way that learners will understand. Extensive explanation of this issue will be discussed in Chapter four wherein Loughran et al. (2004) framework of portraying elements of PCK and Stromdahl et al.'s (1994) framework for analysing content knowledge of teachers will be used.

The way Shulman defined PCK means changing the view of teaching and its impact on learning. PCK refers to the teachers' ability to transform pure content knowledge by regarding learners' difficulties at any point in time in an effort to address factors which may hinder learning of scientific concepts. Teachers need to be knowledgeable about PCK in order to transform the knowledge and improve how they teach. Thus, a prerequisite of PCK is adequate content knowledge.

Shulman (1986) referred to content knowledge as the concepts, principles and skills within a particular subject discipline. The manner in which content knowledge tends to be taught in its original form raises concerns (Chen & Ennis, 1995) and has resulted in a negative stigma of science as difficult. In 1987, Shulman indicated that teachers' have the ability to reshape the knowledge, simplify, identify various representations for concepts to maximise its comprehension by learners. But approximately after two decades the concern of presenting content knowledge in its original form is still an issue of concern and. is still an issue that is under critical study in science education.

After an investigation of teachers' PCK on chemical equilibrium, van Driel et al. (2000) indicated that when teachers address unfamiliar topics they might have little knowledge of potential learners' problems and specific preconceptions, and have difficulties choosing appropriate representations of subject matter. He further says teachers are likely to express more misconceptions when teaching unfamiliar topics. Knowledge of how teachers develop strategies in their practice would be important in developing knowledge base for in-service.

Several studies have been conducted on the development of teachers' PCK. In South Africa, Rhemtula and Rollnick (2002) investigated initial effects of a PCK course on a group of teachers and teacher educators. Initially many of these teachers were diagnosed as having content related problems and conceptual difficulties. After the PCK course most teachers became aware of students' difficulties associated with the topic of isotopes. They became conscious of the knowledge that is required for deciding what should be taught or left out when teaching learners of different age groups.

In other part of the world similar studies on PCK were also conducted. In an investigation by van Driel et al. (2000) on the development of PCK within a group of pre-service chemistry teachers, these teachers were given an opportunity to teach their peers a phenomenon like chemical reactions, macroscopic properties of substances and the relationship between macro and micro level with respect to those concepts. The opportunity to

practice, coupled with the assistance from mentors, helped development of their PCK with respect to the science concepts they were concentrating on.

In their studies on developing science teachers' PCK, Chen & Ennis (1995) and van Driel et al. (1998) identified knowledge of subject matter as a prerequisite for developing PCK and argue that extensive teaching experience is a key source of PCK. They showed their argument by allowing teachers to participate in workshops and giving them opportunity to conduct experimental courses in classrooms. Teachers developed their own metaphors and analogies (i.e. elements of PCK) which they could use to promote students understanding. In addition, Chen & Ennis (1995) found that teachers' knowledge of subject matter content coupled with knowledge of students' learning abilities enable teachers to decide which part of curriculum to include or exclude, thus allowing greater opportunities for their students to understand what they intend to teach in their classrooms.

Most researchers in the field of PCK stress the importance of subject matter knowledge, (e.g. Peterson and Treagust, 1995; Chen & Ennis, 1995; Ball et al., 2004; van Driel et al., 1998, 2000; Rhemtula and Rollnick, 2002 and Loughran et al., 2004). Cochran et al. (1993) talk about the concept of "pedagogical content knowing" (PCKg). The concept is different from what Shulman (1986) contemplated in his definition of PCK. According to Cochran et al., PCKg is an integrated understanding of four main components: pedagogy, subject matter content, student characteristics, and environmental context of learning. They claim that if teachers are able

to integrate and interrelate these four components, it leads to conceptual change and conceptual integration and thus they suggest that this may be a framework for providing pre-service teachers with coherent and integrated set of skills and understanding of teaching. Based on this argument, Cochran et al. (1993) claims that it is PCKg that differentiates an expert teacher from a subject area expert in a subject.

On the other hand, Peterson and Treagust (1995) argue that teachers need to not only develop a knowledge base for teaching but also be able to make sound reasons and decisions regarding their classroom science teaching. Pedagogical reasoning ability is explained as the use of understanding of science matter knowledge (content), knowledge of curriculum and knowledge of learners and ability to make sound decision in their classroom teaching. Those decision making processes involve deciding which curriculum aspect to include or exclude based on the ability of perception of learners. All of these issues mentioned imply that PCK of pre-service teacher should have developed by the time they finished their education programmes. Peterson and Treagust (1995) were concerned that in previous years the time spent in developing pre-service teachers in education programs was short. Because PCK is important in their practice, Peterson and Treagust (1995) suggested that the period of teachers' development should be extended so that comes the time they graduate they would have developed and improved their pedagogical reasoning ability. Although both researchers give different interpretations of understanding of PCK, their explanation points to important issues that are

needed to be acquired by teachers before they begin with their teaching career.

Since what teachers need to know and how they need to know it remains inadequately understood (Ball et al., 2004, 9), there is a need to investigate this area. Studies in this area will assist in finding out how to make basic chemistry concepts covered in high school more comprehensible. A thorough understanding of basic concepts in chemistry by learners is important in order to apply these to concepts, principles, theories and problems associated with them. The service of experienced teachers is important in learning, acquiring knowledge of explanations, examples, analogies, representations etc they use to make science concepts, such as mole. Experienced teachers know the problems and difficulties that learners have with regard to frequently taught topics and they attend to such situations or they are able to come up with a remediation strategy in case of an unforeseen situation (Geddis et al., 1993). Geddis and Wood (1997), elaborated on Shulman's conceptualisation of PCK. They defined PCK as a broad category of those kinds of knowledge involved in pedagogical transformations of subject matter. According to Loughran (2006), Shulman claimed that teachers need PCK to be the "best possible teachers".

Ball et al. (2004) conducted their study in the field of mathematic education but their findings are also relevant to science education. They claim that direct observation of classes suggests that teachers' knowledge of subject matter knowledge and their ability to deploy it in teaching,

matter for the quality of students' opportunities to learn. Dawkins & Butler (2000) also made similar observations when they were analysing prospective teachers PCK. Their study of teaching the mole had an incomplete notion of mole concept and they needed support in making them being aware of issues needed to teach for understanding. Ball et al. (2004) suggest that teaching mathematics involves more than recognising that a student's answer is incorrect. It entails analysing the wrong answers and the source of the error. Error analysis is not only what teachers do. Teaching also involves explaining why error occurs; involves using effective representations. In my understanding what Ball et al. (2004) are suggesting about analysis of errors made by learners will only be possible if educators have a deeper content knowledge (as indicated and alluded to when discussing about PCK) and so will be comfortable to twist or play around with concept to reach learners ability.

Part of the problem why students have a poor understanding of the content can be attributed to misconceptions of learners and teachers. A number of biology teachers in the study by Sanders (1993) and Linkonyane and Sanders (1997) have misconceptions. Although in this study biology teachers were subjects of the study, physical science teachers also have misconceptions. Furio et al., (2000) have pointed out that teachers do not have a good understanding of the mole. They bring these erroneous ideas to class and hinder the process of learning. Textbooks are an immediate resource of teachers but they also play a role perpetuating teachers' misconceptions (Barrass, 1984; Linkonyane and Sanders, 1997).

PCK will allow teachers to understand the factors which makes learning of a specific topic (such the mole) easy or difficult, the ideas and prior knowledge that students of different ages and background bring with them to the learning of the mole. If their ideas about the mole are erroneous, teachers need to have strategies which will remedy the situation. Shulman (1986) further indicates that if teacher themselves have erroneous conceptions it will be difficult for them to identify learners' misconceptions).

Drawing from the various models, Rollnick et al. (in press) identified the difference between domains of teacher knowledge and their manifestation in the classroom. They developed a model that is viewed as an integration or synthesis of knowledge of certain foundational domains of teacher knowledge (often referred to as components or elements of knowledge).

2.5 A Tailored Model for PCK

Rollnick et al. (2008) extracted four fundamental domains of teacher knowledge, viz., Knowledge of subject matter, knowledge of students, general pedagogical knowledge and knowledge of context. According to their study, they consider PCK to be an amalgamated product of these domains. According to Rollnick et al. (2008) the manifestations of teacher knowledge are the products of the amalgamation described below (see figure 2.1) which can be directly observed in the teacher's practice.

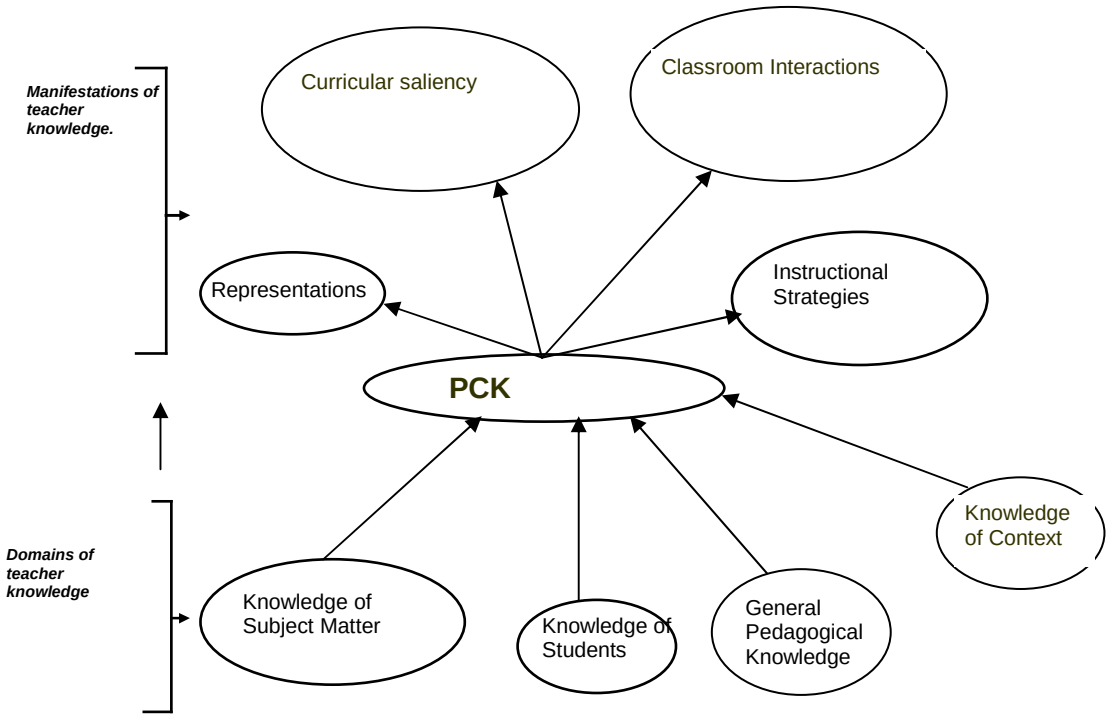

Figure 2.1: Consolidated model for PCK (Rollnick et al.,2008)

These include Representations, instructional strategies, curricular saliency and interactions with students, amongst others. The model is illustrated in figure 2.1 above. The components in the lower part of the diagram describe the components of teacher knowledge which are integrated to produce PCK, while those in the upper section represent the features that become visible in the classroom, i.e. the products of PCK. Components in the model have been expanded into several sub categories. The sub categories will now be further elucidated according to Rollnick et al. (2008)

2.5.1 Teacher Knowledge Domains:

2.5.1.1 Knowledge of subject matter

This construct refers to what may be termed the raw untransformed subject matter knowledge possessed by the teacher. There is considerable debate about how much this needs to be for effective teaching of the content under scrutiny, but few would disagree that the teacher needs to know more than their students in order to teach the expected content. There would also be general agreement that the term "knowledge" as used in this context would imply understanding.

2.5.1.2 General pedagogical knowledge:

This construct refers to the understanding the teacher has of what counts as good teaching in the general sense. It is the understanding that informs the teacher on the best teaching approaches in a given context and could be informed by the teacher's knowledge of applicable learning theories.

2.5.1.3 Knowledge of students

Teachers need to understand their students in several ways in order to make subject matter accessible. They need to have an appreciation of the prior knowledge that students bring to the learning situation. They also need to know how students learn material – for example, whether they have the capacity for independent learning, what their reading and writing abilities are. Most importantly, they need to know something about student interests and aspirations. This last aspect does overlap with knowledge of context below.

2.5.1.4 Knowledge of context

The learning context embraces all the contextual variables that influence the teaching situation. Included in this construct are the availability of resources in the classroom, class size, the socioeconomic background of the students, their linguistic abilities, the curriculum, the situation in the country, the interests of the students, the weather, and the time available for teaching and learning.

2.5.2 Manifestations of Teacher Knowledge

The manifestations below represent an incomplete list of products of the amalgamations of categories of teacher knowledge listed above.

2.5.2.1 Representations:

Representations refer to the analogies, representations, models and illustrations used by the teacher as cited by Shulman (1986).

2.5.2.2 Curricular Saliency

Curricular saliency is a term coined by Geddis and Wood (1997) to refer to the teacher's understanding of the place of a topic in the curriculum. Curricular saliency may be observed in teachers' decisions to leave out certain aspects of the topic on either educational or logistic grounds, and in teachers' awareness of how the topic they are teaching fits in with other topics and part of the curriculum past and present.

2.5.2.3 Classroom interactions

In the classroom, the teacher will show visible evidence of their understanding of the students, in their interactions with them and the opportunities they create for students to interact with each other. The teacher's discourse will also indicate the choices s/he has made informed by knowledge of the students' context and the discourse of the discipline.

2.5.2 4 Instructional Strategies

This category includes the pedagogical strategies chosen for the lesson in a general sense, such as the use of group work and the topic specific choices made such as the sequencing of content and the approach to the content being taught.

Rollnick et al. (2008)'s model gives preference to content knowledge as basic requirement for the development of PCK, which in many developed counties is taken for granted. Since content knowledge is one of the pillars of PCK, they suggest that PCK must be specific to defined content areas.

2.6 Intervention Program

The approach of introducing an intervention program as a means of addressing a problem or an issue of interest in Science Education is common. Depending on the nature of problem or issue of concern that has been identified at that moment, the period for intervention program maybe of long or short duration.

In Netherlands, van Driel at al. (2000) with their one-year postgraduate teachers' education intervention program exposed a group of pre-service chemistry Master's students to a period of 1st semester. During that year students were expected to teach each other chemistry concepts and be able to explain macro -micro relationship that exists. The results showed that a growing awareness of issues /needs concerning teaching situation especially with respect to macro-micro relationship and the use of language carefully. This indicated that they developed means of teaching interestingly and in a manner that demonstrated the development of PCK for teaching those concepts.

Furthermore, by studying responses obtained from 30 minute interviews with respondents and answers from a questionnaire that is based on how learners and educators conceptualise 1 mol idea, Tullberg et al. (1994) were able to identify strategies that are used by educators in Sweden to teach learners the mole. In South Africa, Rhemtula and Rollnick (2002) during a course of PCK in an effort to investigate the extent to which information gained in a course of PCK, a group of educators and science education specialists has affected their PCK. As an intervention, they expected them to prepare a lesson plan on how they will teach average atomic mass after she supplied them with an article (i.e. Geddis et al., 1993) that demonstrated three different approaches of teaching an average atomic mass. Her analysis showed that some of those educators' preparation plans considered knowledge gained during PCK course although the knowledge was not coherent.

All these studies indicate that the period of exposure of intervention program may range from short to longer time. However in all these studies a warning is given that short period of exposure does not give a bigger picture of the effectiveness or intended solution. The current study- a one-day workshop program (3 hour afternoon to be specific) - was an approach that was used in an effort to assist educators with certain knowledge that will be important when teaching for conceptual understanding, a suggestion given by van Driel et al. (2000). Furthermore teachers were observed two weeks after a 3 hour workshop.

2.7 Concluding Remarks

In this chapter extensive literature which has influenced the study was reflected to ensure that the reader has a basic knowledge and the historical development of the "mole" so that one may understand the complexity and difficulties associated with this concept in science education. Furthermore literature on the concept of PCK and how PCK has affected teaching and learning in science education was considered. I have also drawn in literature that has an impact on the methods used in this study will be explained later. In the next chapter methodological approach that was employed in this study will be explained in detail.