

**Describing and understanding the enacted curriculum of selected  
Grade 10 Life Science Teachers in the Western Cape, South Africa**

by

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PTRAND002

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## **Abstract**

This study was conducted in a school in the Western Cape, South Africa situated in a community where learners came from difficult social backgrounds. Previous research has alluded to the challenges faced by teachers equipped with inadequate skills and a lack of effective modelling or mentoring to implement a formal curriculum that is outcomes-based and learner centred. The focus of the study was to uncover the enacted curriculum (and the underlying reasons for the enactment) of four Grade 10 Life Sciences Teachers. This multiple case study is based on data collection strategies that included video and audio-transcripts of the lessons as well as the use of additional relevant documents such as, for example, notes from lesson observations, and learner notebooks. These data were coded using NUDIST and then further analysed using the Pedagogic Content Knowledge (PCK) evidence-reporting table (PCK ERT). Interviews were conducted before the teaching events to allow for content representations (CoRes) to be developed. Overall the teachers lacked planning and the habit of reflection in and of practice. Hence video-stimulated interviews conducted after the teaching events allowed for Pedagogical and Professional experience Repertoires (PaP-eRs) to be developed in order to describe (from a teachers' perspective) what teachers did and why they did what they did. Teachers had varying backgrounds and experience and displayed very individualised and different enactments of the curriculum but they all used a consistent didactic approach in their teaching. The absence of teacher efficacy and the lack of integration of the PCK components limited the transformation of the content in any meaningful way and hence resulted in weak PCK. The relevance of PCK ERT as a descriptive framework for PCK in the context of this research is questioned on epistemic grounds. Factors identified that constrained the enacted practices of teachers included teachers' belief, orientation, poor Subject Matter Knowledge (SMK), school context and their perceptions of learners.



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## CHAPTER ONE

### GENERAL INTRODUCTION

#### **Background and Rationale**

There is little evidence (both internationally and locally) for far-reaching curriculum reform that has been able to transform teachers practice from a traditional to a more learner-centred approach (Stoffels, 2008; Clark & Linden, 2006). The results of a South African study on curriculum reform which included surveys and case studies, and which investigated the introduction of Curriculum 2005<sup>1</sup>, suggested that teachers lack the capacity and support needed for implementation (Rogan, 2004). The unrealistic demand placed on teachers and the lack of effective systemic support, made the implementation of progressive education models such as curriculum 2005 problematic (Stoffels, 2008). In describing the curriculum, van den Akker (1998, p. 421) draws a distinction between an ideal (that which is intended, including philosophical ideas), a formal (written curriculum in prescribed or exemplar form), perceived (how it is interpreted by teachers), experiential (how it is experienced by a learner experience) and attained curriculum (learning outcomes of learners). In the South African context, a disjuncture exists between the formal and the attained science curriculum as illustrated by learner performance (Case, Clark, Gunstone, Davies, Mgoqi, Toerien & Wallace, 2010). Generally speaking, research has shown that science teachers in South Africa have a poor grounding in subject matter knowledge (SMK) and that this impacts on their practice and their Pedagogical Content Knowledge (PCK) (Rollnick, et al., 2008; 2015).

#### **Problem Statement**

Implementing a learner-centred approach such as Curriculum 2005 had considerations of an epistemological, political moral nature and implementation difficulties (Clark & Linden, 2006). In my study the focus was on describing the enacted curricula of selected Life Sciences Teachers in a working class school and concerned the classroom processes and social and academic transactions that took place. It was necessary to provide a heuristic that would adequately described this complexity. Hence a descriptive framework based on PCK was used to explore and describe the teachers PCK.

#### **Aim and objectives of this study**

The aim of this study was to uncover the factors influencing the classroom practices of these teachers and then to describe how these factors potentially influenced their practice. More specifically, objectives of

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<sup>1</sup> Curriculum 2005 was an Outcomes-based curriculum introduced to replace teaching and training which were content-based Rogan (2005).

this study were twofold: first, to describe teaching and learning in four Grade 10 Life Science classrooms.; second, to investigate why teachers do what they do in the classrooms.

### **Research Question**

This study sought to find the answer to the following research questions:

1. What were the enacted practices of selected Grade 10 Life Science teachers?
2. Why did they enact these practices in their classrooms?
3. How can the enactment of the curriculum of selected Grade 10 Life Science teachers in the Western Cape be described and understood?

The first question attempted to portray the PCK of selected Grade 10 Life Science teachers in terms of their orientation towards science teaching, knowledge of students' understanding in science, knowledge of science curriculum, knowledge of science instructional strategies and knowledge of assessment of science learning. The second question sought to describe the underlying reasons for the curriculum enactment, which included the classroom processes that took place, such as, for example, what was taught, how it was taught and how it was assessed. The third question sought to formulate a suitable framework to describe the curriculum enactment.

### **Assumptions of the study**

It was assumed that the observed teachers' curriculum enactment was a fair reflection of their actual approach and that the teachers would respond truthfully during interviews, for example when they describe why they chose to do what they did. Certain assumptions were also made about the teachers' orientation and that teaching would be learner-centred and outcomes-based, as specified in the curriculum.

### **Delimitations of the study**

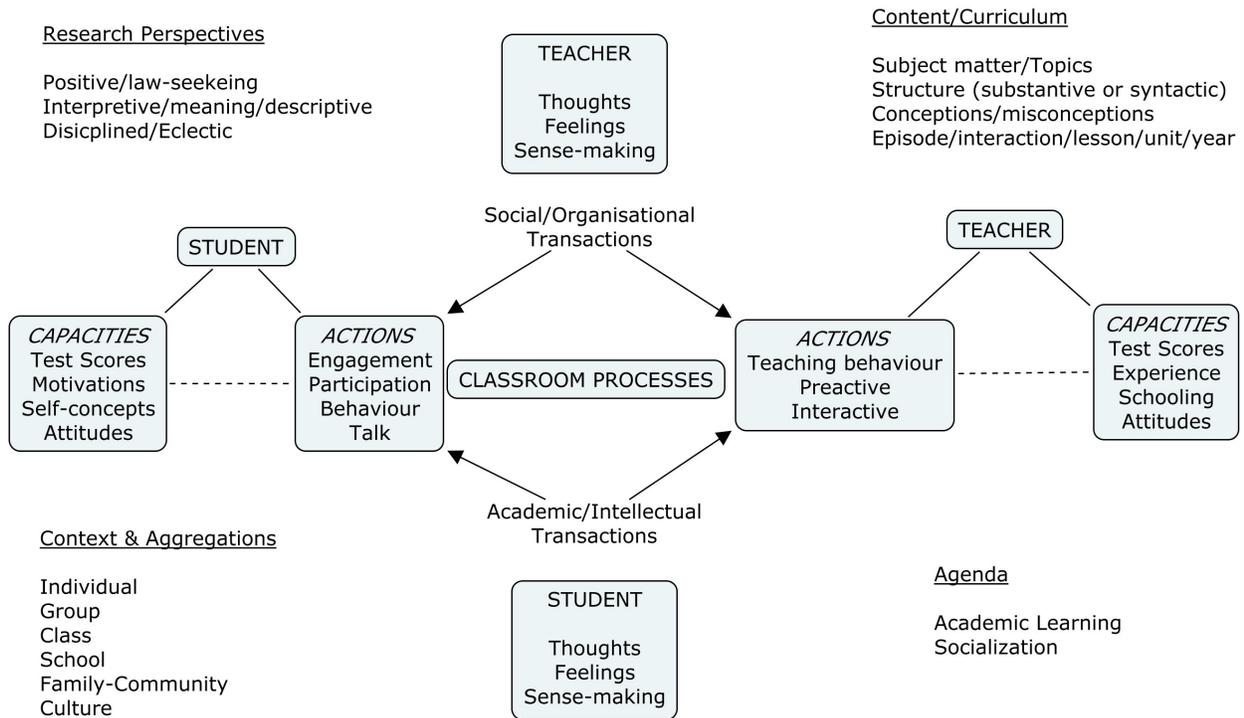
The study was limited to examining the curriculum enactment of four Grade 10 Life Sciences Teachers in one school in the Western Cape. The study focused on how they taught the same topic in the curriculum. The study therefore sets out to portray a glimpse of what their classroom experience is like and is clearly limited to this context. Therefore, the findings are not generalisable beyond the context.

## CHAPTER TWO

### REVIEW OF RELATED LITERATURE AND THEORETICAL FRAMEWORK

#### Introduction

An approach to research on teaching according to Shulman (1986) is first explained in this chapter. This is followed by a description of a progression of various models of Teacher Knowledge, including Pedagogical Content Knowledge (PCK). An appropriate PCK model and suitable approach to describing PCK is identified for the purpose of this research.



**Figure 1:** Synoptic map of research on teaching (modified from Shulman, 1986, pg. 9).

## **Research on Teaching**

Shulman presented a synoptic map of research on teaching (Figure 1). According to this map, the core of what happens in the classroom is determined by two agendas, namely, the curriculum and a socialisation agenda. The content and the purposes for which it is taught are at the very heart of teaching and learning processes (Shulman, 1986, p.80). Shulmans' approach to research on teaching foregrounded the teachers' knowledge that informs their plans and decision making, and describes a shift in the field of research on teaching from prescription to description (Grossman, 1990). Research at that time had renewed its efforts to portray the knowledge base of teachers and had begun to describe a number of models of teacher knowledge (Grossman, 1990).

## **Models of Teacher Knowledge**

According to Shulman (1986, p.8) the knowledge base of teaching included the following seven categories: Content knowledge; General pedagogic knowledge; Curriculum knowledge; Pedagogic Content knowledge; knowledge of learners and their characteristics; knowledge of educational contexts; knowledge of educational ends, purposes, and values, and their philosophical and historical grounds. Grossman (1990, p.5) suggested that four general areas of teacher knowledge as “the cornerstones of the emerging work on professional knowledge for teaching”, namely subject matter knowledge, knowledge of context, general pedagogic knowledge and pedagogical content knowledge.

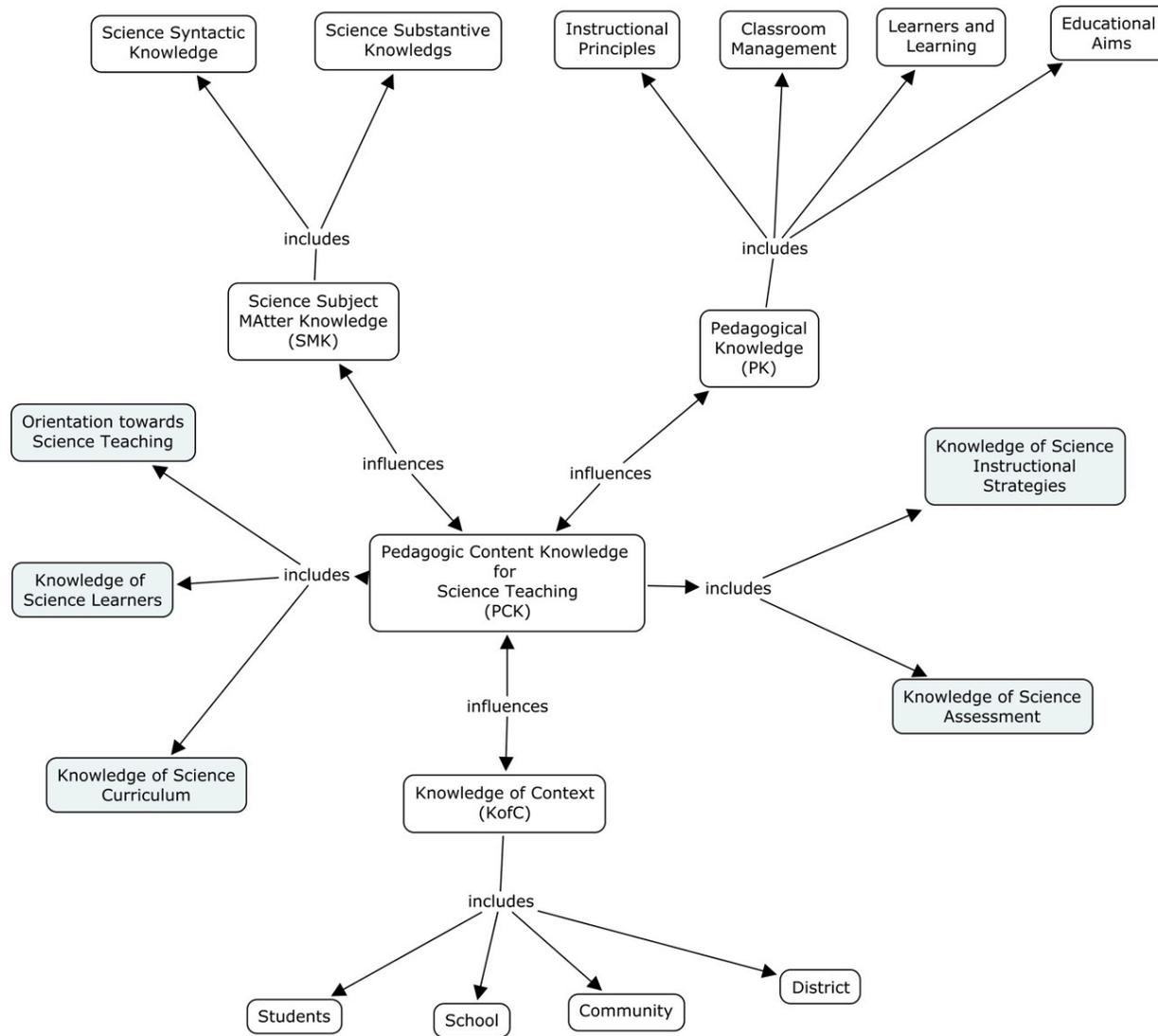
## **Pedagogic Content knowledge**

Pedagogic Content knowledge (PCK) was identified by Shulman (1986, p. 6) as the “missing paradigm problem” in research about teaching:

What we miss were questions about the content of the lessons, the questions asked, and the explanations offered. From the perspectives of teacher development and teacher education, a host of questions arose. Where do teacher explanations come from? How do teachers decide what to teach, how to represent it, how to question students about it and how to deal with problems of misunderstanding?

Various models have been designed to show the relation ship between PCK and the other knowledge domains. Useful reviews, which describe the knowledge components from different conceptualisations of PCK are provided by Park and Oliver (2008, p.265).

Research over the past two decades has emphasised the value of research on teacher knowledge and, in particular, on PCK with regard to science teacher education (Abell, 2007, 2008). Grossman’s ideas were combined with the broader description of PCK by Magnusson et al. (1999) to provide a model of Science Teacher Knowledge (Abell , 2007) , (Figure 2).



**Figure 2:** Model of science teacher knowledge (modified from Grossman (1990) and Magnusson et al. (1999)).

According to the conceptualisation of Magnusson et al. (1999), PCK includes the five components highlighted in blue in Figure 2. A detailed description of the five components of Magnusson et al. (1999, p. 99) follows:

1. Orientations to Science Teaching describes how teachers’ beliefs and practices influence the way teachers view science teaching, how they plan for teaching, enact their plans, and reflect on their

results. The teaching goals and the associated mode of instruction for each of these orientations to teaching science are described in Table 1. For example, in the case of an inquiry orientation to teaching science, the goal of teaching science is to represent science as inquiry and the nature of instruction is investigation-centred. On the other hand, the goal of a didactic orientation is to transmit scientific facts via the lecture method and students are expected to know the scientific facts.

2. Knowledge of Science Curriculum includes the teacher's knowledge and explanation of the lesson goals and objectives for students in the subject they were teaching as well as knowledge of vertical curriculum in the subject(s) taught. The vertical curriculum refers to what students have learnt in the past and what the need to know in the future whereas the horizontal curriculum (or lateral curriculum) which includes a broader knowledge of where the topic fits into the curriculum in general at that Grade level (Grossman 1990; Shulman, 1986). Knowing what is important and how to articulate it is included in a further category called curricular saliency (Park & Oliver, 2008). Research evidence suggests that lack of consistency between the intended goals of the curriculum and what is taught can impact on the coherence of PCK (Magnusson et al., 1999).
3. Knowledge of Students Understanding of Science includes the "knowledge that teachers must have about students in order to help them to develop scientific knowledge and includes the knowledge of requirements for learning certain science concepts and the areas of student difficulty" (Magnusson et al., 1999, p. 104). Further, they argue that an understanding the fundamental requirements for learning and anticipating possible misconceptions is an imperative for effective teaching.
4. Knowledge of Assessment in Science is directly influenced by the teachers level of scientific literacy and understanding of a range of assessment techniques including knowing how, when and what to assess (Magnusson et al., 1999).
5. Knowledge of Instructional Strategies This implies that teachers are able to describe and implement the appropriate subject-specific strategies for the particular orientation goal (e.g., inquiry-based learning). All three knowledge bases (i.e., PK, SMK and K of C) impact on this component. Topic-specific strategies includes topic-specific representations (e.g., models or illustrations or analogies), and topic-specific activities that assist in the learning of particular concepts. Limited knowledge of topic-specific representations impacts negatively on instruction and lesson coherence, and limits a teacher's responses to questions of students needing more complex or different representations (Sanders, Borko & Lockard, 1993).

**Table 1:** Description of each of the PCK Components (Magnusson et al., 2009).

Orientations to teaching Science	Goal of teaching science	Characteristic of Instruction
Process	Help students develop the ‘science process skills’.	Students encouraged by teacher to think like a scientist and engages in activities that develop thinking process and integrated thinking skills.
Academic Rigour	Represents a particular body of knowledge (e.g., chemistry).	Students were challenged with difficult problems and activities (verification of science concepts).
Didactic	Transmits the facts of Science.	Lecture, discussion, questions directed to students to hold them accountable for knowing the science facts.
Conceptual change	The naive conceptions of students were challenged by alternate scientific explanations.	Student ideas expressed and debated to establish validity of knowledge claims.
Activity driven	Active “hands on” activities used.	Hands on activity used for verification or discovery.
Discovery	Provide opportunities for independent discovery of particular science concepts.	Student-centred approach to explore the natural world and find patterns.
Project-based Science	Engage students in investigating solutions to authentic problems.	Project-centred.
Inquiry	Represents science as inquiry.	Investigation-centred.
Guided Inquiry	Community of learners who were responsible of finding out about the world around them using the tools of science.	Learning is community-centred teacher scaffold learning.

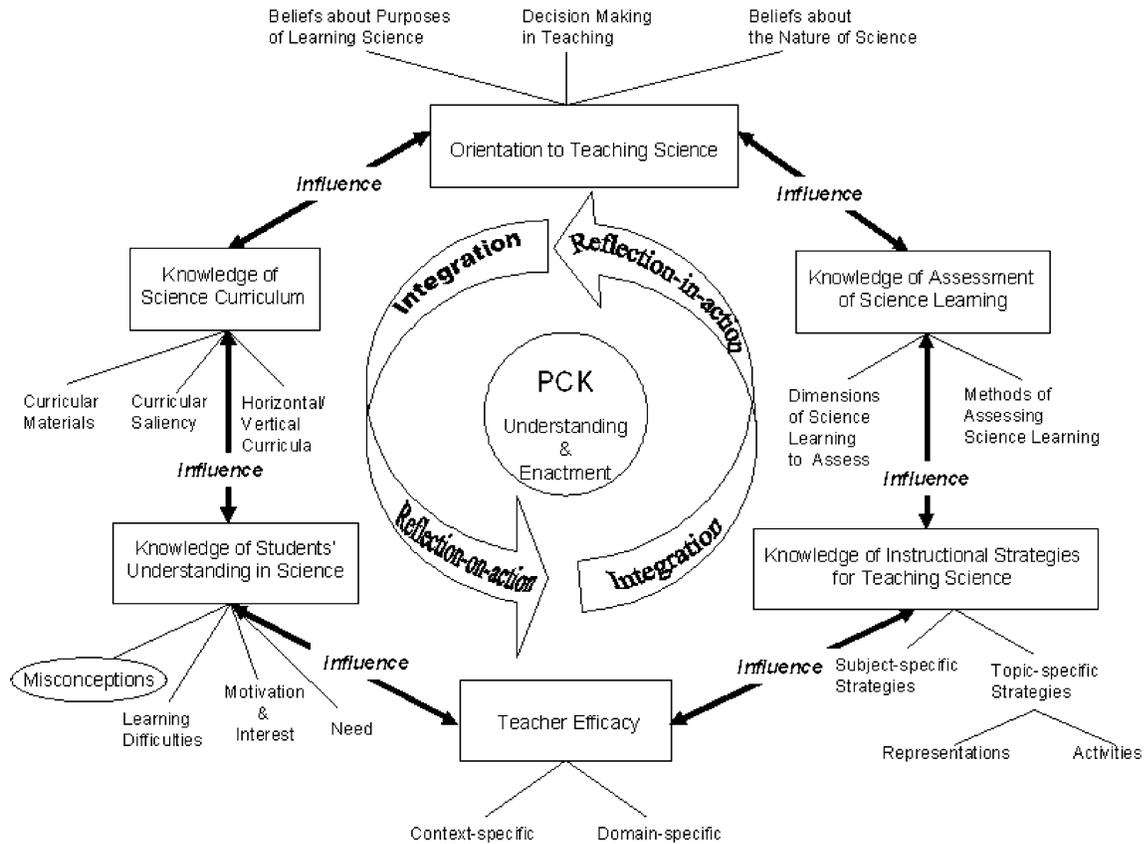
According to a research report, PCK was viewed as dynamic construct involving transformation of other knowledge types and remained a useful idea for science teacher education researchers (Abell, 2008).

PCK exists when subject matter knowledge (SMK), knowledge of context (KofC), general pedagogic knowledge (PK) are transformed into viable instruction, as is aptly described below:

...PCK can be described as how teachers teach their subject by accessing what they know about the subject, the learners they were teaching, the curriculum with which they were working, and what they believe counts as good teaching in their context. (Rollnick et al., 2008, p. 1367).

### PCK Model for Science Teaching

Park and Oliver (2008) developed a descriptive hexagonal model of PCK for Science Teaching which was conceptually grounded in the five components of PCK as described by Magnusson et al. (1999) and elaborated on previously.



**Figure 3:** Hexagonal model of PCK for science teaching (Park & Oliver, 2008).

At this point it is pertinent to explain the significance of this model in the context of my own research. My study sought to find out how the enacted curricula of selected Grade 10 Life Science teachers in the Western Cape could best be described and understood. A further objective of my study was to portray the PCK of Grade 10 Life Science teachers in terms of the five components of Magnusson et al. (1999) namely their orientation towards science teaching, knowledge of students' understanding in science, knowledge of science curriculum, knowledge of science instructional strategies and knowledge of assessment of science learning. In their conceptual definition of PCK they include two dimensions namely understanding and enactment (Park & Oliver, 2008, p. 278). Park and Oliver also developed a PCK Evidence Reporting Table (PCK ERT) which depicted the five components of Magnusson et al. (1999) as categories for describing PCK. The use of the PCK ERT is described in more detail in the next

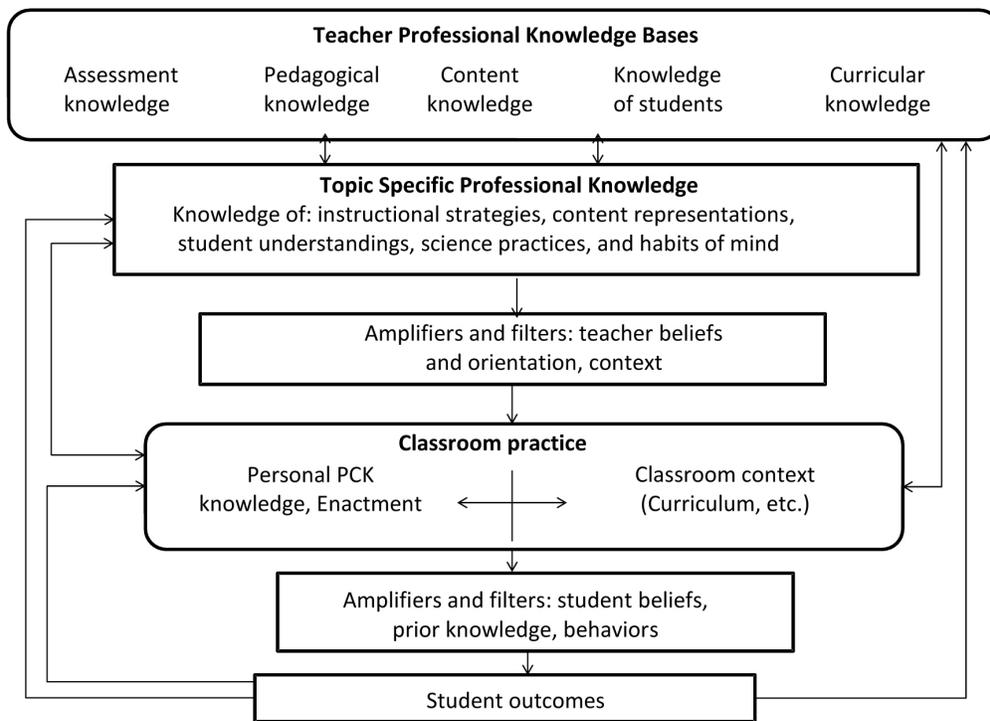
chapter. All of the components of their model met the requirements of a useful heuristic for the purpose of my study and hence I chose to model my thesis on their study. More specifically I used the PCK ERT as an analytical framework and their model as a descriptive heuristic.

In their model they introduced an additional component of PCK, which emerged from their research, which they called Teacher efficacy. Teacher efficacy was an affective component that mediated the enactment of the teacher's understanding (Park & Oliver, 2008, p.278) and they explained their model as follows:

The six components influence one another in an on-going and contextually bound way. In order for effective teaching to occur, teachers integrate the components and enact them within a given context. The integration of the components is accomplished through the complementary and on-going readjustment by both reflection-in-action and reflection-on-action. This implies that as a teacher develops PCK through reflection, the coherence among the components is strengthened. This strengthening reinforces their integration, which in turn facilitates the growth in PCK and further changes in practice.

### **PCK Summit**

A model of Teacher Professional Knowledge and Skill (TPK&S) which included PCK, emerged as an outcome of a conference held in 2012, convened to critically debate the nature of PCK and its relationship to other factors in research about teaching. The TPK&S Model included five Teacher Professional Knowledge Bases (TPKB), namely: Knowledge of assessment; Pedagogical knowledge; Content knowledge; Knowledge of students, and Curricular knowledge. According to this model, these TPKB can be influenced by and/or influence Topic Specific Professional Knowledge (TSPK). TSPK according to Gess-Newsome (2015) was possibly a knowledge previously ascribed to PCK, however, the author pointed out essential differences between the two types of knowledge. TSPK is the kind of knowledge held by expert teachers. The type of knowledge described by Loughran et al. (2006) in the development of CoRes by experienced teachers was given as an example of this type of knowledge. PCK on the other hand was more private and dynamic and more difficult to describe (Gess-Newsome, 2015). According to this model TSPK is then subjected to various amplifiers and filters such as teacher beliefs and then transformed into classroom practice, which is then further influenced by further amplifiers and filters before emerging as a student outcomes.



**Figure 4:** Consensus model of PCK from PCK Summit (Gess-Newsome & Carlson, 2013).

### The influence of Subject Matter Knowledge on Pedagogic Content Knowledge

Rollnick et al. (2008) suggest that a deeper understanding of PCK may elicit the influence of content knowledge on teachers’ practice. Rollnick et al. (2008, p.1366) highlight the importance of content knowledge in the South African context, and suggested that contrary to findings in the USA, Science teachers in South Africa have limited tertiary training. The impact of the teachers’ limited content background has led to a transmission approach to teaching and superficial use of content (Rogan, 2004; Rollnick et al., 2008). This highlights the significance of SMK and it’s influence on PCK in the South African context (Rollnick et al., 2008). Research has shown that teachers with sound Subject Matter Knowledge have the capacity to develop appropriate topic-specific strategies within their field of expertise (Magnusson et al., 1999; Rollnick & Mavhunga, 2015). However, this does not imply that if teachers have adequate SMK this would automatically become transformed into representations which would facilitate learning (i.e., develop into the required PCK) or that they would be able to choose the appropriate representations or activities (Magnusson et al., 1999). It is important that science teachers have the necessary experience about real world phenomenon, and wisdom of practice, which would equip them with the SMK needed to develop effective PCK (Magnusson et al., 1999; Shulman, 1986). Gess-Newsome (1999a) reviewed studies of teachers’ SMK and beliefs about subject matter and its relationship

to teaching, and identified three areas that were considered significant for their study, namely, conceptual knowledge, subject matter knowledge and content-specific orientations to teaching. “PCK and its related knowledge domains represent an effort to develop a model, or a theory of teacher cognition” and to this end Gess-Newsome (1999b, p.10) explored the PCK as an analytical framework in Science Education and developed a continuum of models of teacher knowledge. On the one extreme is the integrated model that is devoid of PCK and on the other extreme the Transformative model which shows PCK as a unique synthesis of the other domains. According to (Gess-Newsome, 1999b) teaching can be described using either an integrative or transformative model depending on the extent to which the knowledge bases are integrated or transformed. Using the analogy of the difference between chemical mixtures and compounds to explain the difference between the two models, Gess-Newsome (1999b) suggests that in a mixture the original ingredients remain chemically distinct in the final product and hence this analogy is used to exemplify the integrative model. However, when a compound is formed the final product is a new substance, which is completely different for the original ingredients (i.e., the PCK that is produced in the transformative model is novel in character). The possible danger of the integrative model is that it can promote a content-based approach without including pedagogical and/or contextual factors. On the other hand the problematic nature of the transformative model is that it is bound by context and limits transferability.

Which model is used has important consequences for understanding how SMK may be included in PCK (Rollnick et al., 2008). Adopting any one of these two models clearly has implications for research. In the case of the integrative model, the focus is on identifying effective strategies and then looking for transfer and integration. On the other hand, the transformative model emphasises identifying instances of PCK in particular contexts to exemplify these practices (Gess-Newsome, 1999b). This dynamic rather than static view of PCK influenced the study design of researchers who used a transformative model in describing PCK and highlighting the interaction of SMK and PK in the development of PCK (Rollnick *et al.*, cited in Abell, 2008, pp. 1408-1409). In my study, the enacted curricula of teachers with varied backgrounds are described in terms of either the integrated or transformative model. Hence the influence of the teachers’ SMK on their PCK will also be considered in my study.

### **Describing Science Teachers’ Pedagogical Content Knowledge**

A number of studies document ways in which science teachers’ PCK may best be explained and represented (Loughran, Milroy, Berry, Gunstone & Mulhall, 2001; Loughran, Berry & Mulhall, 2006; Rollnick et al., 2008). Based on interviews conducted with experienced and successful science teachers,

researchers were able to elicit the implicit nature of PCK and explain why it is that teachers do what they do (Loughran et al., 2001; Loughran et al., 2006). Experienced successful teachers plan teaching procedures, at a particular time for a particular pedagogic reason based on the actual context rather than just to change the routine, according to Loughran, et al. (2006, p.2). Elsewhere, Loughran et al. (2001) in the documentation of their experience of attempting to uncover teachers' PCK noted that this was not an easy process to see and describe it because of the complexity and iterative or reflexive nature of PCK. The authors also suggested that this was also was not a normal expectation of teachers to share this kind of information with others. Teaching is thus seen as complex and problematic, and embraces an individual approach where learning is active and purposeful and where teachers reflect on and plan for teaching in a particular context (Loughran et al., 2006). Awareness of PCK requires an in-depth SMK in combination with appropriate strategies, for example (knowing the big ideas, anticipating problems such as the possible alternate conceptions learners hold, the conceptual hooks and triggers for learning, etc.) (Loughran et al., 2006, p. 9).

Uncovering how, when and why teachers think about what they do becomes an important aspect of making the tacit explicit in attempting to capture and portray PCK (Loughran et al., 2001). Traditional case studies were too restrictive in providing the necessary detail and complexity required to portray PCK, and hence there was a need to offer new ways of conceptualising what PCK is and how it might be captured, documented and disseminated (Loughran et al., 2001). They developed an approach to articulation and portrayal of PCK based on the CoRe (Content Representation) – which represents the particular content/topic of the science teaching – and PaP-eRs (Pedagogical and Professional experience Repertoire) – which help to illuminate specific aspects of the CoRe and therefore offer insights into pedagogical content knowledge itself (Loughran et al., 2001, p. 2). Using a CoRe and PaPeRs approach to conceptualise PCK, offers science teachers the opportunity for revisiting practice and exploring new and better approaches to teaching SMK at an individual level (Loughran et al., (2006). In a two year longitudinal study Bertram and Loughran (2011) reported that practicing science teachers' found CoRe and PaPeRs to be useful in their practice, and for the development of their knowledge of science teaching. In order to my study the PCK of each Life Sciences teacher is unpacked and presented using Loughran's (2001) representation of CoRe. A detailed description of the process is described in the methodology chapter.

### **Science Teacher Education and Professional Learning**

According to Loughran et al. (2006), professional learning is about learning from, and building on, teachers' experiences. This involves sustained reflection on practice and a search to understand and construct new meaning by looking into (teaching) situations from different perspectives. They remind us

of the different contexts in which learning about science teaching and learning takes place namely in schools and pre-service education programmes. It is in the latter context that they also see the potential influence of PCK as a framework for beginner teachers' practice and development as they put it:

We would argue that in teaching generally, but in science teaching in particular, paying careful attention to the notion of PCK is one way of better valuing teachers' professional knowledge of practice while simultaneously creating an expectation for such development as integral to professional learning ( Loughran et al., 2006, p.219).

Nilsson (2008) studied how student teachers' understanding of PCK components in their own classes, during teaching practice, potentially impacted on their PCK development. Their findings suggest that PCK was influenced during collaborative reflection of student teachers experiences and their practice. A comprehensive review of science teachers PCK development was carried out by Schneider and Plasman (2011). This review of research published between 1986 and 2010 searched for articles published on PCK and science teacher learning, and looked at the PCK of different career phases of teachers to understand how teachers learning progresses with the aim of informing more coherent and contiguous Teacher Professional Development Programs. The authors noted the concern expressed by Abell (2008) that there was a paucity of studies of PCK in the literature that examine teacher knowledge at key points in a teachers' career. A further key finding of their research was that teachers need to think about learners first when teaching and that reflection was key to restructuring of ideas and PCK development.

### **Summary**

In this chapter I described the shift in trends in research about teaching which focus more on descriptions of the complex nature of teaching. I then described the knowledge base of teachers and a number of models of teacher knowledge. This was followed by a description of what PCK is and how it has developed over the past 20 years. PCK was identified as a useful construct for Science Education Research and various Models of teacher professional knowledge were introduced. Various interpretations of the interactions of the various knowledge bases with PCK were described. The importance of SMK in the development of PCK in the South African context was also discussed. The Hexagonal model of PCK for science teaching was identified as a heuristic for describing the curriculum enactment of science teachers in the case of my study. The use of CoRes and PaPeRs was also identified as means to give rich descriptions of PCK and to provide insights into pedagogical content knowledge itself. PCK was also identified and a useful tool for reflective practice and professional learning.



## Chapter Three

### METHODOLOGY

#### Research Design

When using a qualitative research design, researchers attempt to make sense of the reality of the participants in the study and how they respond to this reality (Maxwell, 1996). Case studies, which are based on observation, provide a rich explicit description of the actual experience of the participants engaged in the research process (Cohen & Manion, 1991). A case study is a routine method of doing qualitative educational research, especially when your research addresses either a “descriptive question (what is happening) or an explanatory question (why did something happen)” (Yin, 2006, p. 112). Stake (1994, p. 237) identified three types of case studies namely intrinsic, instrumental, and collective. An intrinsic case study has the focus of inquiry firmly on the case itself (e.g., an individual teacher’s practice), whereas an instrumental case study provides more general insight into an issue. In a collective case study, the instrumental case study is extended to more than one case. In one of the seminal studies in the field of teacher knowledge, Grossman (1990, p. 150) pioneered the use of case study methodology to “generalise a theoretical framework about teachers knowledge and its possible sources”. Erickson (1986) used the term ‘interpretive’ to refer to a family of approaches that includes ethnographic, qualitative, participant observational, case study, phenomenological, symbolic interactionist, and constructivist research.

In an attempt to find out how teaching and learning unfolds in the Grade 10 Life Science classroom, it was appropriate to use a qualitative interpretive approach. As this study also required an in-depth study of teachers’ enactment of the curriculum (i.e., what practices occur in the Life Sciences classroom and why they were happening) a narrative case-study approach was most appropriate (Clandinin, 1992). Similar to the approach of Grossman (1990, p. 150), the intention is to “[identify] patterns and themes within the individual case that can be useful in the collective cross-case analysis”. In the context of educational research, the narrative method has as its central feature the reconstruction of classroom meaning in terms of narrative accounts in the lives of classroom participants (Connelly & Clandinin 1986; Clandinin 1989; Clandinin & Connelly 2000). The narrative method seeks to make practice the starting point, the ground for inquiry in collaboration with the researcher and hence the narrative case-study approach is situated within a constructivist-interpretative paradigm (Denzin & Lincoln, 1994). The approach in this study was similar to the approach of Park and Oliver (2008) and used a multiple case study grounded in a social constructivist framework.

## Teacher Selection

The design of this study included multiple case studies of four Grade 10 Life Science teachers with varying degrees of experience and qualifications. This enabled me to map the acquisition of PCK back to individual teacher's background and experience. These teachers were invited to participate in this study as part of a longer-term initiative to improve teaching practice in the school and a selection of the cases were based on their willingness to participate. In order to reduce the complexity of the contextual constraints, each teacher was observed teaching the topic the Chemistry of Life (see appendix C, p.91, for a detailed description of this topic).

**Table 2:** Background information of participants.

	Abrahams	Dawood	Benjamin	Matthews
Education	HDE	BSc,BEd, HDE	HDE, ICT	HDE
Science Background	Biology, Human movement studies	Microbiology	Biology, Geography	Biology, Geography
Teaching years	8 years	24 years	10 years	21 years
Teaching subjects	Life Science, Tourism	Life Science, Natural Science	Life Science, Social Sciences, English	Life Science, Natural Sciences

## Data collection strategies

Assessment of PCK requires the use of various strategies to find out what teachers know, what they believe, what they do and the reasons for their actions (Baxter & Lederman, 1999; Park & Oliver, 2008, p. 267). In this research study, which is modelled on the study by Park and Oliver (2008), data were gathered using multiple data sources including semi-structured interviews, lesson observations and stimulated interviews using video and/or audio recordings of the lessons. A description and the rationale for using these data collection strategies are given in Table 2. The value of using standardized open-ended interviews is that it improves the comparability of the responses, provides complete data that can easily organised and analysed (Cohen, Manion & Morrison 2000, p. 271). Teacher resources used in preparing their lessons, including textbooks and other relevant materials, were collected. Face-to-face interviews were conducted before and after teaching the topic. The pre-lesson interviews (using the questions in Table 3) probed teachers understanding of the topic as well as their planning strategies, explanations, and resources used in their lessons. Post-lesson interviews included a stimulated reflection of the lesson (including video and/or audio transcripts) and as the need arose further interviews were held to clarify

issues that arose during data analysis about the teachers practice. This is similar to the “stimulated recall” method described by Clark and Peterson (1986, p.259) in their description of methods of inquiry for studying the thought processes of teachers. Nilsson (2008) also used stimulated recall sessions to generate “thick descriptions” of student teachers reflections (Geertz, cited in Nilsson 2008, p. 1287).

**Table 3:** Data collection strategies and rationale for using these strategies.

Strategy	Rationale
Interview using questions to generate CoReS	In order to elicit details about what teachers teach and why, interviews were conducted using the prompts listed in Table 4. Initially this served to identify what teachers considered to be the “big ideas” associated with teaching a Grade 10 life sciences topic. These ideas were then discussed, refined and interrogated further using the prompts. (Loughran et al. (2001) (See Appendix A)
Lesson Observation	This enabled a more detailed narrative description of the classroom context and the pacing and or flow of the lesson. A simple observation sheet recorded the activities that transpired as the lesson proceeded and comments about the significance of the selected tasks and their enactment in the form of chosen instructional activities. At least four lessons were observed for each teacher teaching the same topic using non-participant observation (Park & Oliver, 2008).
Stimulated Interview	These interviews were designed to uncover how the teacher perceived that the lesson proceeded and progressed and to generate research texts and to develop resource folios. Using selected video-clips that arose during the video analysis, enabled the PaPeRs to emerge and elaborate and give insight into the interacting elements of the teachers PCK. In addition, these interviews captured the teachers’ reflection on the lesson and gave some insight into the teacher’s perceived curriculum and their Knowledge of practice.
Additional Data Sources:	To provide further evidence for the types of representations, tasks and chosen materials used during lessons were collected. Learner notebooks (at least three from each class to represent a spread of a learner ability), tests and memos and photocopied notes distributed to the learners were gathered, for photocopying and archiving. Field texts were archived and used for cross-referencing.

In order to identify the unique knowledge of teachers and/or the curriculum enactment, PaP-eRs and CoRes were used as methodological tools to represent the PCK of the Life science teachers (Loughran *et al.*, 2001; Rollnick *et al.*, 2009). A description of the methodological tools (CoRe and PaPeRs) used to generate research texts (Clandinin & Connelly, 1994; 2000) follows. A CoRe provides a composite overview of how a teacher conceptualises the content of a topic (Loughran *et al.*, 2006). The key issues addressed in the CoRe were what teachers consider to be the “big ideas” associated with teaching a Grade 10 Life Sciences topic. These ideas were then discussed and refined and then interrogated using the prompts listed in Table 4. The underlying reasons for using these prompts was based on research findings by Loughran *et al.* (2006) and outlined in Table 4. The prompts guided the initial interview session.

Table 4: Prompts used in the interviews to generate CoRes (Loughran *et al.*, 2006, p.25)

Prompts	Reasons for using these prompts in the interview
1. What you intend the students to learn about this idea?	To reveal teachers’ understanding of what matters to them.
2. Why is it important for students to know this?	To uncover the reason for teachers’ teaching what they do, based on experience or contextual factors or other curricular aims.
3. What else might you know about this idea (that you don’t intend your students to know yet)?	To find out if there is appropriate selection of materials in relation to the learning trajectory.
4. What were the difficulties/limitations connected with teaching this idea?	To uncover the teachers’ understanding of learner’s potential conceptual problems with the given topic and the teaching and or learning strategies employed with particular reference to “constructivist views of learning”.
5. What Knowledge about students’ thinking do you know of which influences your teaching of this idea?	To elicit teachers’ experiential knowledge and how this influences their thinking about their teaching in relation to the ideas of learners.
6. What other factors influence your teaching of this idea?	To unpack the contextual Knowledge and General Pedagogic Knowledge in order to explore the impact these may have.
7. What teaching strategies did you use and Why? (and particular reasons for using these to engage with this idea)?	To uncover the purposeful procedures that teachers decide to use – when how and why to achieve different aspects of learning.
8. What specific ways of ascertaining students’ understanding or confusion around this idea (include likely range of responses).	To reveal the meta-cognitive and other strategies used by the teacher for gaging the understanding and progress of learners.

To avoid compromising the data during the classroom observations, my role as researcher did not involve any participation and hence my observer status was as close as possible to being that of complete observer (Cresswell, 2009). Lessons were recorded using videotape or audiotape<sup>2</sup> enriched by field texts gathered during the lesson observations. These field texts recorded the events that occurred during the lesson in an attempt to further elucidate the PCK of teachers. Clandinin and Connelly (1994) use the expression field texts and research texts to describe the data gathered during field work (including journal entries, field notes and so on). The lesson observation schedule was a narrative account of the lesson as it unfolded and simply recorded the actions of teachers and learners as they transpired and any other relevant anecdotal detail. After teaching the topic, interviews were conducted with teachers about how the lesson proceeded and progressed. This was to enable identification of the teachers' "knowledge of practice" and to generate research texts and build resource folios for the topic for each teacher (Berry et al., 2009, p. 578).

### **Data capture and analysis**

Raw data collected during the study included audio-recordings of two interviews (one interview conducted before the topic was taught and one interview after the lessons had been taught), audio-recordings or videos of four lessons, lesson observations of four lessons, field notes were recorded during each lesson observed, lesson plans, copies of at least three learner books (learners of varying ability) from each teacher; tests and memos and any other hand-outs used during the teaching of the topic - the chemistry of life. (See appendix D on p.92 below for a more detailed description of the data sources).

The analysis of both types of audio recording followed a stepwise procedure based on the constant comparative method (van Driel et al., 1998; Park & Oliver, 2008).

#### *Stage 1: Defining the CoRes and developing PaPeRs*

CoRes and PaPeRs were based on the interview data and other data sources (e.g., learner notebooks, tests and memos, photocopied notes) involved the following steps:

1. Read through of the pre-topic interview transcripts and use the prompts (Table 3) to build the CoRe for each of the big ideas.
2. View video of the lesson, and together with the lesson observation notes expand on the CoRe and build the PaPeRs.
3. Read through post-topic interview transcripts to validate the CoRe.
4. Develop the PaPeRs based on the additional evidence from the other data sources.
5. View videos to identify "classroom windows" for the stimulated interview session.

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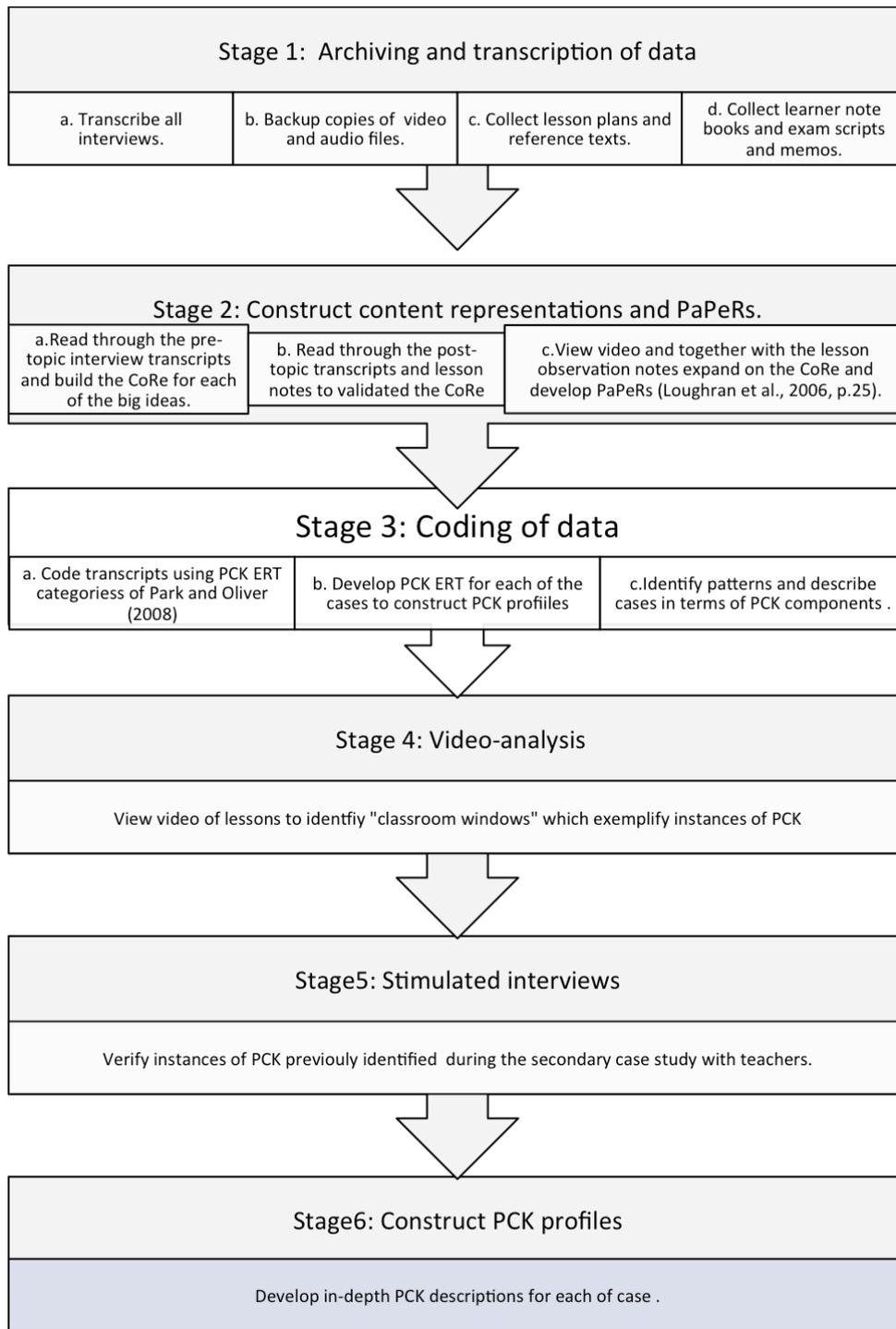
<sup>2</sup> One of the participants (Ms. Abrahams) was not prepared to be video taped due to personal reasons

### *Stage 2: Coding of data*

This stage of the analysis followed the enumerative approach of Park and Oliver (2008, p. 267) and used the PCK Evidence Reporting Table (PCK ERT) (Appendix B) to identify the characteristics of each teacher's PCK. The lesson transcripts from the case studies were initially coded using the categories of the PCK ERT and then the same lesson transcripts indexed and classified using a non-numerical Unstructured Data Indexing Searching and Theorising programme (QSR NUD\*IST). The coding categories in QSR NUD\*IST were based on the five PCK components of Magnusson et al. (1990), described earlier and elucidated in the PCK ERT of Park and Oliver (2008).

### *Stage 3: Constructing PCK profiles*

PCK profiles were drawn up for each of the teachers so as to reflect the differential influences of the different components of PCK. Stimulated interviews: PaPeRs formed the basis of the audio and video-analysis sessions. Using a stimulated interview about instances highlighted in the first phase of the video analysis, PaPeRs were developed and offered opportunities for reflective practice (Rollnick et al., 2008). This allowed for verification of the key instances identified in the interview in order to validate the assertions made. During this stage of the analysis the purpose was to develop resource folios for each teacher based on the topic taught. "A resource folio of a given content area contain the CoRes and associated PaPeRs which create complimentary representations" of PCK (Loughran et al., 2006, p. 9). These resource folios together with the PCK ERT profiles allowed for a rich description of the four cases and where these cases were positioned in terms of the integrative-transformative continuum. The data analysis process is summarised in Figure 4 below:



**Figure 4:** Flowchart of analytical framework.

## Validity of the research

Two key issues that emerge in conducting interpretive research were representation and legitimation (Denzin & Lincoln, 1994). The representational crisis concerns one of the key assumptions of interpretive research, namely, that one can directly capture lived experience. Such experience is "... it is now argued, can only be created in the social text written by the researcher." This is clearly subjective, since the direct link between experience and text is problematic (Denzin & Lincoln, 1994, p. 11). The second assumption is the legitimation crisis, which has required a serious rethinking of such terms as validity, generalizability and reliability (Denzin & Lincoln, 1994, italics in the original). It is therefore imperative that "... qualitative researchers deploy a wide range of interconnected interpretive methods, always seeking better ways to make more understandable the worlds of experience that have been studied" (Denzin & Lincoln, 1994, p. 12). Validity in qualitative research is dependent on the rigour, ability and skill of the researcher where in fact the researcher is the instrument (Bornman, Clarke, Cotner & Lee, 2006, p. 130). Dependability and consistency of results obtained from data analysis can be achieved by triangulating data collection methods and providing details of data collection and analysis procedures (Lincoln & Guba, cited in Bornman et al., 2006, p. 130). In this study, various sources were used to triangulate the data (Janesick 1994). This is similar to the approach used in other studies in the field of PCK (van Driel, Verloop & de Vos 1998; Loughran et al., 2001, Berry et al., 2006). This will include the use of texts and post lesson reflections. Four key strategies were suggested for increasing the validity of the research findings, namely, procedures to:

... to (1) reduce bias in how you select information (e.g., sampling bias), (2) increase the accuracy of your description of what you have selected, (3) increase the plausibility of your interpretations through audit trails and triangulation and (4) establishing the reasonableness of your conclusions through seeking participant feedback." Robinson and Lai (2006, p. 58)

In this study, the strategies for ensuring the accuracy of the data included having an independent person transcribing the various audio- and video-taped lessons and interviews. Added perspective was provided in order to corroborate inferences by supplementing the interview and recorded video and audio-data with a narrative description of the observed lessons and other data sources such as learners notes, teachers notes, tests and memos, and so forth. In gaining feedback from participants in the post-lesson interviews and stimulated interviews, "respondent validation" further increases the validity of the study (Hammersly & Atkinson, cited in Robinson & Lai, 2006, p. 62). Similar to the approach of van Driel et al. (1998), the validation of interpretations that emerge from the analysis of the data were achieved by applying the constant comparative method (Park & Oliver, 2008). The initial coding of the lesson transcripts, using PCK ERT as an analytical framework, was done independently by the researcher and an independent rater

(a language expert). The independent raters' interpretations were compared with those of the researchers to improve the reliability of the data interpretation. The assertions that emerge from the transcript analyses were cross-referenced against interpretations from additional artifacts gathered in the study to map the origins of the teachers' representations of subject matter (including lesson plans, assignments, assessments and any other relevant items used in the design and teaching of the actual lesson). The use of a video-interview in the secondary case study included the use of limited case writing to strengthen the construct validity (Wallace, 2004; Berry et al., 2009).

### **Summary**

In answering the research questions in this study the PCK ERT was a useful framework to address the research question on how the teachers' enacted practices could be portrayed in terms of teachers' orientation towards science teaching, knowledge of science learners, knowledge of science curriculum, knowledge of science instructional strategies, and knowledge of science assessment. The PCK ERT is therefore useful as a tool for describing a teacher's PCK. Some of the components (e.g., the type of questions used in the lessons) are quantifiable, however, a number of issues and potential assertions emerge from the PCK overview that needed to be substantiated via cross-referencing with other data sources and follow-up interviews. An in-depth analysis of the evidence of PCK based on the use of CoRes and PaPeRs illuminates the second sub-question, namely, why teachers enact these practices.



## Chapter Four

### RESULTS

#### Introduction

The enacted curricula of individual teachers are described below with regard to three aspects, namely, what the teacher does, what the teacher knows and why the teacher enacts these practices. These descriptions of the teachers' enacted curricula are grounded in lesson observations, but augmented by other data sources collected before, during and after the teaching episode. In these descriptions, case studies are developed by, firstly, sketching each teachers' background and experience and to provide possible insight to their orientation to teaching. This is followed by a glimpse of the classroom experience, which depicts the discourse and classroom atmosphere. In order to portray what the teacher knows, data was analysed using the enumerative approach of Park and Oliver, (2008) expanded on in Chapter 3 (pg. 29). This approach uses the PCK ERT as an analytical framework. The PCK ERT is an adaptation of the PCK categories of Magnusson et al. (1999). Explaining why the teacher does what she does concludes each case study. This explanation is based on reflective interviews, which took place after the teaching episode (Chapter 3, pg. 25). Finally, PCK profiles are presented at the end of the chapter.

#### Case Study 1: Ms. Abrahams

##### Teacher background

Ms. Abrahams (pseudonym) is a 38 year-old teacher with eight years of teaching experience. At the time of this study, Ms. Abrahams had only been working at the school for just over a year and, amongst other things, taught Natural Sciences at Grade 8 level, as well as Tourism, Life Orientation and Life Sciences at Grade 10 level. Apart from teaching Life Sciences for this one year, her previous experience of teaching Life Sciences was limited to five years at Grade 10 and Grade 11 levels at a previous school. Having taught her current Grade 10 Life Sciences learners Life Orientation in the previous year allowed her to develop good relations with this class. This was evident in her positive interaction with these learners, which is further discussed in the section "Teachers' knowledge of learners" below. In conversation with her about her science background, she revealed that she had not taken science as a subject at school and further, that her HDE<sup>3</sup> course had not include any Chemistry or Biochemistry.

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<sup>3</sup> HDE is an initial teacher education qualification offered at teacher training colleges/University

## What does the teacher do?

A typical lesson is depicted in the vignette below:

When I arrive at the class the learners are lining up in two rows outside the class. Ms. Abrahams stands at the door on the veranda and waits for the learners to get organised and then lets them in row by row, girls first. There a low background chatter as the learners settle into their desks and after two minutes the teacher starts the lesson by greeting the learners who greet her in return. At the start of the lesson she reminds the learners that the fun is over (referring to a brief break in studies) and says that they need to get back to business. As I look around the class, I notice that despite the usual graffiti on the desks, Ms. Abrahams' classroom is fairly neat with learners' work displayed on the walls and project work displayed on benches. The desks are arranged in three large blocks (one block in the centre of the room facing towards the board, with the other blocks facing at right angles towards the centre of the room), with the teachers' desk at the back of the class. There are 35 learners in the 10 G class, which is one of seven Grade 10 Life Science classes at the school.

Ms. Abrahams starts the lesson by revisiting the summary of a few concepts from the previous lesson on the black board. She rarely makes notes on the black board, but prefers to read through a printed hand-out with the learners, at times engaging with individual learners by name. When teaching, Ms. Abrahams generally engages with individual learners seated at the front of the class, but she rarely interacts with the learners at the back of the class. As she reads through the hand-out with the learners she explains the significance of learning about the chemistry of substances and attempts to draw out the learners ideas. "Have you heard of organic things?" "Yes, miss at Woolworths" (a learner responds). Ms. Abrahams continues: "At Woolworths, yes?" The same learner then comments, "fresh, herbs!" to which the teacher responds "Organic, right? So, organic compounds. So, just that word compound, what does it tell you?"

A learner then retorts "combined". Ms. Abrahams responds to this comment "It's built up, it's combined, lovely! Right, so it's more than one element involved, right? Now, compounds consist of carbon, consist of carbon and that carbon is produced by living things. Example, your plants, OK, and then you have examples of those and examples of that would be a carbohydrates. You've heard of that?" Some learners respond by giving examples of carbohydrates. She attempts to link these learners' ideas to more familiar examples such as carbo-loading in marathon runners. In her discussion with learners about good and bad fats, she explores learners ideas further "What is that? Poly-unsaturated. Have you heard those word? Polyester! [laughter] OK, yeah, but we are going to get to that". After 10 minutes, she recites the definition and examples of organic compounds from the hand-out, at the same time explaining the ideas and checking learner understanding as she proceeds. Then, finally, she engages in a more deliberate manner with individual learners to check for understanding. "You don't understand! OK, I will explain it again. Right, a compound, where we said we combine elements, right? Now, organic compounds, it's a compound that consists of carbon, right? Consists of carbon and it's produced by living organism like a plant. Do

you get that? That is organic.” Ms. Abrahams then repeats the same explanation again and then emphasises that all she needs the learners to know at this stage is to define the terms and to be able to give examples. She then asks the learners to repeat what she has just said and then instructs the learners to read the text with her again. The teacher then moves on to the next topic namely inorganic substances. After exploring the learners understanding in a similar way she asks one of the learners to read from the hand-out. When the bell sounds for the end of the lesson, she instructs the learners to read through the hand-out for homework and greets the learners who then leave.

### **What does the teacher know?**

What follows is a detailed description of this teacher’s enacted curriculum based on the PCK categories in the PCK ERT. This description is based on the analysis of data collected from four lessons and interviews conducted before and after the teaching episode. The first of these categories describes her orientation to science teaching.

#### **Orientation towards teaching science**

This component of PCK deals with teachers’ “conception of purposes for teaching subject matter” (Grossman, 1990, p. 5). During the pre-observation interview, Ms. Abrahams stated her intended goal of teaching: “...I would rather do this amount of work and know that the learners have a good understanding, instead of running through the whole syllabus for the sake of completing it.” Further exploration of Ms. Abrahams’ ideas during the pre-observation interview highlighted her perceived difficulties /limitations connected with teaching this topic:

“Like I have done there, I'll take the words out and whatever and explain to them and, once again, repetition and let them, you know, memorise these things and just going over on a daily basis. Because I've done this lesson when ... now two days ago ... this is foreign again to them today. So, because I've planned now for today, the organic compounds, inorganic and things like that, but before I can even go back ... start with that again, I will have to go through this again, you know, because that all forms part of the elements and what, the compounds elements, it's part of the compound. So, I 'm going to have to go back again so that we can link that again. So ... it's always going back, going back.”

#### **Knowledge of Instructional strategies and representations**

This Component of PCK describes the teachers’ Knowledge and approach using PCK ERT as an analytical framework, and whenever possible, NUDIST was used to do the enumerative analysis as described in Chapter 3 (e.g., the types of questions asked in the lesson).

*Types of activities and language devices*

When teaching the “Chemistry of Life” (a topic in the Grade 10 Life Sciences syllabus), Ms. Abrahams chose a hand-out with simplified notes and basic diagrams of the different organic compounds. No additional activities or questions designed to challenge the learners were included in any of the lessons. Ms. Abrahams often repeated her explanations to learners and (on occasion) used mnemonic devices to help learners to remember the facts. At times the whole class engaged in a form of choral like chanting repeating a definition in unison. She explained her strategies for eliciting learners’ ideas when dealing with the Chemistry of Life, and how she expected them to respond as follows:

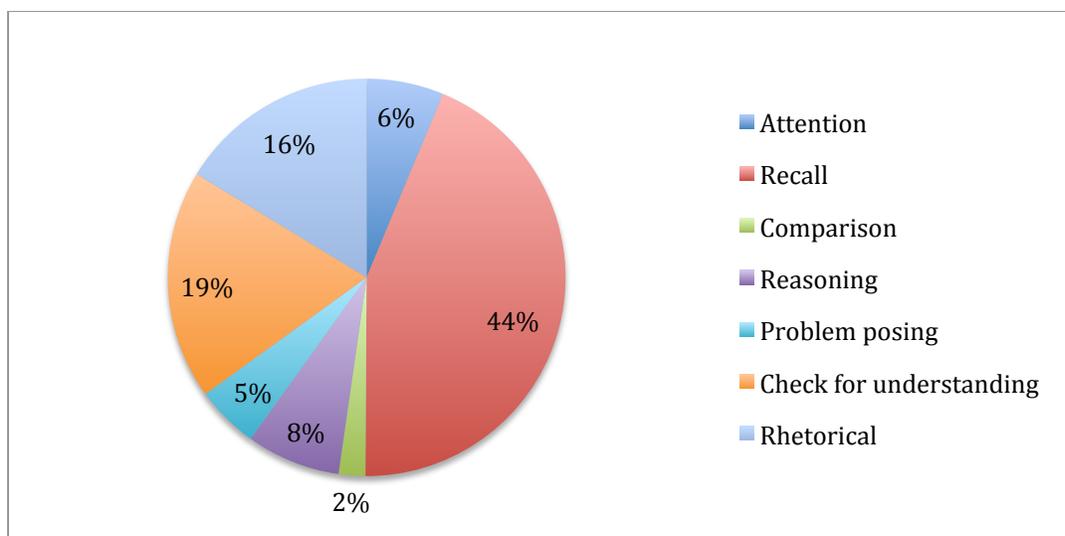
“Questioning them, you just have to mention something and you know the things that they come up with. You can see, you can gauge whether they have an understanding or if there is a misconception of the whole idea, so. Because they are very open, even though the answers is farfetched, or whatever, they feel free because they feel free to say what they think, I can easily gauge whether, you know, what’s cooking or not, because of that.”

Her strategy of dealing with these learners was explained as follows. Taking out the key words from a text and explaining them to the learners; using repetition to reinforce the learning and let them memorise these things; linking new knowledge by repeating the previous lesson topic. She explained her approach in dealing with this particular cohort of learners who (in her opinion) had no real motivation to learn and were disinterested: “... their interests and just their background and, you know, I think that I know how they think, but we are never going to go there, so let’s just go through the motion. That’s the way they think.”

Ms. Abrahams also indicated during the pre-observation interviews that it was important to make what was learnt in this topic more relevant to the learners’ daily lives. She claimed that she took into consideration the interests of the learners, their background and how they think about schooling. Hence, she extended the discussion about carbohydrates in her lessons by including examples that she felt that the learners could relate to like bodybuilders and marathon runners.

### *Questioning*

An enumerative analysis was carried out to show the types of questions used by Ms. Abrahams in the four lessons observed. Lesson transcripts from these four lessons were coded using the question categories from the PCK ERT. This is described fully in Chapter 3 (pg.29). These were then tallied using NUDIST to generate the data represented in Figure 5.



**Figure 5:** Enumerative analysis of the types of questions asked by Ms. Abrahams (n=529) during the four lessons taught on the Chemistry of Life.

What is evident from the data in Figure 5 is the extensive use of factual recall questions (44%) and rhetorical questions (16%). There was limited individualised engagement with the learners as reflected by the limited use of checking for understanding questions (19%). Attention focussing (6%), reasoning (6%) and problem posing (4%) and comparison (2%) type questions were rarely employed.

### **Types of content elaboration**

Park and Oliver (2008, p 281) define Topic Knowledge as the ...“depth beyond the intended goal of text,” whereas Domain Knowledge is defined as the ...“breadth beyond the intended goal of the text.” Based on the pre-observation interview and the four lessons observed, there was no instance to show evidence of Topic Knowledge.

Ms. Abrahams’ Domain Knowledge was only evident in the two instances where she discussed lactose intolerance and xerophytic plants.

### **Knowledge of students**

Based on my pre-observation interviews and my lesson observation experiences, this teacher had good insight into the type of learner she was dealing with. According to Ms. Abrahams, these learners had little interest in the subject, had weak background knowledge and struggled with the terminology of the subject. During the pre-observation interviews she commented on their unfamiliarity with the terminology:

“Terminology.... the physics, atoms, molecules, it's like another language so immediately I know how they would respond. Well, that is chemistry, I'm not a chemistry student, you know, so, I think that, they don't respond very well to those things. Because it's strange to them and they don't use it in every day.”

Ms. Abrahams explained that the learners in 10G were not in the Mathematics and Physical Sciences stream, and because of this she was of the opinion that these learners struggled with the chemistry component in Life Sciences.

### **Knowledge of Curriculum**

#### *Knowledge of vertical curriculum*

According to Grossman (1990), the vertical curriculum refers to what students have learnt in the past and what the need to know in the future, particularly w.r.t. conceptual progression. Initial interviews were conducted, prior to teaching the topic, in order to elicit the teacher CoRes and to get a better idea of the teachers knowledge. This is explained more fully in Chapter 3 (p. 29). In response to the question on what she intended the students to learn, Ms. Abrahams had the following to say:

“What they need to know, [how] molecules, atoms, how it all fits into the bigger picture and so on. Yes, they could see, because as you move on further, they can see how it fits into life itself ....the sugars and things like that. And then they won't just see it as sugars and fats and whatever, but they will see how it is made up and so on.... Yes, because if we look at, eh, the compounds, how it's put together ... to them it's just ... we are just having this but where does it come from. So, now they will have a better idea of how it's put together, where, you know, scientifically.”

She justified these goals because in her view,

“It's part of their everyday life and so they can make informed decisions about , especially if you look at healthy eating and [and] obviously, if they wish to go study further, this is like basics that we are doing I mean, the background for them to continue and to just make things easier for them.”

In her explanation of why it was important for the learners to know this, Ms. Abrahams suggested that they needed “...to have a scientific understanding of how compounds are formed”.

#### *Knowledge of horizontal curriculum*

Evidence of the teacher knowledge of the horizontal curriculum is suggested by her making possible links with the “Chemistry of Life”, and knowledge of other topics to be covered in this grade. Thus her knowledge of the horizontal curriculum was evident in her first lesson where she explained homeostasis:

“...In order for the body to work, there needs to be an environment, an internal environment that needs to be kept constant, things needs to be working, right? So, that process, keep things constant, where things in the internal system is kept constant, that is called homeostasis, OK? This is just an introduction for you people. Now, why is it important that at certain things in the system, the internal system, the environment must be constant? Now, this is a few of the kinds of things that must be constant. That is the concentration of glucose, concentration of the sodium, concentration of oxygen, carbon dioxide, temperature.”

This was again evident in her discussion about photosynthesis, which is a Grade 10 topic introduced later in the year.

### *Curricular saliency*

Curricular saliency underpins "...the tension between covering curriculum and teaching for understanding" (Geddis et al., 1993 cited in Park & Oliver 2008). In her teaching Ms. Abrahams displayed some attempt at teaching for understanding as evidenced in the following lesson extract:

"So now we have an understanding of what a compound, organic compound is. Right. We all do?"

" yes Miss." "Raise your hand if you don't ..Jamie? do you understand? Ilaam are you with me? Yes, dear? You don't understand! OK, I will explain it again. Right, a compound, where we said we combine elements, right? Now, organic compounds, organic compound, it's a compound that consists of carbon, right? Consists of carbon and it's produced by living, by living organism like a plant DO you get that? That is organic. When it's organic it consists of carbon and produced by living organism like your plants, right? The other things that we mentioned was examples of organic compounds, right? We will look how, later, how it's formed but now I just want you to get what it is. Do you understand that now? Would you like to tell me what you understand what an organic compound is?" "An organic compound is made by living organism like plants". "It's formed by plants. What does it consist of ... what is in there that makes it organic?" "Carbon"! "Carbon! Yes, OK, carbon is always present in an organic compound, alright? ... Let's just read through that piece and maybe we will have a better understanding. [Reads from handout] Most of the compounds that make up the bodies of living organisms contain the element carbon. When carbon combines with element hydrogen to form a compound we say that the compound is ...? Learners chant "Organic!"

The discourse above is a typical example of the exchange that took place in her lesson.

### **Knowledge of Assessment**

During the teaching of the "Chemistry of Life", Ms. Abrahams only used one "spot test" to check her learners' understanding. The test was based on the hand-outs (which were the learners only source of information), and was not very demanding and some of the questions were vague (e.g., How do disaccharides form?). At the end of the test learners swapped scripts and marked each other work. She felt that it would benefit learners to mark the tests themselves as it would give them an idea of what they needed to know. No other formative assessment tasks were used during the teaching of this section. At no other stage were the learners given any form of comprehension or any other revision activities, which reflects a limited approach to assessment.

### **Summary of findings and PCK Profile of Ms. Abrahams as depicted in the PCK ERT**

In the first part of the case study each teachers' profile is displayed using the PCK ERT of Park and Oliver, (2008). The PCK ERT Table below captures the evidence for PCK based on a rating scale.

Orientation to Teaching Science	Knowledge of Instructional Strategies and Representations			Knowledge of Students	Knowledge of Curriculum	Knowledge of Assessment		
	Types of Activities	Types of Language Devices	Types of Content Elaboration			Types of Assessment		
Process	Inquiry-based lab.	Explanation	Metaphors	Depth beyond the intended goal of text (TOPIC KNOWLEDGE)	Misconceptions			Knowledge of vertical curriculum
Academic rigour			Analogies			Learning difficulties	Formative	
Conceptual change	Hands-on	Examples	Similies		Motivation/ interest			
Didactic			Demonstration			Narrative	Related	
Activity Driven	Simulation	Illustration		Similar situation	Need		Knowledge of horizontal curriculum	Knowledge of students' learning goals important to assess in a given unit
			Stories/ Anecdotes	Breadth beyond the intended goal of text (DOMAIN KNOWLEDGE)		Diversity		
Discovery	Problem-solving	Questioning	Biography		Background			
			Recall/factual	Flexibility beyond the viewpoint of text		Background		
Project-based Science	Investigation	Questioning	Mnemonic device		Background		Curricular salency	Knowledge of students' learning goals important to assess in a given unit
			Attention focusing questions	Flexibility beyond the viewpoint of text		Background		
Inquiry	Investigation	Questioning	Action		Background			
			Reasoning	Flexibility beyond the viewpoint of text		Background		
Guided inquiry	Investigation	Argumentation	Comparison		Background		Curricular salency	Knowledge of students' learning goals important to assess in a given unit
			Rhetorical	Flexibility beyond the viewpoint of text		Background		
			Checking for understanding		Flexibility beyond the viewpoint of text			
Guided inquiry	Investigation	Argumentation	Logic	Background		Curricular salency		
			Induction		Flexibility beyond the viewpoint of text		Background	
			Deduction	Flexibility beyond the viewpoint of text				Background

KEY: Evidence Reporting	
very prominent	
regularly evident	
limited evidence	
very limited evidence	
not evident	

**Table 5:** PCK Evidence Reporting Table for Ms. Abrahams (adapted and modified from Park & Oliver, 2008).

Despite her stating that her intended goal of achieving good understanding, during lessons, Ms. Abrahams often used repetition when explaining concepts and a form of choral-like chanting, which was consistent with a didactic teaching approach<sup>4</sup> as reflected in Table 5 (pg. 37). Despite her limited experience in life science teaching, she believed that she had the adequate background knowledge to teach “Chemistry of Life”. She also believed that she was giving the learners a scientific grounding in her lessons. However,

<sup>4</sup> The goal of a didactic orientation to teaching science is described by Magnusson *et al.* (1999) as the transmission of the facts of Science.

the approach in the lessons focused on no more than a basic description of organic compounds (such as sucrose and fructose); She made no attempt to discuss the underlying chemistry behind the formation of the compounds, nor any description of their reactivity. The type of content elaboration displayed in her lessons and from the interview data shows no evidence of topic knowledge and very little evidence of domain knowledge (Table 5, pg. 37). Ms. Abrahams stated that this particular topic “Chemistry of Life” was challenging for her learners due to the abstract chemistry. She believed that that the learners had little interest in the subject, had weak background knowledge and struggled with the terminology of the subject. Ms. Abrahams’ approach therefore seemed more to be shaped by her perceptions of the type of learner she was dealing with than based on sound judgement. What this limited approach may also suggest, is that her poor grounding in Chemistry affected the saliency of her approach (e.g., unable to truly stretch her able learners, do practical work, not knowing where to pitch the topic) and had an impact on her teaching. Having said this, my experience of her lessons gave me a sense of a teacher who had good insight into the contextual factors that were playing out in her classroom.

Ms. Abrahams’ knowledge of the learners’ difficulties and background was clearly evident (see Table 5, pg. 37). Because she knew the learners (having taught them Life Orientation the year before) she was able to interact with them in a calm yet assertive manner and showed empathy towards them. Ms. Abrahams’ use of language devices was limited to mnemonic devices and the occasional use of familiar examples (Table 5, pg. 37). Ms. Abrahams clearly asked the most questions in relation to the other teachers in the study (529 questions in total, see figure 5, pg. 34). A closer analysis of the data showed the extensive use of closed questions (mainly factual recall) and to a lesser extent rhetorical and checking for understanding questions (Table 5, pg. 37). Generally the spread of questions asked included no evidence of higher order thinking questions (i.e., problem-posing, and comparison questions). Reasoning questions were very limited and instructional strategies that promoted metacognition (e.g., argumentation) were not evident. What is evident from the above data is that despite her ability to engage with the learners the outcome of the interaction was superficial. She believed that she was probing learners’ understanding, but in her teaching she did not provide adequate scaffolding for effective learning.

### **Why does the teacher do what she does?**

During the follow-up interview, selected clips of audio-recordings<sup>5</sup> of the lessons taught were referred to in order to stimulate discussion. The purpose of the stimulated interview was to enable the capture of the teachers’ reflection on the lessons and to give insight into the teachers’ perceived curriculum and hence

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<sup>5</sup> Ms. Abrahams was the only respondent in the study who chose not to be videoed. All of the transcripts are therefore based on audio recordings.

the underlying reasons for the teachers enacted curriculum. One possible explanation for Ms. Abrahams' pedagogic orientation can be traced back to her background and previous experience. Ms. Abrahams' Science background at school and at tertiary level did not include any chemistry or physics nor did it include any practical work. Despite this lack of background experience, the reason she gave for not doing practical work was that she did not have access to the laboratories. More telling because her main subject was tourism; perhaps she indicated that her Life Sciences teaching was very much a secondary concern. Ms. Abrahams classroom practice was clearly also shaped by her knowledge of the students' social context and her perception of their ability. I explored her knowledge of students' thinking and how this could influence her teaching of this topic:

“... and, like I say, the [approach] works with them specifically, and, this is a special class, that's why. I have to do it that way, because if I do something today and I just continue with something new tomorrow, yesterday's work is a gonner. So, I spend time with, you know, going back to the day's before work as well... [It is] a special class in terms of performance, there they, ... academically they're not doing very well and I think that all just boils down to language, you know, coming, stemming from their English ..... language, understanding and that is why I say with terminology and things like that, also because they don't have the vocabulary, so, if they don't have the English vocabulary, what about the science, still?”

Ms. Abrahams gave her reasons for her selection of the content for teaching the “Chemistry of Life”: “...that they can see the broader picture about life itself and to lay the foundations for them during later years”. She claimed to make her teaching relevant to the learners' context and emphasised the need for appropriate hand-outs for this group of students (the non-science group): “So that they can understand the terminology once again, but if they see it like the drawing and whatever makes it simple”. The notes that she chose for the section on “Chemistry for Life” included simple diagrams of organic molecules and pictures. She also said that she used mnemonic devices as a tool to enable learners to simplify things and to aid memory. In fact she had seen some of the learners using the rhymes when answering questions during the question on life processes during the examination. She felt that learners were put off when confronted by chemistry when taught the “Chemistry of Life” topic because of their perception that they were not chemistry students.

## **Case Study 2 : Mr Dawood**

### **Teacher background**

Despite not taking physics or chemistry at school Mr. Dawood was well qualified to teach his subject. He had completed Physics I and Chemistry II at university where he studied towards a BSc degree in Microbiology. He then went on to complete a Higher Diploma in Education (HDE) and a Bachelors

degree in Education (B Ed).<sup>6</sup> He is an experienced teacher with over 24 years teaching experience, including 12 years of teaching at matric level and a period of secondment as a curriculum advisor.<sup>7</sup> Despite this wealth of experience, at the time of the study, he only taught Life Sciences to two Grade 10 classes and to all of the Grade 9 classes. At the time of the study he was Grade 9 subject head (which meant that he set the tests for the Grade 9 classes). During earlier interviews to identify his role in the science department he mentioned that he was not recognised by the school management and as a result was reluctant to get involved in other school matters.

### **What does the teacher do?**

A typical experience in Mr. Dawood's class is captured in the vignette below:

Walking towards Mr. Dawood's classroom which is situated in one of the neglected rear blocks of the school, I immediately become aware of the rowdy classes and the tension in the air. When I arrive at the class, Mr. Dawood greets me and says that I am welcome to sit anywhere. The floor of the classroom is littered with lunch wrappers and paper and, apart from the occasional poster, the walls are bare. The chalkboard is filled with neatly written notes and chalk drawings.

Learners arrive more or less at the same time and fill the desks that are arranged in single rows or pairs from the front of the class. Initially, they bustle about but then eventually settle down and take out their notebooks and their textbooks. Some learners arrive at the door late and the teacher, who appears to be in a ratty mood, walks briskly to the door sends them to the office (to report for being late) and slams the door. One of the learners who are clowning about at the back of the class by making gestures to a friend, immediately stops when he eventually catches the fixed glare of Mr. Dawood. The teacher starts the lesson by recapping the previous lessons' work about elements and the difference between inorganic and organic substances and different types of carbohydrates. He introduces the topic, and then starts to write on the board but stops and confronts a learner, "I am waiting for this girl here to settle down. If you don't want to be here, there's the door, there's people outside having fun, go and join them". He continues to draw simplified, labeled structures of sugars on the black board and explains the structures as he draws but does not engage with the learners at this point. I hear some learners commenting in the background whilst he is talking and asking rhetorical questions. The teacher, who initially ignores this behavior, eventually approaches a learner who is talking to a friend and instructs the learner to turn around. He then continues to explain the significance of carbohydrates in the human diet and how it is stored in the liver. At this point, learners appear to be listening and copying down notes. He then explains the relative solubility of carbohydrates in relation to structure, and gives the learners instruction to write down the sub-heading 'functions' in their notebooks. At this point in the lesson, he asks "What are the functions of carbohydrates in the human body?" He asks the question again and then

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<sup>6</sup> B Ed this is a further degree in Education whereas an HDE is an initial teacher education qualification.

<sup>7</sup> A curriculum advisor is an education specialist appointed by the education department to oversee the implementation of the formal curriculum and to moderate assessment across a number of skills.

immediately answers the question himself. “Comes from the advert “sugar gives us go!” The main function of carbohydrates is the source of energy in the body. It is a source of energy for our bodies.” He then paces around room and repeats “...A source of energy which we use as a fuel. What do I mean by fuel? You burn it in the presence of oxygen to release energy.” At this point it appears that learners are all expected to write down what he dictates to them. This is reinforced when he says “...that boy, you don't need a book, my boy, I am telling you don't need a book” (here the teacher was referring to a text book). Mr. Dawood then uses the rest of the lesson to explain the tests for different types of organic substances. He refers to the test for glucose in the textbook and then explains why he does not do practical work. “They say that the test for glucose ... I had to do these experiments with you, but it is very difficult because we do not have a lab first of all and secondly, from past experience, when one goes about doing this test then there's all the clowns in the class who act like fools and some of these substances are dangerous and poisonous and we also want to work with a Bunsen burner, so it's not easy to do tests in our situation. OK, but we might do some demonstrations of this. It is a very simple test.” Some of the learners are simply looking at him and one or two are writing down notes. Mr Dawood then explains that when one tests for glucose in real life, for example, when testing for glucose during pregnancy to check for renal failure. He then explains the positive test for starch. At this point a learner yawns loudly and the teacher explodes, “I am still having problems with you my girl, you can't have a social conversation while I am teaching!” For the last few minutes of the lesson he explains the different food tests and the structure of lips and fats. When the bell rings he simply stops talking without ending off the lesson and the learners simply pack up and leave.

### **What does the teacher know?**

As in the previous case, what follows is a detailed description of this teacher's enacted curriculum based on the PCK categories in the PCK ERT. This description is based on the analysis of data from four lessons and interviews conducted before and after the teaching episode. The first of these describes his orientation to science teaching.

#### *Orientation towards science teaching*

Based on my observations, the learners spent most of the lesson copying down notes from the board and writing down what Mr. Dawood dictated. A more detailed analysis of the four lessons I observed him teaching, revealed 11 instances of dictation. There was no evidence to suggest that he planned lesson activities and the teacher in fact confirmed this during the pre-observation interviews:

“When you teach a lesson like this to the kids, it's very difficult, you cannot plan, I am going to do this, this amount of work is 50 minutes. You might not even get past the first definition of the first little word we discuss. You might discuss carbohydrates for a whole period”. In my lessons I hardly ever refer to text books, because you know and I know the experience I have in teaching Matric for twelve, thirteen years. The difficulty though, is, when teachin grade ten it's not actual content, but the depth to which you should go. But

now we teaching grade ten's, you must know how far you must go, how deep you must go into the discussion, but then again you can't do it in such a way that you just skimp.”

Because of the level of complexity of the chemistry he was concerned about the detail that was needed at a Grade 10 level. He also did not include any practical investigations in the four lessons he taught and, as suggested in the vignette above, he indicated that he had no intention of doing so while teaching the topic “Chemistry of Life”.

#### *Knowledge of instructional strategies and representations*

During the preliminary interviews, when I questioned him about what strategies he thought were appropriate for teaching this topic, he said: “Firstly, I will, teach it, give a little summary and then also, before I teach the subject, I'll try and get their prior knowledge. Just to gauge how slow or how fast I must go and also, how, I should structure my lesson.” Mr. Dawood claimed that the nature of the interaction with the learners in class often determined the pace of the lesson; however, this was not self-evident during my classroom observations. He did not give the learners given any independent work. There were isolated instances where he began to explore learners’ ideas in an attempt to bridge from known to novel ideas. In the first lesson Mr. Dawood taught, he questioned the learners about their prior knowledge about the Periodic Table and previous work done in Grade 9. However, this was not the norm and this limited interaction with the learners did not interfere with the pacing of the lesson and limit the content that was covered. During the initial interview he did not suggest the use of any meta-cognitive strategies for dealing with learner misunderstandings, nor were these evident during any of the lessons.

During the pre-observation interviews Mr. Dawood also stated that he hardly ever gave the learners homework, and said that most of the work he did with the learners had to be done at school. Because of the unsatisfactory home environment and inadequate facilities, he could not depend on the learners to do large amounts of homework as he indicated in this pre-lesson observation interview:

“I try to give them, most, I give them about 5 or 10 minutes to do exercises or do a summary in class. Ok. There is times when I am forced to give large amounts of work at home, but I try to do that over a longer period of time. I don't expect them to do it tomorrow. They might not have the facilities to sit and work; there might be too many people in the house, there might be problems, there may be, you know, they might be doing certain chores that they have to do, most time I drive home and you can see the kids walking with their baby sisters, brothers, you know, picking up siblings, so, I mean, my expectations is, try and do as much in that 50 minutes in the class as possible, you know, and try and, don't expect to much too much from them to do at home.”

What the above excerpt highlights is the strong influence of contextual factors on learning. An example of this was students not having the resources to do to any project work at home:

“Because, firstly, they haven't got the resources, the resources is a big problem. I mean I can tell the learners from a school [referring to a better school in the district] and say, do a research on diseases of the lung. They can come home and in no time they can get those resources. But if these kids got it, I mean, you expect them tomorrow to have something on (inaudible) a little paragraph or a little page, I mean, you are wasting your time and you are asking too much. You'll have to say, like, I'll give you two, three, four days to it. Whereas other learners, maybe, at other schools in better areas can do it in five, ten minutes.”

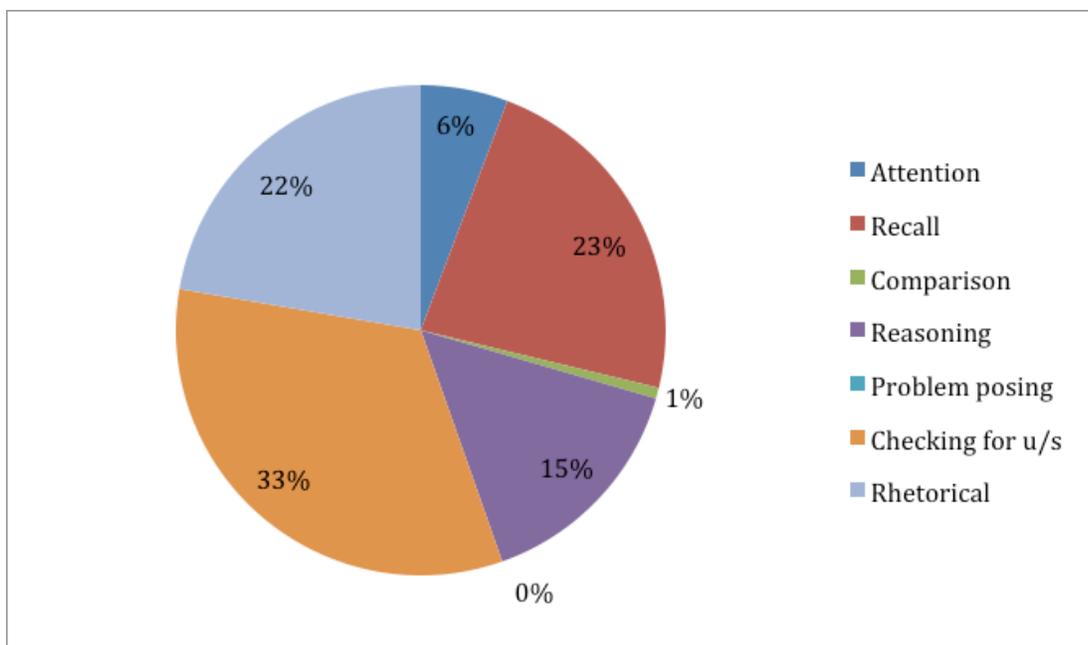
A concern raised by Mr. Dawood was the challenge of teaching complex biochemical concepts in such a way that learners would understand it: “It's a good lesson [Chemistry for Life], but, when it comes to the molecular structure, then it scares them.” A concern for teachers was that biochemistry was moved from Grade 12 to Grade 10. A consequence of this reshuffling of the curriculum, according to Mr. Dawood, was that learners at Grade 10 level experienced difficulty in understanding the complexity of the biochemical pathways in the Krebs cycle and the dark and light phase of photosynthesis. A consequence of this shift was that teachers had to be selective about the content and the level at which it is taught. He shared his concern: “The difficulty though, is, when teaching Grade 10, it's not actual content, but the depth to which you should go, how deep you must go into the discussion, but then again you can't do it ... in such a way that you just skim.” Mr. Dawood said that his approach was a superficial one and that he preferred to make the links with nutrition and food rather than teach complex biochemistry as required by the curriculum that the learners would not understand.

### **Types of activities and language devices**

What was evident from Mr. Dawood's approach in the four lessons I observed was the frequent use of narratives (anecdotal stories) and, to a lesser extent, the use of analogies that provided a context that was relevant to the learners. A tally of the language strategies used by Mr. Dawood revealed that he used a narrative approach 42 times, analogies were used in explanations 12 times during the four lessons, and illustrations eight times.

#### *Questioning*

Figure 6 represents an enumerative summary of the types of questions used in the four lessons observed. During the four lessons observed, more than half of the questions were asked mainly for the purpose of regulatory control rather than as a strategy to interact with the learners. This is reflected in Figure 6 where over 50% of the questions were either recall, rhetorical or attention focussing. About 50% of the questions suggested some form of engagement with the learners (i.e., checking for understanding and reasoning); however, no problem-posing questions were used.



**Figure 6:** Enumerative analysis of the types of questions asked by Mr. Dawood (n=139) during the four lessons he taught on Chemistry of Life.

### **Types of content elaboration**

A tally of the types of content elaboration shows that more than half of the instances (193) reflected good topic knowledge, whereas his domain knowledge (143) instances was also prominent. Only seven instances in the four lessons taught, showed evidence of a more flexible approach.

### **Knowledge of students**

When asked during the initial pre-observation interview about the difficulties connected with teaching the Chemistry of Life, Mr. Dawood spoke of the difficulties the learners had in conceptualising abstract biochemical concepts. Again, when asked about how his knowledge about students' thinking influences his teaching, he said:

“They don't read enough, because they can't read with understanding, they find it very difficult to actually understand things. You can write down a definition on the board, you explain it, break it down in simple words and tomorrow you can ask them to explain the definition, they won't be able to, because they wrote it down, they did not understand what they wrote down.”

During the pre-observation interview, Mr. Dawood also emphasised the issue of the learners' lack of understanding despite his attempts to try relate biochemical concepts to everyday life. Another factor that he believed influenced his teaching of this topic was the learners' inability to grasp the concepts:

“They are not thinking of what they are reading. So, they read the terms well, they can mention things ... big biological terms, you know, but when it comes to them trying to explain it, in definitions, that's when we find the problem, you know.....So, now they see the word osmoregulation. I ask, 'define what is osmoregulation?' Simple definition, it is the process by which the body rids itself of excess water, or the water we drink. Yet, I give a definition, I give it in the class lesson. When it comes to the exam, a lot of them, because they see the word 'osmo' they said it's to do with osmosis, you know. Water moving in and out of a membrane.”

## **Knowledge of Curriculum**

### *Vertical Curriculum*

In response in the initial interview question about what concepts he knew about that he did not want students to know yet he said:

“We know about enzymes, we know that enzymes is, involved in homeostasis, the changes within the body, the ovarian cycle, and then also cellular respiration how its going be broken down, that's going to come later.”

This explanation suggests that he is aware of the significance of learning biochemistry in order to learn about enzymes and cellular respiration the future.

Further evidence for his knowledge about the vertical curriculum is provided in the lesson excerpt below:

“You understand that they form part of food that we eat? OK? Therefore the reason why we study them, we eat it we eat this every day. When we eat the rice, when we eat bread, when we eat the toast, when we eat pasta, when we eat chocolates, when we eat chips, when we eat sweets, this is what we are eating. Carbohydrates is a form of mono, di or polysaccharides. In our bodies, the reason why we eat this, because these carbohydrates are all broken down into the simplest form, which is glucose. And glucose in actual fact, is the main source of energy in our bodies.”

What this explanation suggests is that he is able to link the source and importance of glucose to cellular respiration.

### *Horizontal Curriculum*

Mr. Dawood suggested two key ideas for the topic The Chemistry of Life. First, that molecules are either broken down or built up to form part of our body, and, second, that molecules have in them energy which we require to live or to breathe. He spoke of the need to introduce atoms and molecules and the difference between organic and inorganic molecules. During the initial interview, Mr. Dawood gave diet, health and basic living as the main reason for why students needed to know this topic. The link between an unhealthy diet and disease (e.g., diabetes and the link between saturated fats and heart disease) was again emphasised during the lessons he taught on the section. As he put it in the post-topic interview: “It's very

relevant because nowadays everybody is concentrating on eating healthy, you know. It has to be relevant, eating healthy, eating good foods, you know, obesity, overeating of carbohydrates.”

### *Curricular saliency*

There was little evidence of curricular saliency in his teaching. In fact, contrary to this, during the second lesson I observed, a few instances where he made mistakes when explaining the structure of an organic compound:

“Six one ... there might be six oxygen ... there's 12 hydrogens ...OK... so, what this girl has said now, [goes to the board and points] people count the oxygens ... one, two, three, four, five, ... there must be another one, I think it is on here [draws on board] six ... people, you count the carbons, one, two, three, four, five, six ... then count the hydrogens, one, two, three, four, five, six, seven, eight, nine, ten, eleven ... there must be another one ... here, there's twelve ... one, two, three, four, five, six, seven, eight, nine, ten, ... we are missing some there . [learner calls out] right at the top, there, there, right at the top [learner gets up and point to the spot] it must be there, sir.”

There are two errors here. Firstly, the oxidation of the open ring form to the closed ring form does not involve the loss of a hydrogen atom. Secondly, in explaining the formation of the glucose, ring he refers to the formation of a keto- ring when in fact glucose is a pyranose ring. Another misconception, which became evident when Mr. Dawood was discussing the function of fats, was the notion that the camel would be able to use the fat stored in the hump as a source of water<sup>8</sup>. This misleading fact is written in the current textbook and represents potentially another source of unchecked error for the learner.

### **Knowledge of Assessment**

There was no evidence of any formative assessment being used or planned for during the teaching of this topic. Neither was there any assessment exercises being used or planned for in the learner notebooks.

### **Summary of findings and PCK Profile of Mr. Dawood as depicted in the PCK ERT**

In the first part of the case study each teachers’ profile is displayed using the PCK ERT of Park and Oliver (2008). The PCK ERT Table below captures the evidence for PCK based on a rating scale.

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<sup>8</sup> In reality, despite producing an equivalent amount of water for every gram of fat metabolised there is net loss of water from the system due to the loss of water vapour during gaseous exchange.

Orientation to Teaching Science	Knowledge of Instructional Strategies and Representations			Knowledge of Students	Knowledge of Curriculum	Knowledge of Assessment	
	Types of Activities	Types of Language Devices	Types of Content Elaboration			Types of Assessment	
Process	Inquiry-based lab.	Explanation	Metaphors	Depth beyond the intended goal of text (TOPIC KNOWLEDGE)	Misconceptions		
Academic rigour			Analogy			Learning difficulties	Formative
	Similarities	Related	Summative				
Conceptual change	Hands-on	Examples		Similar situation	Motivation/ interest	Knowledge of horizontal curriculum	Knowledge of assessment methods
Didactic			Demonstration	Narrative			
	Biography						
Activity Driven	Simulation		Illustration	Need	Curricular salency	Knowledge of students' learning goals important to assess in a given unit	
Discovery			Problem-solving				Questioning
	Project-based Science	Investigation		Argumentation			
Inquiry			Attention focusing questions		Flexibility beyond the viewpoint of text	Background	
	Guided inquiry	Problem-posing	Logic	Checking for understanding			
Reasoning		Induction					
Comparison	Deduction						
Rhetorical							
Checking for understanding							

KEY: Evidence Reporting	
very prominent	
regularly evident	
limited evidence	
very limited evidence	
not evident	

**Table 6:** PCK Evidence Reporting Table for Mr. Dawood (adapted and modified from Park & Oliver, 2008).

Mr. Dawood’s extensive teaching experience was reflected in his adequate knowledge of the vertical curriculum and to a lesser extent horizontal curriculum (as evidenced in the results in Table 6, pg. 47). Mr. Dawood’s didactic orientation (evidenced by the regular instances of dictation during the four lessons observed) (Table 6, pg. 51) was further reinforced by an oratorical teaching style. Mr. Dawood did not include any practical investigations in the four lessons he taught. Based on his schooling experience, and his tertiary educational experience (and that of successful peers who in his opinion had succeeded in Scientific careers despite the limited schooling experience), he said that he was not convinced of the beneficial effect of practical work on learning outcomes. Despite alluding to an understanding of their background and their learning difficulties (Table 6, pg.47) during the interviews, Mr. Dawood’s attitude

towards the learners did not reflect sensitivity to the learners, and this resulted in him having low expectations of learners in terms of performance. He was of the opinion that the Grade 10 learners in his class were not able to cope with the conceptual level of the topic The Chemistry of Life and that this affected the way that he taught and consequently, he rarely planned more than one lesson at a time. When it came to teaching the topic he made occasional mistakes because he relied on memory a lot of the time. What was clear was that Mr. Dawood perceived that the learners in his class struggled to cope because of their problematic social backgrounds and poor attitude towards schooling. This was used as an excuse, as he did not give them homework.

Based on my lesson observations, overall, in class, he appeared aloof and disconnected and rarely engaged with individual learners. During the four lessons observed more than half of the questions were asked mainly for the purpose of regulatory control rather than as a strategy to interact with the learners. The types of questions he asked (mainly rhetorical and factual recall) reflected this limited interaction (see Table 6, pg. 47). What was evident from Mr. Dawood's approach was the more frequent use of narratives and to a lesser extent analogies. These language devices that were regularly evident (Table 6, pg. 47), were intended to provide a context during the lesson which learners could relate to. Despite claiming that he chose activities to engage the learners and that the nature of the interaction in class often determined the pace of the lesson, however, this was not self-evident during any of the lessons. Based on my interaction with Mr. Dawood, he displayed limited knowledge of assessment methods, let alone what it was (in terms of curriculum goals) that needed to be assessed. There was no evidence of continuous assessment during the four lessons. This may have been due to the time constraint of having to complete the section before the examinations, but even so this reflects a further lack of learner engagement.

### **Why does the teacher do what he does?**

Follow-up video-stimulated interviews enabled the further elicitation of reasons for Mr. Dawood's classroom practice. Each of the knowledge areas is considered in turn and the reasons for the teachers' actions explored and documented. When explaining his teaching approach, Mr. Dawood gave the impression that he would use learners' ideas/misconceptions intuitively and that this would shape his practice. His actual practice painted a different picture as he put it in the post-lesson interview:

“...there is no simpler strategy to use, you know. The ideal situation would be, go read up on proteins, we will discuss the molecular structure, the functions and the tests. Then next, they can have a discussion. Here we are doing chalk-and-talk on the board, you know, our school is one of the few schools that actually do this.”

This implied that he would be using a different approach had he been at another school. During the follow-up interview he explained his teaching approach:

“So what we do as a facilitator, as a teacher, you try to show them that even though there's a lot of words, a lot of terminology. you just break it down into smaller ....bite sized...little things and then see if you can make sense of it, that's what we do as teachers all the time, you know, getting bite sized chunks out of this text book and hopefully they understand it, and at the end of the day you still have to put it together into one big global picture, but rather let them understand the bite size.”

Mr. Dawood suggested that difficult home circumstances were not conducive to learning and severely impacted on the culture of learning. The problems he listed include poor living conditions, pseudo parenting<sup>9</sup>, domestic responsibilities, poor facilities, and lack of resources. He again emphasised the problematic learner background as a key factor in the lack of learner motivation and the absence of a culture of learning both at home and at school. As he put it in the follow-up interview:

“...there are a few learners that have a culture of learning ... but the majority of them when they get home, they put down their bag, that's the end of their learning for the day.”

During the follow-up interview he suggested that the main idea that he taught in the Chemistry of Life topic was that carbohydrates and fats are all made up of organic molecules, carbon, hydrogen and oxygen. He also stated that they were basically the building blocks of our bodies and that we also needed to include the structure, the functions and then how we test for them. During the CoRe interviews (Ch.3, pg.29) Mr. Dawood said that it was not possible to plan lessons in advance because the nature of the interaction with the learners was unpredictable and took time. He did not believe that practical work would make any difference and based this opinion on his experience of successful persons and role models. The reason he gave for not doing practical work was that he was in a classroom and that if he had been in a laboratory he would have done demonstrations.

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<sup>9</sup> Pseudoparenting – Children who are in the care of their siblings. 66 500 child headed households in the Western Cape in 2005.

### Case Study 3: Mr. Matthews

#### Teacher background

Mr. Matthews is an experienced teacher with over 21 years teaching experience. An exploration of his Science background revealed that during his college years, he studied towards a Higher Diploma in Education (HDE). This HDE included Biology, but did not include any courses in chemistry or physics. Biology was one of his subjects in matric but he did not do physics or chemistry at school. Despite this, his teaching experience before the current position had included teaching Grade 11 Physical Sciences and Biology to Grades 10-12. At the time of this study, he was Subject Head of the Physical Sciences and taught the Physics component to seven Grade 9 Natural Science classes and Life Sciences to two Grade ten classes.

#### What does the teacher do?

Mr. Matthews teaches in a neglected classroom at the back of the school. The desks in this classroom are covered with the usual graffiti and a few pictures and newspaper clippings adorn the walls. This is a small classroom and besides the desks arranged in compact rows, there are two tall cupboards in the corner of the room and a small Table for the teacher. The vignette below provides a glimpse of the actual classroom experience:

As the learners arrive, the teacher directs learners to fill the seats towards the front of the class. Initially the learners are chatting, but then soon settle down and greet the teacher who then begins the lesson. "10A, we started with the Chemistry of Life during the last lesson and we want to continue. Listen, let's start, open your books, take your pens out, put it down and then we can start. Just first put it down and then all the other distractions are out of the way. OK? Noleen, if you have your things let's carry on. Last week we started with a section and our time quickly ran out. 10A we just have this week to complete this chapter and then we must start to prepare for the exams, so I hope you realise the seriousness we are concerned with, so let's carry on." He then praises a learner: "I was not aware that Justin was even here, Justin is so calm I hope it stays this way. Ok listen we started with the Chemistry of Life, now when you see the saying goes like this, 10A, that a person is what he eats. OK if you live on chips and sweets then you will look like chips and sweets in the future hey? You must have a balanced diet. Noleen first put that away, girl, please put that away first. I know the task must come in but first put that away Noleen, away. Thank you!. So you will realise if you look further into things, most illnesses are due to peoples' eating habits or if we can put it this way lifestyle alright? Uh when you look at illnesses for example diabetes, sugar sickness which is a common thing [pats LNR on her shoulder] in our communities OK? OK it is often as a result of being genetic but in most cases it is as a result of peoples' habits. But now let's take a look at what is inside of most of the things we eat alright?"

Washiema very important man. Let's first get your attention. I want to digress slightly. If you look at your petrol, if you look at your diesel, paraffin. If you look at your gas, everything that is used as fuel contains this element carbon and in our bodies carbon is burnt up and what do we call that process, of burning up in our body? It starts with a 'R' ? Good, Washiema, respiration OK? Quickly what is respiration Washiema?" He corrects this learners' misconception about respiration being combustion of gases and then proceeds with the lesson by writing an abbreviation for single sugars on the board and asks learners to recall what they stood for from the previous lesson. Some learners shout out the answer which he ignores and then asks. "OK, the three, those are your single sugars alright? Giovanni quickly give me their names of those single sugars or monosaccharides, quickly. Giovanni can we quickly recall Thursday? Giovanni here I have written it down. People, it's a way of learning for pete's sake, you can't remember everything so you have to make it easier for yourself. So we often make use of abbreviations which perhaps don't make sense. Those simple sugars Giovanni. Those we looked at, are glucose, fructose and galactose. Now these days the girls use that 'g-m-g'." He reminds learners of hair product which sounds similar to the three letters and explains why it is important to use abbreviations/rhymes to remember things. Mr. Matthews continues to write notes on the board and then explains what he has written to the learners. "If you carefully notice then you find if you look at glucose for example then you find that glucose, the carbon always has a six, hydrogen has twelve atoms and oxygen six atoms. Noleen have you got it? Because you are in another place. I just quickly recap further then I will write the notes on the board for you". His expectation is that learners follow him and copy the notes down as he writes on the board. A learner complains that she did not have enough time to copy down the board notes during the previous lesson and the teacher responds by referring to progress other learners in the class had made.

"Then you should have finished it. It is your responsibility if you don't finish then you must get someone's book. I think we have had enough time. No she's finished. Here Jean-Claude is finished, he's finished, everybody is finished!" "They worked when Sir explained!" to which Mr. Matthews replies, "No I have given you enough time. We are not going to argue about it but look up now please." For the remainder of the lesson he continues with his pattern of explaining what he has written on the board, whilst constantly having to redirect distracted learners' attention to the lesson. When the bell rings he instructs the learners to read through the notes at home. They greet him and leave.

### **What does the teacher know?**

As in the other case studies, PCKERT (Park & Oliver, 2008) was used as a descriptive framework to describe the teachers' enacted curriculum.

### **Orientation towards science teaching**

During the pre-lesson observation interview Mr. Matthews said that his preferred teaching strategy was ‘chalk and talk’ and that he used a combination of writing and diagrams to “create a picture in the mind” of the learners. As in the case of the vignette depicted above, the learners were expected to copy down notes from the board during all of the lessons that I observed. During our initial interview he stressed the need for a “science friendly environment” for the learners. Despite stating that it was his belief that learners needed to experience doing science in a laboratory, the learners did not do any scientific investigations.

### **Knowledge of Instructional strategies and representations**

One strategy Mr. Matthews mentioned, during the pre-lesson observation interview, was the idea of bridging from the learners existing knowledge to the new knowledge. “So, the reason why I always do that is so that they see where the other things fits in. So, it's always important, that's the basic principle of teaching, to start at the existing knowledge and carry it through.” This he did during the introductory lesson when he used the Periodic Table to revisit the elements involved in the Chemistry of life.

### **Types of activities and language devices**

Mr. Matthews often used analogies (45 instances during the four lessons), and on occasion used humorous anecdotes. He used an analogy to get across the prefixes used to describe the different forms of carbohydrate and single and double sugars as follows:

“Take a person then it is a single person but now the two together then we no longer just talk about the one then we talk about two. OK disaccharides. And then ‘poly’ means many the whole class in its entirety. Alright? First look at the board please. Glucose and glucose combine the two become one, they married each other alright? See at first he was ‘single’ but now he is married.”

In another situation he attempted to explain the structure of complex carbohydrates as follows:

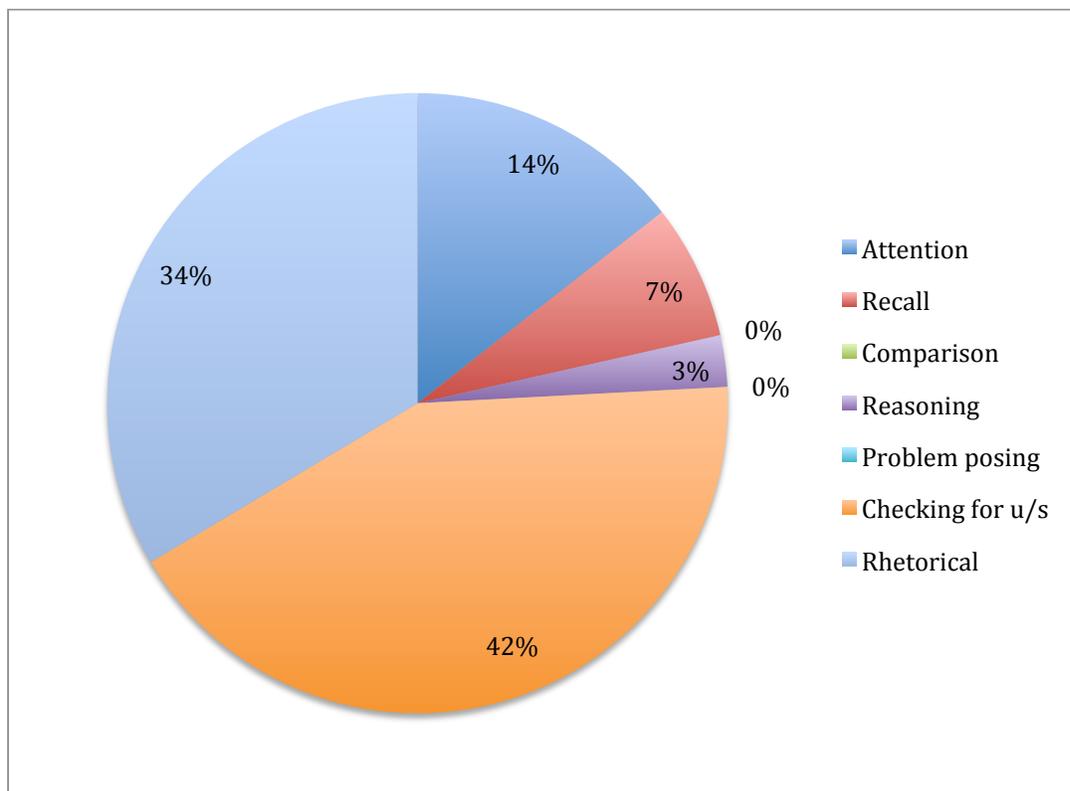
“I explain to you simply we are now discussing polysaccharides it’s just a long chain alright? ...‘poly’ means many, ‘poly’ a lot OK? If you look at your different types of plastic like your ruler sorry Wilhelmien, your polysaccharides are for example your type of plastic. When you go to the shop and you want to buy a pipe then you ask, yes a water pipe then you ask for ‘polycarb’, it’s a water pipe or a copper pipe alright? Now it’s a copper pipe but ‘polycarb’ is your plastic pipe. No it’s made of plastic which means more carbon

compounds. Copper is more expensive yes. Thank you ...yes. But copper has got nothing to do with this I was showing you about 'polycarb' alright? 'Poly' many."

In one example of an analogy he explained random assortment of genes using dominoes. In another, he explained the structural components of plants using the analogy of building soccer stadiums.

### *Questioning*

Figure 7 represents an enumerative summary of the types of questions used in the four lessons observed. Most of the questions were either 'checking for understanding' questions, rhetorical (34%) or attention focussing (14%). The use of reasoning questions was limited (3%) and no comparison or problem-posing questions were asked.



**Figure 7:** Enumerative summary of the types of questions asked by Mr. Matthews during four lessons taught on the Chemistry of Life (n=298)

### **Types of content elaboration**

Evidence of Mr. Matthews' Domain Knowledge is reflected in the following lesson instances. In one lesson he extended the discussion to the sources of carbohydrate (e.g., different types of sugars), farming

using monocultures, and the effect of the processing of food (e.g., refining sugar to produce white sugar and polishing rice). His explanation from another lesson, he also outlined the reasons for having a balanced approach to nutrition: “You look at the perfect figure, everybody wants to be slim ...There are problems related to that. You are depriving your body of those important reserves that also causes problems. OK?” The extent of his topic knowledge as evidenced by extended discussions in his lessons, occurred in less than 25% of the recorded instances.

### **Knowledge of students**

A number of issues arose when addressing the question of Mr. Matthews’ knowledge about students’ thinking, and how this influenced his teaching approach. As he put it during the pre-lesson observation interview:

“Many of them find it difficult to see things that you want to let them see, because the biggest difficulty is that they tend to be very playful and if you use something and continue, they still hang onto that old idea... For them to stay focussed and keep on concentrating they find it very difficult. They lose the line completely and quickly. So you need to, basically, stick to the point.”

Despite having a small class of 29 learners, the lessons were at times noisy because of learners who shouted out, and were generally outspoken in the class. He tended to spend a lot of time disciplining learners, and arguing with learners.

### **Knowledge of Curriculum**

The first big idea Mr. Matthews suggested for this topic during the pre-lesson observation interview was the idea that all things are made of smaller things. The second big idea was the importance of all these elements in our balanced lifestyle and what constituted a healthy diet (e.g., vegetarianism). “A balanced lifestyle is what is important for every person. And I always stress the importance of all these things in your diet, in your lifestyle and all these things, to have balance.” During the four lessons I observed, each of the ideas discussed above were developed further, especially the significance of this topic in the lives of the learners.

#### *Knowledge of the vertical curriculum*

A particular challenge for this teacher was to teach the Chemistry of Life in enough detail to make it understandable, without learners having to deal with the complex chemistry (part of this detail required

learners to grapple with concepts like oxidative phosphorylation and the electron transport chain or the light and dark reaction is photosynthesis). As he put it during the interview:

“The difficulties that I will think of is, for example, that some of them find it difficult to relate to what proteins, carbohydrates are. Because, normally we just speak about bread, but that's the ideal form of your carbohydrates. Some people prefer lots of meat, that's proteins, sometimes they find it difficult because they just see meat, instead of meat consists of, is an example of proteins.”

Mr. Matthews also stated that it was his opinion that neither homeostasis nor biochemistry needed to be taught in detail at a Grade 10 level despite the policy requirement to introduce biochemistry as a topic at Grade 10 rather than at Grade 12 level.

### *Knowledge of horizontal curriculum*

This excerpt from his lesson suggests evidence for his knowledge of the horizontal curriculum:

“Respiration takes place in every cell in your body. Your cell requires food, your cell requires energy so oxygen is the important element here. Listen carefully, I am using the little word again, the important element oxygen combines with those different types of foods that you take in and now the food gets burnt up, broken down and in the process energy is released and that allows us to do what we are able to do. OK?”

Here he is referring to cellular respiration, which is taught at a later stage.

### **Knowledge of Assessment**

During the pre-lesson observation interview, Mr. Matthews highlighted the need to check for real understanding:

“It depends many a times on how they understand or perceive things. Even though they say, yes, we understand, and if you ask them, do you follow, do you understand, does it make sense to you, they will say yes, but when they need to go and maybe look at an exercise or do things on their own, then you realise, here's the shortcoming.”

This he suggested could be achieved by giving learners an exercise to do independently in order to see whether or not they could apply what they have learnt to another context. One concern he had was that there was not always enough time to include worksheets or activities in the formal teaching sessions. When reviewing the learners' notebooks, I noted that one in-class assessment was given shortly after teaching the four lessons. This appeared to be an exercise taken straight from another textbook as not all the questions included were directly relevant to the section, although they did include some data response question and application type questions.

Mr Matthews' response to a learners question during one of the lessons, highlights the importance of summative assessment in the school:

“What is the question? You should have done the work now, look here, if we look at the revision next week, Monday then we are going to look at all of those things. In the meantime I am going to ask you again, next week we will I will look at exam questions then we can all the things we are looking at now but first feed you with a lot of information so that we have enough for the exams.”

### **Summary of findings and PCK profile of Mr. Matthews as depicted in the PCK ERT**

In the first part of the case study each teachers' profile is displayed using the PCK ERT of Park and Oliver (2008). The PCK ERT Table below captures the evidence for PCK based on a rating scale.

Mr Matthews 'chalk and talk' strategy for teaching the Chemistry of Life reflects a didactic orientation to teaching with the goal of transmitting the facts (Table 7, pg.57). Contrary to his belief that learners needed to engage in the “world of science” he made no attempt to challenge learners thinking in that direction. He also did not include any practical work. Having taught these learners in a previous Grade, Mr. Matthews believed that he had a good sense of what the learners were capable of and what their limitations were. His assumptions about the learners included that they had behavioural problems, learning problems and that they were unfamiliar with the context of science. Because he believed that the learners were incapable of learning independently and were easily distracted, he felt that he needed to guide their thinking by explaining the notes he had written on the board. He used what he called question and answer technique, but the types of questions he used in his lessons lacked higher order thinking (like reasoning and or problem solving) and were mainly checking for understanding or rhetorical, mainly for the purpose of regulatory control (very prominent, see Table 7, pg. 57). During the four lessons observed, over 75% of the coded instances of the types of content used, depicted his good domain knowledge (this was regularly evident, Table 7, pg. 57). There was very prominent use of analogies and regular use of humorous anecdotes, which he attempted to use in order to make the topic more relevant to the context in an attempt to try to engage the learners and to which the learners appeared to respond to (Table 7, pg. 57). Some of the analogies may have instilled curiosity, however, most were often constructed off the cuff and were not entirely relevant leading to even more distraction and confusion amongst the learners. The extent of his topic knowledge, however, as evidenced by extended discussions in his lessons was regularly evident (Table 7, pg. 57). Mr. Matthews believed that it was important to maintain what he called “the line of learning” and as a result rarely used a more flexible approach in class. There was limited evidence of Knowledge of assessment (one in-class assessment was given after teaching the topic).

Orientation to Teaching Science	Knowledge of Instructional Strategies and Representations			Knowledge of Students	Knowledge of Curriculum	Knowledge of Assessment		
	Types of Activities	Types of Language Devices	Types of Content Elaboration			Types of Assessment		
Process	Inquiry-based lab.	Explanation	Metaphors	Depth beyond the intended goal of text (TOPIC KNOWLEDGE)	Misconceptions			Knowledge of vertical curriculum
			Analogies			Formative		
Academic rigour			Similies		Learning difficulties	Summative		
Conceptual change	Hands-on	Examples	Related		Motivation/ interest	Knowledge of assessment methods		
			Similar situation					
			Dissimilar situation					
Didactic	Demonstration	Narrative	Stories/ Anecdotes	Need				
			Biography					
Activity Driven	Simulation		Illustration	Diversity				
			Mnemonic device					
Discovery	Problem-solving	Questioning	Recall/factual	Flexibility beyond the viewpoint of text	Background	Curricular salency	Knowledge of students' learning goals important to assess in a given unit	
			Attention focusing questions					
	Problem-posing							
Project-based Science	Investigation							Action
			Reasoning					
Inquiry								Comparison
		Rhetorical						
Guided inquiry		Argumentation	Checking for understanding					
			Logic					
			Induction					
			Deduction					

KEY: Evidence Reporting	
very prominent	
regularly evident	
limited evidence	
very limited evidence	
not evident	

**Table 7:** PCK Evidence Reporting Table for Mr. Matthews (adapted and modified from Park and Oliver, 2008).

### **Why does the teacher do what he does?**

During the follow-up interview, Mr. Matthews spoke about the classroom size and the fact that the lack of resources restricted his teaching. He claimed that he simply wrote on the board because he did not have an overhead projector (OHP). He said that using an OHP gave him more control in terms of managing the learners, whereas now, when he turned his back, the learners took advantage of the situation and became distracted. When he was able to write the notes on the board before the lesson started (e.g., during a free period), things were different. He also felt that not having more up-to-date teaching aides (e.g., electronic white board and/or data projector) restricted the learning opportunities he could create. He also commented that another physical limitation of his teaching environment was that he was no longer able to do practical work. When asked why he did not do practical work, he felt that he did not want to inconvenience his colleagues who were in the laboratories. It is interesting to note that he had occupied a laboratory the previous year but had moved out. Given access to this facility, he said that he would have included demonstrations whilst teaching the topic “Chemistry of life”.

When he described the main teaching strategies he had used during the first lesson, he said that in addition to the ‘chalk and talk’ approach, he also used the question and answer approach to try and establish what the learners knew and to get them to think about how the concepts related to their own lives. As he explained during the post-lessons reflection.

“Yes, because when you speak of a compound, that's when two or more elements combine, old knowledge, but now when you look at carbohydrates, the three elements involved there is carbon, hydrogen and oxygen. So, now, they can see the link from those things to where they need to be.”

His reason for using the ‘chalk and talk’ strategy was that in order to truly understand the facts, the learners needed to read through the notes he wrote on the board without distraction, before they actually wrote them down. His underlying rationale for using this approach was that his learners were incapable of making their own notes. His response then was to make notes for them, which they copied verbatim into their books and these notes then served as their only source of information. In consequence learners were exposed to a very narrowly framed curriculum. His previous experience was that learners simply pasted notes given to them into their books without reading them. He also believed that the learners were more prone to remember what they had written down, as his comment during the post-lesson reflection suggests. “That's why we try to keep them busy, to let them write it in their own handwriting again. You will realise that they remember many of the things that they write down instead of giving them a note.”

He felt that engaging with the interested learners was at the risk of losing the “line of learning”. He stated his concern about the learners’ lack of focus during the follow-up interview.

“By just writing things down they are under the impression that they are working ... but they don't really have an idea of what [the lesson] is all about ... and even when they [are] writing you will notice ... that some of them are constantly talking so they are not even concentrating on what they are doing and in that way, they lag behind or they don't know what it's all about, when it comes to the, to the testing of the thing.”

Mr Matthews’ attitude towards the learners was encapsulated by his comments during the post-observation reflection when he said that he found it problematic having to deal with the learners’ spontaneous, often immature, remarks. In his opinion, this distracted them from the “line of learning” where his expectation was that students were attentive and listened to his teaching. He used the example of learners being distracted by forming familiar but often-derogatory word associations that prevent them learning the actual scientific term. In the same post-lesson reflection he also mentioned that having to deal with learners trivial and often-irrelevant questions slowed down the pace of the lesson and hampered their progress. He also mentioned that the language of Science was a problem and that it almost needed a process of enculturation to get the learners into the “Life Science” way of thinking.

“OK, here we are in life science, we need to now think life science. So, it takes a while before they start getting used to the idea, here we are now, we come from where we have been and now this happened there and now you take a few minutes before that idea is put to the back of the mind before we move on.”

One of the other major challenges highlighted during a post-lesson observation interview was the problem learners faced when having to learn scientific concepts and to relate these ideas to everyday life.

“The big problem is that our learner sometimes struggle to understand, not because they don't know what it is all about, but because they can't relate to the terms used in science, many a times, and bring it to the more every day things. So, if they can find the common ground, then they will understand it easier, because there is many of the students that do understand that's carbohydrates but there are others that don't. So, the levels also, are where they find themselves, that tends to be a bit different.”

A further challenge Mr. Matthews faced was in how to utilise a differentiated approach with his mixed-ability group of learners. Whereas some learners would grasp the concepts quite readily, there were those that did not, which in his opinion slowed things down. As a result he said, he ended up pitching the lessons mainly at the level of the ‘lowest common denominator’ and this did not give him an opportunity to really push top learners. After the follow-up interview, we had a brief discussion about the class that he was teaching and it turns out that he had in fact taught most of these learners in Grade 9, and it was his opinion that he had a good relationship with the learners. What I did notice during lesson observations was that whenever he interacted with them, he called them by name.

Examinations have a huge impact on the learning ethos at the school. During a follow-up interview that occurred after the exams, he mentioned that 10A had had a good success rate in the exam (70% had passed). A major focus of teaching in this school and in the case of his classroom is to cover the content for the purpose of examination. This does in a sense contradict Mr. Matthews' comments in the follow-up interview where he stated that teaching for understanding was more important than covering the content. However, the external pressure of having to conform to the schools emphasis on structured testing may limit his approach to learner engagement. When questioned about the choice of questions in the revision exercise, Mr. Matthews claimed that these were indeed questions that he had thought about. He had given the learners the tasks for homework and then spent a lesson working through the questions by inviting the learners' responses and then doing corrections with the whole class.

#### **Case Study 4: Ms. Benjamin**

##### **Teacher Background**

Ms. Benjamin is a forty-year-old teacher. Her science background includes a Higher Diploma in Education (HDE) with Biology as one of the specialisations. Physics and Chemistry training was limited to courses offered during the second year of the HDE. Despite doing Biology at matric level, she did not do Physics and Chemistry at School. Her experience of her own schooling was doing Life Science in large classes where they simply copied down notes and never did practical work. She has previously taught mainly Life Sciences, Social Sciences and English. During the term when this research was conducted, Ms. Benjamin was teaching Geography and Biology at Grade 10 level. She taught two Grade 10 Life Sciences classes. In conversation with about her previous experience, she mentioned that she has spent some time teaching abroad where she taught most of the sciences and English up to Grade 10 level. Teaching overseas was in her opinion a lot more organised and fast-paced than at her current school context. She had taught small classes (less than 20 learners per class) and the resources were always available as apposed to the large classes (50 learners per class) in a largely under-resourced school.

##### **What does the teacher do?**

Ms. Benjamin's classroom is situated upstairs in the preferred front block of the school where the classrooms seemed to be better resourced and roomier. The back of the classroom was cluttered with previous projects and maps (as noted above, Ms. Benjamin's other teaching subject was Geography). A typical lesson is depicted in the vignette below:

When the class arrives they saunter to their desks and chat amongst themselves as they wait for the teacher. Ms. Benjamin greets the class who then sit down. While she switches on the laptop there is noisy chatter amongst the learners who take out their notebooks in preparation for the lesson. She calls the class to attention and briefly reminds them of the assignment that is due. She attempts to make a link between the previous lesson about rocks and the new topic. She introduces the new topic by inviting learners to list the characteristics of life: "Ok, now in order for you to be alive what do you think we must be able to do?" At this stage of the lesson there is constant background chatter, as the teacher invites learners by name to give their ideas, which she then includes in the mind-map, which she is developing on the board. "You are using big words here, anybody else? Move, eat, growth development, what else? Respond to stimuli, Mr. Alexander. Is that it? Lets go on. So this comes from you, breathing, eating, reproducing, growth development, and movement – Mr Alexander ate his cornflakes this morning - response to stimuli. One two three four five six seven. Anyone else, with something more? Now all of these seven things that you mention show you are alive." Ms. Benjamin then extends the mind map by getting learners to list the organs involved and to explain each of the characteristics of life. She regulates the learner behaviour, and waits for learners to explain their thinking in an attempt to get learners to see the bigger picture. At this point Ms. Benjamin refers to the Power Point presentation: "Now lets see in my notes if I have something similar to what you have. Ok, Life Processes, any living organism can carry out these processes, now let's see if you have any of them here...If you do all those seven processes then you will be a living organism."

Now what about people who can't move miss?"(a learner asks). "What kind of people are you talking about? Disabled! All right what is a moving object, your eye. Hush now we will do all the moving parts of your body, just because you cannot move like a paraplegic."

The teacher's attempts to get learners to list the kinds of things that they need to do to keep their bodies healthy. Eventually she introduces the analogy of maintenance of a car to get across the idea of homeostasis. She then reads the definition from the Power Point slide and continues to explain the principles of homeostasis. She then returns to the slides to explain the hierarchical organization of living organisms, working from tissues up to the level of organism. She uses diagrams of the different tissues in the human body to explain their different functions and then works up to the level of an organism. For the remaining 16 minutes of the lesson she instructs learners to take out notebook and copy down the slides (they are given five minutes per slide). For the first time in the lesson, Ms. Benjamin moves from the front of the class and walks along the rows and talks to some learners about their assignments (all the while counting down the time on the clock every minute). After five minutes she moves to the next slide despite protest from some of the learners. She gives instructions about drawing and about next lesson on atoms: "Tomorrow will start with the atoms ...still need to answer revision questions." She then spoke to individual learners about the project and then makes an announcement to the whole class. "Two weeks before the exams, I suggest you start to study. Don't forget your homework for Friday. We want to know what is your body temperature."

The bell sounds and the students begin to leave the classroom.

## **What does the teacher know?**

As in the case of the previous cases a detailed description of the teachers enacted curriculum follows.

### **Orientation towards science teaching**

During the very first lesson of the topic The Chemistry of Life, she explored learners' ideas about the Characteristics of Life in order to construct a mind map on the board. During the pre-lessons interview, Ms. Benjamin had explained her reason for using this approach "they actually find it more interesting, in that way, to see, actually the visual parts of it, than me talking, talking, talking, talking all the time. Questioning and answering works, you know, but also to a certain extent."

During the course of all four of the lessons I observed, Ms. Benjamin presented the main lesson material using Power Point slides which she said, she had downloaded from the internet. During the pre-lesson interview she had the following to say about her approach to teaching and learning:

"If they have enough prior knowledge for me to move on, then I would be more comfortable knowing that they understand what I am going to do. And it will be that difficult for them to understand the topics that we are going to deal with. But, if they don't have any prior knowledge, it actually just means that I have got to teach it to them." During a further pre-lesson interview she further outlined her approach: "OK, tomorrow, basically I am going to play around with elements and compounds and things, just to know what they have done, because tomorrow is a very short period, so I can't go into too much depth tomorrow. So, I'm just going to test their background knowledge of, you know, what an atom is made up of or what is an atom, what is an element, compound, how it is put together, how it gets its name and so on. So, if they know that, basically, then I know how far I can take the lesson."

About her approach to doing practical work she said that she thought it was important to do hands-on work, but this needed to be pre-arranged with colleagues:

"We all make arrangement with Mr X, if he doesn't have a class. He will set up the experiment what we need and then, I will send a few kids with a worksheet. Like we had a recent one, we were studying the xerophytes and we sent them to the garden across the road, just here on campus and they seem to want to go into the garden, looking at plants and we gave them a guide what to look for and then we set the questions for them and they enjoyed it a lot ...But, like I said, hands-on would be a much better approach for, especially for life sciences. Because I am patiently waiting to go to the gardens again, Kirstenbosch, they love that trip."

There was no evidence of a work schedule and or year planning. The planning document I was able to peruse was limited to a one-page summary of the main ideas for this topic.

## Knowledge of Instructional Strategies and representations

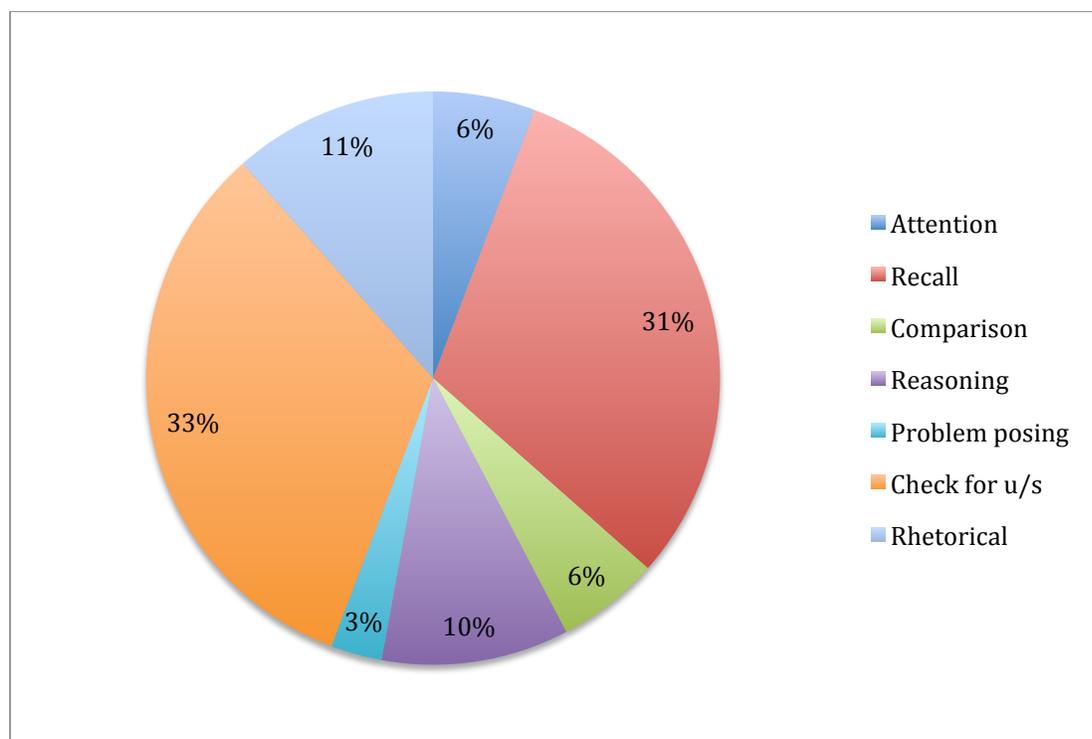
The components of PCK are described using PCK ERT as a descriptive framework.

### *Types of activities and language devices*

When asked what specific ways of ascertaining students' understanding or confusion around this idea, she said that she used questioning in class and revision.

### *Questioning skills*

More than half of questions asked during the four lessons were either factual recall (31%), or checking for understanding (33%) or rhetorical (11%). Comparison, reasoning and problem posing and attention focussing questions were in the minority. Additional language devices were limited to the single use of an analogy and a single mnemonic device.



**Figure 8:** Enumerative summaries of the types of questions asked by Ms. Benjamin (n=104) during four lessons taught on the Chemistry of Life.

## **Types of Content elaboration**

Based on my lesson observations there was very limited evidence of Domain Knowledge where she attempted to explore learners ideas about the characteristics of life.

## **Knowledge of students**

A contextual constraint highlighted by Ms. Benjamin during the pre-lesson interview was the challenge she faced, when teaching large classes and where the learners were not studious. During the four lessons, I witnessed Ms. Benjamin use various punitive measures (e.g., threatening to ring the intercom, showing learners the door) and various non-verbal strategies like hand claps and “ssssh” sounds. When not copying down notes or listening to Ms. Benjamin, the learners appeared to be disruptive and were at times quite disrespectful of her (my view is that some of the learners appeared to be aware the situation and knew the work). When questioned during the pre-lesson interviews about her knowledge of students’ thinking that influenced her teaching, she mentioned that learners had varying degrees of prior knowledge:

“So, you know, I am actually more scared of them than (laughs) they will be tomorrow because of their background knowledge, that's the only other thing. But, it will be interesting, because ... I learn from them, they learn from me. Like I say, I sometimes have to go and do my homework still, before I can actually tackle them.”

## **Knowledge of Curriculum**

The big idea that Ms. Benjamin intended the students to learn for this topic was the need to cover molecules, tissues and systems of the body because she felt that they needed to know how their bodies worked and to respect their bodies. When asked during the initial interviews about what else she knew about the big idea that she didn’t intend her students to know yet, she mentioned organ systems and their functions, (e.g., the heart as an organ and the skeleton as a system is taught in Grade 11). During the lesson she covered the characteristics of life, the basic principles of homeostasis and a simple review of organic and inorganic compounds and their formation.

Examples of some of the misconceptions from the classroom discourse around these topics are expanded on below. In the first part of the excerpt below, Ms. Benjamin is discussing the principle of homeostasis:

“To look after your car you need to do what? ...Maintain it. The same ways as you look after that lovely car. Your body is exactly the same and it is important that you keep it healthy. In other words, in order to keep your body healthy wealthy and wise, they call it a process of homeostasis. To maintain a constant internal environment,[reading off the Power Point slide]. So where is the internal environment, inside your body. So if you keep everything nice and cool on the outside the inside will also be cool too.”

During one of her lessons Ms. Benjamin also erroneously explained how bananas can increase the concentration of sodium and potassium: “Elements, that will be the intake of sodium and potassium.” To which a learner responds “Not too many bananas!” and the teacher replies “Not too many bananas.” Despite being a reasonable source of potassium, bananas are low in sodium.

In the following excerpt Ms. Benjamin explains the idea of negative feedback, “The only thing that can change the above is negative feedback. What does that mean? In other words if you do not maintain these things in your body then you will have negative feedback, you will become ill, your temperature will go up, your lungs will not function, your sugar level will go up, your high blood pressure will go up and so on.” Here Ms. Benjamin explained how a compound was formed. “There we go, then if you add more than two It will give you a compound so ... We are not trying to balance an equation we are only trying to see that some factors involve the molecule and when there is more than two of them we get a compound.” Finally an explanation of the difference between carbohydrates and starches: “ Which one is better to take up the carbohydrates or the starches? The starches which you have a resource to use from (or) use up, that’s the ones that are stored in your body.”

#### *Knowledge of Vertical curriculum*

During the pre-lesson interview Ms. Benjamin commented on what learners needed to know about this topic in the future: “Starting off with the smallest one, molecules, tissues, and then eventually go onto the organs and the systems of the body. Eh, we don’t go very much too, too much in depth in Grade 10, but it links up with Grade 12 work as well. ...in Grade 11 they learn of the skeleton again how the skeleton supports the organs, how it protects. So, this is the first year, actually, that, they are doing the organs. ...So, we don’t really deal with the functions as much, but we are obviously dealing with the biggest parts of the body.” Apart from this explanation the only other evidence of the Vertical Curriculum was a discussion about the implications of improper nutrition (e.g., the different types of fats) in one of her lessons.

#### *Knowledge of Horizontal curriculum*

Evidence of the horizontal curriculum was reflected in the classroom discourse about how glucose is derived from fats and the link with diabetes: “So let’ s see what you do. Glucose has nothing to do with the sugar you are taking a lot. Do not eat too many fatty things, watch the concentration of glucose and

your sugar levels and don't eat too many fatty things like all those lovely pies, hot chips, chocolates, cup cakes."

### *Curricular saliency*

No additional classroom texts were used, and the learners copied down the Power Point notes verbatim into their notebooks. Ms. Benjamin did mention that she did at times consult with her peers. She mentioned that her colleagues had taught the chemistry section the previous year, and knew what needed to be taught (although this was not evident when she taught this section).

### **Knowledge of Assessment**

When dealing with types of assessment there was some attempt by Ms. Benjamin at using diagnostic assessment to uncover the learners prior knowledge about the characteristics of life. Apart from an exercise where learners had to list the full names of twelve elements, no formative assessment took place. Ms. Benjamin did do revision work for the other sections of the work that she had previously taught, but there was no evidence of her doing this for this topic. Learners' notebooks were given a cursory glance with random ticks and a signature at the end. No attempt was made to correct any of the work, nor did she write any comments, nor did she give them any formal homework for this section.

### **Summary of findings and PCK Profile of Ms. Benjamin as depicted in the PCKERT**

In the first part of the case study each teachers' profile is displayed using the PCK ERT of Park and Oliver (2008). The PCK ERT Table below captures the evidence for PCK based on a rating scale. Based on the evidence, Ms. Benjamin mainly used a didactic approach (Table 8, pg. 67). Despite on occasion using question and answer to explore learners prior knowledge this was not the norm. Ms. Benjamin's approach to the subject was limited and reflected inadequate topic specific knowledge and some domain knowledge (Table 8, pg. 67). Ms. Benjamin perceived poor grounding in Chemistry (which she alluded to when she spoke of her lack of confidence in chemistry in an interview) came across in her lessons where she did not engage the learners in the key concepts, like learning the basic chemical structures of organic compounds. Her lack of curricular saliency (Table 8, pg. 67) was evident in her explanations (e.g., in her explanation of homeostasis, she confused exothermy with endothermy). She was also not able to adequately explain the link between diabetes, lipid breakdown and glucose, furthermore the notion that an excess intake of bananas can increase the concentration of sodium as well as potassium is erroneous, the latter being the major mineral constituent)

Orientation to Teaching Science	Knowledge of Instructional Strategies and Representations			Knowledge of Students	Knowledge of Curriculum	Knowledge of Assessment		
	Types of Activities	Types of Language Devices	Types of Content Elaboration					
Process	Inquiry-based lab.	Explanation	Metaphors	Depth beyond the intended goal of text (TOPIC KNOWLEDGE)	Misconceptions	Knowledge of vertical curriculum	Types of Assessment	Diagnostic
Academic rigour			Analogies		Learning difficulties			Formative
Conceptual change	Hands-on	Examples	Similies				Motivation/ interest	Knowledge of horizontal curriculum
Didactic			Demonstration		Narrative	Related		
Activity Driven	Simulation	Illustration		Similar situation		Diversity		
Discovery			Problem-solving	Questioning	Dissimilar situation		Background	
	Project-based Science	Investigation			Reasoning	Stories/ Anecdotes		Curricular salency
Inquiry			Thinking tools (e.g., mind map)	Comparison		Biography	Flexibility beyond the viewpoint of text	
	Guided inquiry	Argumentation			Rhetorical	Check for understanding		Background
Logic								
Induction								
			Deduction					

KEY: Evidence Reporting	
very prominent	
regularly evident	
limited evidence	
very limited evidence	
not evident	

**Table 8:** PCK Evidence Reporting Table for Ms. Benjamin (adapted and modified from Park and Oliver, 2008).

Besides displaying a degree of conceptual confusion, Ms. Benjamin's explanations of how a compound is formed and the notion that starch is the storage form of carbohydrates in humans certainly also suggests limited Subject Matter Knowledge (SMK) for this topic. During the lesson she covered the characteristics of life, the basic principles of homeostasis and a simple review of organic and inorganic compounds. Despite explaining her interest in finding additional resources (including images which the learners could relate to), the material that she chose to use was a set of Power Point slides that was arranged in a

particular sequence and not sufficient to cover the content necessary for Chemistry of Life topic. The emphasis was on the organisation of the human body and the different levels of organisation but scant attention was paid to the chemistry component of this topic. The level of detail of the content appeared to be dictated by the Power Point text and excluded some of the important topic knowledge (e.g., role of enzymes and effect of temperature on enzymes, molecular structure of organic substances, food tests). In her lessons concepts were not explored in any great depth and as a result of this there was limited discussion of Chemistry concepts. Her poor grounding in Chemistry coupled with her limited range of appropriate teaching strategies (which did not enable a differentiated approach to teaching) diminished her effectiveness and as a result the outcome was a restricted curriculum.

With the exception of the introduction to the very first lesson, there was limited scaffolding and or constructive engagement with the learners. The limited number of questions asked overall, and the limited use of higher order thinking questions reflects a limited learner engagement. In fact for most of the four lessons learners were expected to copy down the notes from the slides. (i.e., the learner notes were copied down verbatim from the Power Point sides. No attempt was made at scaffolding the resources provided to reinforce learning (e.g., no worksheet or questions relating to the slides were provided).

Additional factors that she mentioned influenced her teaching included the constraints of teaching different ability groups. It was her opinion that the top classes have better language skills and a better understanding of things. Based on my observations it appeared that there were a few of the learners who were ahead of their peers and who challenged Ms. Benjamin, and evidence suggests that she was not able to respond to them. Ms. Benjamin used a limited number of questions (104 in total for the four lesson). Although there was some indication to suggest that Ms. Benjamin was trying to get the learners to reflect on their understanding by asking reasoning, comparison and problem-solving type questions these were in the minority (see Table 8, pg.67). Most of the questions were either factual recall, checking for understanding (regular evidence, chapter 8, pg.67), or rhetorical with limited response from the learners. Additional language devices were very limited (Table 8, pg.67) to the single use of an analogy and a single mnemonic device. There was no evidence of continuous assessment strategies during the lessons observed.

### **Why does the teacher do what she does?**

During the same follow-up interview, Ms. Benjamin explained her strategy for developing the mind map on the board, as a means of:

“using their own knowledge and building on that to continue with the new work and to give them a graphic picture of the content that they are going to do, because most of the time they writing notes, a lot of notes, for the chemistry of life and its a lot of knowledge to get into your head, so I do, the sketch in order to give them an idea where its linked.”

When asked about how effective she thought Power Point notes were for the learners, she said:

“If I give them the notes, I try as far as possible to minimise the content, because, if its too much notes then they don't want to read it. So what I did was, when it came to the exam time, then I would tell them those are the things to focus on, but I try as far as possible not to give them too much, because what's the use of writing down things if its not part of the lesson.”

She also mentioned that as this was the first year that Life Science was compulsory for all the Grade 10 learners, there was a shortage of textbooks and hence learners could not take a copy home. Ms. Benjamin explained that her teaching approach was to use a question and answer technique to build on their previous knowledge. She felt that by encouraging learners to share ideas, “you boost their ego in class and they feel they have contributed positively to the lesson.” In conversation with her about learner attitudes, and the fact that some of them always made comments during the lesson, her opinion was that this was typical of the learners of this age who needed to be noticed in class. Further to this, she had taught these learners for the past two years, and knew what behaviour to expect. She felt that being too harsh with them would undermine their self-image. When questioned about the learners’ attitude to homework, she said that more than half of the learners did the homework, but that she needed to check this at the door from time to time. She also signed off their notes in their books.

During the post-topic interview in response to questions about the big ideas, Ms. Benjamin emphasised that learners need to know what they were made up of, and how things fit into their daily lives. When questioned about the extent of biochemical knowledge she covered, she said that she did not teach the learners the chemistry of the molecules, neither did she teach them “how it was put together” nor did she teach them about dehydration synthesis because the curriculum did not require that level of detail. As she put it: “Because the curriculum is so broad and the time is so limited ...so we rather stick to what, we teach what is needed at that point and maybe for enrichment, if you have the time you could go into it.” When questioned about her strategy for teaching homeostasis, she said that she intended that they use the analogy of looking after or polishing a car and in this way learners would think of maintaining their bodies as she put it, “so what you do the outside you do to the inside.” When questioned about her explanation of how fats contribute to sugar levels, she stated there was a common assumption was that consumption of sweets caused diabetes but that it was her understanding that it was more the consumption of fatty things that increased sugar levels. She also explained that negative feedback was when body gave off wrong reaction to, what it was supposed to be doing. She explained further, “it’s like

a cell ...if you feed it something that its not supposed to be getting it will react in a different way and that will be the negative feedback.”

Despite not having done Physical and or Life Sciences up to matric at school and not having the experiences of doing practical work, Ms. Benjamin mentioned that her experience of doing field trips and using a microscope at college had had a positive impact on her approach to practical work. She had indicated that a hands-on approach was a useful strategy. Ms. Benjamin said that she would have liked to do practical work for this section of work, but that this was not possible because of a lack of equipment. She therefore needed to pre-arrange this with the other science teachers who needed to accommodate her in the laboratory.

### **Chapter Summary**

In conclusion in this chapter, case profiles were presented for each of the teachers concerned. The chapter introduced the background of the teachers and gave insight into their enacted curricula. Each case was presented in three stages, first a glimpse of the actual classroom experience to elicit what the teacher does, followed by an in-depth description of what the teacher knows using PCK as a descriptive framework (Park & Oliver, 2008) and finally describing the reasons for the teachers' actions. Out of which PCK profiles were charted using PCK ERT for all the case studies.



## Chapter Five

### DISCUSSION

#### Introduction

#### Background and Rationale

Despite clear guidelines in the formal curriculum in terms of what needs to be taught, as well as how a topic needs to be taught and assessed, researchers claim that there is disjuncture between the formal and the attained curriculum and that this is mainly due to teachers' curriculum enactment (Case et al., 2010). Further studies in South Africa suggest that inadequate SMK impacts on what science teachers do in the classroom and hence influences their PCK (Rollnick et al., 2008; 2015). There is also a lack of evidence in the literature to support the transformation of teachers' practice at implementing learner centred teaching (Clark, 2006). It was against this background that this study set out to describe and understand the enacted curricula of selected Grade 10 Life Science teachers in the Western Cape in South Africa. These Life Science teachers were from different science backgrounds and had different levels of teaching experience. Because of the potential influence of some of the factors discussed in the background to the study above (e.g., individual and systemic level challenges of implementing a learner centred curriculum, poor learner performance, potential impact of the poor grounding in SMK of teachers) it was deemed necessary to explore what was happening in the classroom, and to understand why this was happening.

#### Research questions and outline of the discussion chapter

The first research question allowed the investigation of the PCK of Grade 10 Life Science teachers in terms of the five components of Magnusson et al. (1999), namely, their orientation towards science teaching, knowledge of students' understanding in science, knowledge of science curriculum, knowledge of science instructional strategies, and knowledge of assessment of science learning. PCK ERT (Park and Oliver, 2008) was identified as a useful analytical framework to depict the five components of PCK.

In this chapter I present my interpretation of the findings with reference to the literature. I then discuss and explore common practices and anomalies between the four cases. In answering the first part of the research question (What were the enacted practices of selected Grade 10 Life Science teachers) I attempted to uncover the teachers' PCK. The portrayal of PCK, required the use of various strategies to find out about what teachers know, what they believe, what they do, and the reasons for their actions (Baxter & Lederman, 1999; Park & Oliver, 2008). In this study, which is modelled on the study by Park and Oliver (2008), data were gathered using multiple data sources including semi-structured interviews,

lesson observations, and stimulated interviews using video and/or audio recordings of the lessons. During the previous chapter the enacted practices of the teachers were described. Firstly a vignette or ‘classroom window’ (Loughran et al., 2001) gave a glimpse of the actual classroom experience. This was followed by a description of the enacted practices using PCK-ERT, (Park & Oliver, 2008) as a descriptive framework. In the description of the cases in this study, the PCK for each teacher was built around their CoRe (Content Representation (Loughran *et al.*, 2001). The CoRe was based on pre-lesson interviews and lesson observations. To portray these teachers’ ‘manifestations’ (Rollnick et al., 2008) or what the teacher knew, these data were analysed using NUDIST (Park & Oliver, 2008). The first part of the discussion chapter describes how the teachers’ background, their experience and the school context potentially influenced their practice. The final part of the discussion chapter deals with the third research question, how the enactment of the curriculum of selected Grade 10 Life Science teachers in the Western Cape be described and understood.

### **Assumptions of the study**

An expectation was that the teachers had followed the curriculum requirements in terms of what needed to be taught and in terms of the and approaches that were implied. It was also assumed and that the teachers’ classroom practices were real and their responses truthful. As mentioned above, the curriculum requirements clearly define the expectations in terms of the goals and scope of the topic that needs to be taught. The observations of teachers’ practice were based on a series of lesson observations conducted over the period of a week and hence this gave the researcher adequate opportunity to describe the context and to uncover the enacted curriculum. It was assumed that the interviews conducted before the delivery of the lessons and the reflective practice interviews provided adequate triangulation to substantiate the claims made.

### **Limitations of the study**

The study was limited to examining the enacted practices of four Grade 10 Life Sciences teachers teaching the same topic in the curriculum in the same working class school context in the Western Cape and as such the findings are not generalisable beyond the local context. The use of CoRes and PaP-eRs (Ch.3, pg. 29) made certain assumptions about teaching in general. It was expected that teachers as a matter of course would include three stages of thinking and decision making (Shulman cited in Stoffels, 2008, pg. 27) namely the pre-active stage (they would have a plan) the interactive stage (they would engage in metacognition whilst implementing the plan) and the post-active stage (they would critically reflect on the process). In developing PaPeRs, the expectation was that teachers would do some case-

writing to support the documentation of their teaching. However, due to time pressure and circumstance, teachers were not able to respond to this hence the video interview was used as an opportunity to get retrospective input from the teachers. The implications of this for study was that the nature of the enacted curricula descriptions were of a declarative nature (Alonzo & Kim, 2015) rather than the teachers' reflections of what happened in practice.

### **PCK model for science teaching**

Park and Oliver (2008, p.280) (refer to pg. 16) presented a hexagonal model of PCK for Science teaching, which essentially portrays both the teachers "understanding of how to teach subject matter effectively and also their enactment of this understanding." Using the hexagonal model as a heuristic device to show PCK, Park and Oliver (2008) further suggest that the six components of PCK influence one another in an on-going and contextually bound way. This hexagonal model is used to frame the part of the discussion in this chapter about how the enactment of the curriculum be described and understood. The findings are discussed with respect to these PCK components, namely:

- What is the teachers' Knowledge of the Science Curriculum (including the selection of curriculum materials and curricular saliency) and how is this influenced by the teachers' orientation to Teaching Science (including Beliefs and Purposes of Learning Science, Decision Making In Science) and vice versa?
- How does the teachers' Knowledge of the Science Curriculum influence the teachers' Knowledge of Students' understanding in Science (including misconceptions, learning difficulties, motivation and interest and need) and vice-versa?
- How does the teachers' Knowledge of the Students' understanding in Science impact on their choice of instructional strategies (including subject and topic specific strategies) and their Knowledge of assessment of Science Learning and vice versa?

### **The influence of teachers' background and orientation on teaching**

To better understand why these teachers in the same school, teaching the same grade of learners have a very individualised or idiosyncratic practice, it was useful to consider the potential influence of each teacher's background and the broader school context on their practice. Park and Oliver (2008) identified four factors that shaped the idiosyncrasy of teachers' PCK, that is 'orientations to science teaching', 'characteristics of students', 'teaching experience' and 'personal experience'. Similarly evident in my

study was how these factors influenced the enacted practices of each teacher. All four teachers participating in this study appeared to use a persistent didactic approach to teaching science. Their epistemic origins are firmly rooted in their individual experience and background. At no stage did any of the teachers use any other orientation to teaching science. The teaching of the topic The Chemistry of Life lends itself to some form of practical work (i.e., in order to consolidate the learning of biochemical concepts effectively). However, none of the teachers used any practical activities listed (i.e., hands-on tasks, demonstrations, investigations). Teachers did have access to equipment and the laboratory but by arrangement with the teacher who used the laboratory as a teaching room.<sup>10</sup> When exploring the backgrounds of these teachers, a common feature found in all of the cases was that the teachers' own schooling experiences did not encourage them to see any sense of usefulness of practical work and hence do not see the value of practical work in their teaching (refer to PCK profiles in Chapter 4 above). Perhaps the underlying rationale for their actions in this regard is that in all four instances, none of them had in their own schooling background experienced practical work, hence it had little or no utilitarian value. During their experience of secondary and tertiary education, it can reasonably be assumed that these teachers would only have experienced a teacher-centred approach, and would not have been exposed to other models of teaching and learning. During the apartheid era black teachers experienced inadequate teacher training and delivery of training was mainly through transmission teaching (Rollnick & Mavhunga, 2015). If teachers are not engaged in learning new approaches to science teaching and learning in school or during in-service training contexts, then they continue to perpetuate the traditional teacher-centred practices (Loughran et al., 2006). This phenomenon has been described as “conservatism of teaching” (Grossman, 1990, p.10).

### **The enacted curriculum**

Despite the fact that the curriculum was very clearly specified in the curriculum documents, a number of factors influenced how the curriculum was enacted in the various classrooms. A comparison of the big ideas as suggested in the pre-lesson observation interviews suggested some common themes, (eg., basic organic chemistry and the application of this in daily living). However, there was also no evidence of curriculum planning, neither at an individual level nor at a collaborative level. Based on my observation whilst attending meetings at the school, there was a lack of effective governance and curriculum leadership in the science department. During the time of this study, science department meetings were held once a term and based on my observations these meeting were purely for logistical reasons, and

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<sup>10</sup> This school is regarded as one of the high performing schools in the district had two well-equipped science laboratories.

centred around deciding on who was going to set what examinations. At no stage did I witness Life Science teachers meeting to share ideas about teaching. There was also no accountability or monitoring of classroom practice. My observations, concurred with the results of a survey done at the same school to look at “Management practices that promote teaching and learning” at the same time as the study, reported that the Subject Heads did not meet with their teams on a regular basis.<sup>11</sup> The same survey reported and that the Subject Head did not adequately monitor curriculum implementation, and that there was inadequate support for teachers and insufficient Professional Development.<sup>12</sup> The implications of this lack of accountability was that it was simply up to each individual to decide what and how to teach. The influence of each individual teacher’s perceived curricula (i.e., what they decided was important to teach) resulted in the choice of curriculum materials differing from class to class.

### **Knowledge of Learners**

Seeing as the teachers were all teaching the same topic, it was assumed that this common feature would reduce the complexity of the contextual constraints and allow one to uncover the teachers “unique enactment” (Park & Oliver, 2008, p. 276). The influence of context, however, influenced the outcome of teachers’ enacted practices in very different ways. Although the teachers had quite different academic qualifications and level of experience and attitudes, they shared similar perceptions of the learners’ work ethic and content deficit. The difficult home circumstances and the learners unfavourable social backgrounds were factors that teachers believed influenced the learners’ work ethic. Mr Dawood, aloof and disengaged, had decided that the learners were not intellectually capable and that they had a poor work ethic. Mr. Matthews believed that the learners were incapable of independent learning and believed that he had to mediate their acquisition of knowledge at all times. Ms. Benjamin believed that learners were not studious, whilst Ms. Abrahams believed that learners lacked the background to learn.

The poor work ethic was the main reason teachers gave for not giving the learners homework. What was evident from the interview discussions about the curriculum was that teachers believed that the biochemical concepts that students were required to learn in this section were too abstract for learners to grasp at this level. This together with the fact that they believed that the learners were not capable, made

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<sup>11</sup> This study formed part of a broader whole school initiative to support Maths and Science teachers at the school, and as a requirement, project surveys were conducted by senior staff as part of their portfolios.

<sup>12</sup> There were also some personal agendas like in the case of Mr. Dawood, despite being seconded to the education department as a curriculum advisor and his university background chose not to be involved in the school. He believed that he had been side-lined. The current HOD at the time was essentially a language specialist and merely performed an administrative function.

matters worse. The conundrum experienced by this teacher is echoed in the literature and is aptly described below by Loughran *et al.* (2006, p.219):

“There is an inherent difficulty in science teaching whereby complex and abstract concepts and ideas need to be taught in ways that make them accessible and understandable for learners. As a consequence teachers’ attempts at simplification may inadvertently reduce such subject matter to propositional forms that, sadly, foster reliance on rote learning as opposed to encouraging the development of rich and deep understandings.”

Based on my findings, teachers’ lacked the capacity to effectively scaffold the learning of the concepts for the topic Chemistry of Life and at best used very simplistic representation in their explanations. Empirical evidence suggests that to show the link between the PCK of teachers and learner outcome in the classroom is not clear-cut (Alonzo & Kim, 2015). In describing the place of PCK in the Model of teacher professional knowledge, student beliefs, prior knowledge and behaviors are identified as potential amplifiers and filters of student outcomes and can influence what happens in the classroom (Gess-Newsome, 2015).

### **The influence of teachers’ SMK on their teaching**

Based on the limited content representation evident from their lessons and their Knowledge of Curriculum, Ms. Benjamin (refer to pg.34) (and similarly Ms. Abrahams, refer to pg. 64) clearly lacked the SMK needed to teach this topic. Ms. Benjamin limited her engagement with the class because she was unable to use a differentiated approach and challenge the more capable learners. The outcome of both of these teachers’ lessons was that delivery was at a more superficial level. In another local study, Rollnick *et al.* (2008, 2015) claimed that the role of subject matter knowledge is even more important in a country where many teachers have a low content base. In a study of Biology teachers the influence of SMK was evident in the teachers use of SMK from textbooks and in their verbal explanations (Hasweh, 1987; Rollnick *et al.*, 2008). Teachers with inadequate specialised knowledge used a transmission approach:

“Informational approaches were twice as likely to be encountered when the teacher was teaching outside his discipline area and that this increase was at the expense of more effective problem-solving and inquiry approaches” (Rowe, 1985, cited in Stoffels, 2008).

Teachers also preferred to use more concrete curriculum materials when teaching outside of their specialist areas (Stoffels, 2008). In a survey of secondary chemistry teachers the most significant influence on curriculum implementation was found to be the backgrounds in chemistry or chemistry teaching. Teachers with limited SMK relied more heavily on text- books (Lantz & Krass, cited in Gess-

Newsome, 1999). This is similar to the findings in my study where the teachers who poor SMK relied on simplified texts. In a discussion about teacher amplifiers and filter in the Summit Model (Gess-Newsome, 2015, p.46) suggests that incoming teacher affect and knowledge influence learning and act as an amplifier or filter between knowledge and practice.

### **General Pedagogic Strategies**

A comparison of the general pedagogic strategies used by the teachers revealed interesting differences that can be linked back to the teachers' orientation, experience and SMK. A comparison of the teachers' types of content representation in my study revealed that the more experienced (and more qualified) teachers had greater in-depth knowledge (topic knowledge) and breadth of knowledge (domain knowledge). This could account for the greater range of language devices used in the case of Mr. Dawood (e.g., more frequent narratives, examples and analogies and in the case of Mr. Matthews the use of analogies was more prominent).

None of the types of activities listed under the PCK ERT category of Knowledge of Instructional Strategies and Representations were evident in any of the cases (i.e., inquiry-based learning, hands-on, demonstration, simulation, problem-solving, investigation). (see PCK ERT Tables in Chapter 4 above) This is consistent with the transmissive teaching model that was dominant in all of the lessons observed. An interesting, but not unexpected observation was that the teacher who had a better relationship with the learners, engaged more with the learners and asked many more questions than the teachers in the other three cases. Even so, was perhaps more glaring in all four cases was the general lack of challenging and higher order questions.

### **Concluding Comments**

The first part of my research question attempted to answer the question of what the enacted practices of selected Grade 10 Life Science teachers were. A commonality that emerged when describing these teachers' enacted practice is that all four teachers appeared to overemphasise the school context, with the less experienced teachers being more disempowered by the contextual constraints and their own limitations. Teachers approached the teaching of the topic The Chemistry of Life differently, however, they were not able to offer the kind of scaffolding required for effective learning. Teachers taught mainly from the textbooks and lacked the pedagogic repertoires that are required to mediate learning with understanding in a context where learners come from difficult social backgrounds. Teachers were not able

to transform this knowledge into a form that could be appropriated by the learners, nor were they able to mediate understanding, nor use representations that enabled this process. The findings in this study concurs the findings of Stoffels (2008), that teachers did not have the capacity or the will to change their approach to teaching and learning. A general concluding remark about all the teachers in this study is that their approach lacks the capacity for true integration (Rollnick et al., 2006; Gess-Newsome, 1999b). The outcome was a restricted curriculum and poorly defined PCK and their practice can at best be described using Gess-Newsome (1999b) integrative model that favours a content-based rather than more contextually relevant approach. Teachers taught mainly from textbooks and lacked the pedagogic repertoires that are required to mediate learning with understanding in a context where learners come from problematic backgrounds.

The second question sought to describe the underlying reasons for these enacted practices, which included the classroom processes that took place, such as, for example, what was taught, how it was taught and how it was assessed. The second part of the research questions was to consider how we could best describe and understand the enactment of the curriculum of selected Grade 10 Life Science teachers in the Western Cape. Various factors like teachers orientation, poor content knowledge, limited pedagogic strategies from a constructivist perspective and various other contextual factors influenced the way in which teachers perceived and enacted their roles in their classrooms. PCK ERT may not have been the best heuristic device for describing South African in-service teachers' PCK as was the case of my study although it may have been useful in identifying gaps in teachers' knowledge. The PCK ERT framework is underpinned by a constructivist epistemology (Park & Oliver, 2008) and as such makes assumptions about the kinds of enacted practices that should be in place. A study which described the PCK of physics teachers distinguish between declarative (knowing that) and dynamic PCK (PCK in action) (Alonzo & Kim, 2015). Dynamic PCK is seen as implicit and is described as "Knowledge in and of practice" rather than "Knowledge for Practice". This has implications for the way in which we portray and/or measure PCK. Since dynamic PCK is implicit and in the moment of teaching, it is more difficult to describe and measure (Alonzo & Kim, 2015). Any evidence of PCK in this study was essentially of a declarative nature.

A more recent perspective on PCK was introduced at the PCK Summit (see pg. 16) where a model of teacher professional knowledge was introduced that included PCK. The TSPK model included Topic Specific Professional Knowledge (TSPK), which is a new category of knowledge akin to expert knowledge according to Gess-Newsome (2015). PCK has been used with success elsewhere to describe exemplary practice of experienced teachers in the normalised classroom (Berry et al., 2001; Bertram &

Loughran, 2011). The PCK ERT may be a useful framework in contexts where teachers are adequately trained and exposed to appropriate learning strategies, however, in the case of this study the use of PCK ERT as descriptive framework has proved to be less useful. Factors such as inadequate training, modelling, insufficient SMK, lack of regulatory practice, teachers' perception of their learners have an impact on the outcome of learning in the school. Referring her to the summit model again, various factors influence the transformation of TSPK into enacted practices and act as filters or amplifiers. PCK ERT is essentially describing TSPK. Particularly significant factors that may have acted as filters in the case studies I have described included teachers' beliefs, orientations, prior knowledge and context.

### **Significance of the study**

A framework was sought to best explain the enacted practices of teachers and to this end the hexagonal model for Science teaching developed by Park and Oliver (2008) and the Summit Model (2015) proved useful. The findings of study were discussed and critiqued using these models. Comments about the contribution to the scholarship in the field, include that there was an implied assumption that teachers would engage in reflection in and on action. If this is not ingrained in their practice, then we need to be creative in the way we gather data (e.g., video stimulated interviews allowed for reflection and for the elicitation of the teachers' dynamic PCK, as described by Alonzo and Kim [2015]). We also need to be clear on what we are describing (e.g., declarative versus dynamic PCK). Similarly, we need to consider the epistemic origins of the tools used to describe the enacted practices. PCK ERT is ideally used to describe exemplary practice of teachers using constructivist approaches and hence the study highlights the need to foreground context and the need to consider the teachers' theoretical orientation first.

### **Recommendations**

Possible avenues for future research should include a study on the challenges and opportunities of the teacher as reflective practitioners. It would also be useful to get an understanding of how to better align individual teacher's conception of learning and assessment of learning with a view to developing a common purpose/vision in their institutions. Although the study was able to identify common practices amongst the teachers, an obvious limitation of the study is the lack of generalisation of the findings.

With regard to the practice of teaching and learning science, this study highlighted the need for teacher professional development to include various strategies such as the relevance of practical work, and the setting up of communities of practice to share contextual challenges and solutions. Bertram (2011) examined the implications of teacher learning and teacher knowledge for professional development in

South Africa and argued for more productive teacher development, and the need to be more explicit about what kind of teacher knowledge is developed in what kind of learning spaces. This author suggested that :

“Knowledge-in-practice is developed through participation by actually practicing a new teaching or assessment strategy in the presence of a supportive colleague usually in a school situation. This kind of practical learning is enhanced when a teacher is part of a supportive community of practice where teachers are committed to learning from one another in informal ways”. Bertram (2011, p.20).

Similarly, in the case of my study the teachers would benefit from being exposed to models of reflective practice where teachers are encouraged to plan collaboratively, observe the lessons of their peers, and engage in reflexivity towards improving their own practice.

## References

- Abell, S.K. (2007). Research on science teacher knowledge. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education* (pp. 1105-1149). Mahwah, NJ: Lawrence Erlbaum.
- Abell, S.K. (2008). Twenty years later: Does pedagogical content knowledge remain a useful idea? *International Journal of Science Education*, 30(10):1405-1416.
- Alonzo, A.C., & Kim, J. (2015). Declarative and Dynamic Pedagogical Content Knowledge as Elicited through Two Video-based interview Methods. *Journal of Research in Science Teaching*, 53(8), 1259-1286.
- Baxter, J.A. & Lederman, N.G. (1999). Assessment and measurement of pedagogical content knowledge. In J. Gess-Newsome & N.G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95–132). Dordrecht, The Netherlands: Kluwer.
- Berry, A., Loughran, J. & Smith, K. (2009). Capturing and enhancing science teachers' professional knowledge. *Research in Science Education*, 39, 575–594.
- Bertram, A., & Loughran, J. (2011). Science Teachers' Views on CoRes and PaP-eRs as a framework for articulating and developing PCK. *Research in Science Education*, 42(6), 1027-1047
- Bertram, C. (2011). What does research say about teacher learning and teacher knowledge?: Implications for professional development in South Africa. *Journal of Science Education*, 52, 1-26.
- Bornman, K.M., Clarke, C., Cotner, B., & Lee, R. (2006). Cross-Case Analysis. In Green, J.L., Camilli, G., & Elmore, P.B., (Eds.). *Handbook of contemporary methods in educational research* (p. 111-122) Mahwah, NJ: Lawrence Erlbaum.
- Case, J. M., Clark, J., Wallace, N., Davies, N., Mgoqi, N., Toerien, R., & Gunstone, R. F. (2010). Learning intended but not attained: A case study of a South African Physical Sciences Classroom implementing the new curriculum. In: *proceeding of the 18<sup>th</sup> conference of the South African Association for Research in Mathematics, Science and Technology education*. University of Kwazulu-Natal. , p. 290-298.
- Clandinin, D.J. (1989). Developing rhythm in teaching: The narrative study of a beginning teacher's personal practical knowledge of classrooms. *Curriculum Inquiry*, 19, 121-141.
- Clandinin, D.J. (1992). Narrative and story in teacher education. In Russell, T., & Munby, H. (Eds.), *Teachers' and teaching: from classroom to reflection*. London: Falmer Press.
- Clandinin, D.J., & Connelly, F.M. (1994). Personal experience methods. In Denzin, N.K., & Lincoln, Y.S. (Eds.), *Handbook of qualitative research* (pp. 413-427). Thousand Oaks, CA: Sage.
- Clandinin, D.J., & Connelly, F.M. (2000). *Narrative Inquiry: experience and story in qualitative research*. (1<sup>st</sup> ed.). CA: Jossey-Bass.

- Clark, J., & Linden, C. (2006). *Changing Teaching, Changing Times: Lessons from a South African Township Science Classroom*. Rotterdam, The Netherlands: Sense Publishers.
- Clark, C.M., & Peterson, P. L., (1986). Teachers Thought processes. In Wittrock, M.C. (Ed.), *Handbook on research on teaching* (pp. 255-296) (3rd ed.). New York: Macmillan.
- Cohen, L., & Manion, L. (1991). *Research methods in education* (3rd ed.). London: Routledge.
- Cohen, L., Manion, L. & Morrison, K. (2000). *Research methods in education* (5<sup>th</sup> ed.) London: Routledge Falmer.
- Connelly, F.M., & Clandinin, D. J. (1986). On narrative method, personal philosophy, and narrative unities in the story of teaching. *Journal of Research in Science Teaching*, 23, 15-32.
- Connelly, F.M., & Clandinin, D.J. (1990). Stories of experience and narrative inquiry. *Educational Researcher*, 19, 2-14.
- Cresswell, J.W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. (4<sup>th</sup> ed.) Thousand Oaks, CA: Sage.
- Denzin, N.K., & Lincoln, Y.S. (1994). Introduction: Entering the field of qualitative research. In Denzin, N.K., & Lincoln, Y.S. (Eds.), *Handbook of qualitative research* (pp. 1-17). Thousand Oaks, CA: Sage.
- Department of Basic Education. (2011). *Curriculum and Assessment Policy Statement (CAPS) Grade 10-12 Life Sciences*. Cape Town & Pretoria: Department of Basic Education, Republic of South Africa.
- Erickson, F. (1986). Qualitative methods in research in teaching. In Wittrock, M.C. (Ed.), *Handbook on research on teaching* (pp. 119-161) (3rd ed.). New York: Macmillan
- Gess-Newsome, J., (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK Summit. In Berry, A., Friedrichsen, P., Loughran, J. (Eds.), *Re-examining pedagogical content knowledge in science education*. (pp. 28-42).
- Gess-Newsome, J., (1999a). Secondary teachers' knowledge and beliefs about subject matter and their impact on instruction. In Gess-Newsome, J., & Lederman, N. G. (Eds.). *Examining pedagogical content knowledge*. Dordrecht, The Netherlands: Kluwer.
- Gess-Newsome, J., (1999b). Pedagogical content knowledge: an introduction and orientation. In Gess-Newsome, J., & Lederman, N. G. (Eds.). *Examining pedagogical content knowledge*. Dordrecht, The Netherlands: Kluwer.
- Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.
- Janesick, V. J. (1994). The dance of qualitative research design. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research design* (pp. 209–219). Thousand Oaks, CA: Sage.
- Loughran, J., Milroy, P., Berry, A., Gunstone, R., & Mulhall, P. (2001). Documenting science

- teachers' pedagogical content knowledge through PaP-eRs. *Research in Science Education*, 31, 289–307.
- Loughran, J., Berry, A. & Mulhall, P. (2006). *Understanding and developing science teachers' pedagogical content knowledge*. Rotterdam, The Netherlands: Sense Publishers.
- Maxwell, J.A. (1996). *Qualitative research design*. London: SAGE.
- Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N.G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95–132). Dordrecht, The Netherlands: Kluwer.
- Morine-Dersheimer, G., & Kent, T. (1999). Sources of teachers' pedagogical knowledge. In J. Gess-Newsome & N.G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 21–50). Dordrecht, The Netherlands: Kluwer.
- Nilsson, P. (2008). Teaching for Understanding: The complex nature of pedagogical content knowledge in pre-service education. *International Journal of Science Education*, 30(10), 1281-1299.
- Park, S., & Oliver, S. (2008). Revisiting the Conceptualisation of Pedagogical Content Knowledge (PCK): PCK as a Conceptual Tool to Understand Teachers as Professionals. *Research in Science Education*, 38, 261-284.
- Robinson, V., & Lai, M.K. (2006). *Practitioner research for teachers: A guide to improving classrooms and schools*. Thousand Oaks : Corwin Press.
- Rogan, J.M. (2004). Out of the frying pan?: Case studies of the implementation of Curriculum 2005 in some science classrooms. *African Journal of Research in SMT Education*, 8, 165-179.
- Rollnick, M., Bennett, J., Rhemtula, M., Dharsey, N., & Ndlovu, T. (2008). The place of subject matter knowledge in pedagogical content knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education*, 30, 1365 - 1387.
- Rollnick, M., & Mavhunga, E. (2015). The PCK Summit and its effect on work in South Africa. In Berry, A., Friedrichsen, P., Loughran, J. (Eds.), *Re-examining pedagogical content knowledge in science education*. (pp. 135-146).
- Sanders, L.R., Borko, H., & Lockard, J.D. (1993). Secondary science teachers' knowledge base when teaching science courses in and out of their area of certification. *Journal of Research in Science Teaching*, 30, 723–736.
- Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15, 4–14.

- Schneider, R.M. & Plasman, K. (2011). Science Teacher Learning Progressions: A Review of Science Teachers' Pedagogical Content Knowledge Development. *Review of Educational Research*. 81(4), 530–565.
- Stake, R.E. (1994). Case studies. In Denzin, N.K., & Lincoln, Y.S. (Eds.), *Handbook of qualitative research* (pp. 236-247). Thousand Oaks, CA: Sage.
- Stoffels, N. (2008). Why teachers do what they do. In Weber, (Ed.), *Educational Change in South Africa: Reflections on Local Realities, Practices, and Reforms* (pp. 25-40). Rotterdam, The Netherlands: Sense.
- van Driel, J., Verloop, N., & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, 35, 673-695.
- van den Akker, J.A.N. (1998). The science curriculum: Between ideals and outcomes. In Fraser, B. & Tobin, K. (Eds.), *International handbook of science education* (pp. 421-447). Dordrecht, The Netherlands: Kluwer.
- Walker, R. (1986). The conduct of educational case studies: ethics, theory and procedures. In Hammersley, M. (Ed.), *Controversies in classroom research* (pp. 187-219). Milton Keynes: Open University Press.
- Wallace, J. (2004). Introduction: Science Teaching Cases as Learning Opportunities. *Research in Science Education*, 31, 185-190.
- Yin, R. (2006). Case study methods. In Green, J.L., Camilli, G., & Elmore, P.B., (Eds.). *Handbook of contemporary methods in educational research* (pp. 111-122) Mahwah, NJ: Lawrence Erlbaum.

## **Appendices:**

### Appendix A: Interview questions for Content Representations (CoRes)

1. What do/did you intend the students to learn about this idea?
2. Why is/were it important for students to know this?
3. What else might you know about this idea (that you don't intend your students to know yet)?
4. What were /were the difficulties/limitations connected with teaching this idea?
5. What knowledge about students' thinking do you know of which influences your teaching of this idea?
6. What other factors that influence your teaching of this idea?
7. What teaching strategies will/did you use and why (and particular reasons for using these to engage with this idea)?
8. What specific ways of ascertaining students' understanding or confusion around this idea (include likely range of responses) do/did you intend using?

Appendix B: PCK Evidence Reporting Table modified from Park and Oliver (2008)

Orientation to Teaching Science	K of Instructional Strategies and Representations						K of Students	# of evidence of K of Student	K of Curriculum	# of evidence of K of Curriculum	K of Assessment		# of Assessments
	Types of Activities	# of Activities	Types of Language devices	# of lang. devices	Types of Content Elaboration	# of Content Elaboration					Types of Assessment	Diagnostic	
Process	Inquiry-based lab		Explan-	Metaphors		Depth beyond the intended goal of text (Topic Knowledge)		Misconceptions	K of vertical Curriculum		Types of Assessment	Diagnostic	
Academic rigour				Analogies									
Conceptual change	Hands-on		Examples	Related								Summative	
				Similar situation									
Didactic	Demonstration		Narration	Stories/ Anecdotes					K of horizontal curriculum			K of assessment methods	
				Biography									
Activity Driven	Simulation			Illustration		Breadth beyond the intended goal of text (Domain Knowledge)		Need					
				Mnemonic device									
Discovery	Problem-solving		Questioning	Recall./ factual Qs				Diversity	Curricular saliency			K of students learning goals important to assess in a given unit	
				Attention focusing Q									
Project-based Sci	Investigation		Questioning	Problem-posing Qs									
Inquiry				Reasoning Qs									
Guided Inquiry	Etc		Argument	Comparison Qs		Flexibility beyond the viewpoint of text		Background					
				Rhetorical Qs									
				Logic									
				Induction									
				Deduction									

Appendix C: Description of the topic *Chemistry of Life* (Curriculum and Assessment Policy Statement (CAPS) Life Sciences Grade 10-12 , 2011)

TERM 1				
STRAND 1: LIFE AT THE MOLECULAR, CELLULAR AND TISSUE LEVEL				
<p>All living organisms are made of atoms which combine to form molecules, and these make up the basic units of life i.e. cells. Plant and animal cells have a complex organisation which enables them to carry out the basic processes of life, i.e. movement (movement in and around the cells and some cells move), nutrition (cells produce food or obtain food from elsewhere), respiration, excretion, growth, reproduction and responding to stimuli. Cells are specialised and form tissues which perform particular functions. The tissues are arranged in organs which are also specialised to carry out particular functions. This strand introduces learners to life at the molecular, cellular, tissue and organ level. (Links to Grade 9).</p>				
TIME	TOPIC	CONTENT	INVESTIGATIONS	RESOURCES
2½ weeks (10 hours)	The chemistry of life	<p><b>Molecules for life:</b> Organic molecules made up of C, H, O and some also contain other elements, e.g. N and P. Cells are made up of proteins, carbohydrates, lipids, nucleic acids and vitamins. (Only basic structural detail required.)</p> <p><b>Inorganic compounds</b></p> <ul style="list-style-type: none"> <li>Water: 2 H and 1 O</li> <li>Minerals: e.g. Na, K, Ca, P, Fe, I, nitrates, phosphates. Macro and micro elements. Main functions and deficiency diseases (<i>link to nutrition and Grade 9</i>)</li> <li>Need for fertilisers in over utilised soils e.g. where crops are grown and regularly harvested, problem of fertilizers washed into rivers, and eutrophication. (<i>Link to ecology</i>)</li> </ul> <p><b>Organic compounds</b></p> <ul style="list-style-type: none"> <li>Carbohydrates – monosaccharides (single sugars) e.g. glucose, fructose; disaccharides, (double sugars) e.g. sucrose, maltose; polysaccharides (many sugars) e.g. starch, cellulose, glycogen</li> <li>Lipids (fats and oils) – 1 glycerol and 3 fatty acids: unsaturated and saturated fats. Cholesterol in foods. Heart disease (<i>link to Grade 9</i>).</li> <li>Proteins – amino acids. (C,H, O and N and some have P, S, Fe)</li> </ul>	<p>Optional: Construct models of simple and more complex molecules using beads or plasticine.</p> <p>Analyse nutritional content on food packaging: vitamins, minerals and other nutritional content.</p> <p><b>Essential:</b> Food tests for starch, glucose, lipids and proteins. Investigation to test the working of a "biological" washing powder (with enzymes).</p>	<p>Textbook Charts Equipment Test tubes</p> <p>Selection of Food packaging showing nutritional content</p> <p>Chemicals Bunsen burners Thermometers Washing powder or H<sub>2</sub>O<sub>2</sub> and chicken liver</p>

18

	<p>Proteins are sensitive to temperature and pH: loss of structure and function. Role of enzymes in breaking down/synthesising molecules. Influence of temperature and pH on enzyme action. Lock and key model of how enzymes work. Enzymes in everyday life, e.g. washing powders.</p> <ul style="list-style-type: none"> <li>Mention of Nucleic acids: DNA and RNA – Consisting of C, H, O, N and P (No details of structure required).</li> <li>Vitamins: e.g. A, one of B vitamins, C, D and E</li> </ul> <p>(Simple diagrams to represent molecules. Review briefly why these substances are needed in plants and animals i.e. build on prior knowledge. No detail of structure or function - functions will be dealt with in later sections where appropriate. This is a brief introduction to the molecules making up organisms)</p>	<p>or Hydrogen Peroxide and chicken liver to demonstrate effect of enzyme. or Fresh pineapple juice, solid egg white in plastic drinking straw. Observe, measure and record results of the experiment done at different temperatures.</p> <p>Compare Recommended Daily Allowance (RDA) with usual diet of individual learners. Draw a pie chart of the food types and discuss implications of the usual diet of learners.</p>	<p>or pineapple juice, egg white, plastic drinking straws</p>
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#### Appendix D: Details of the data sources

	Abrahams	Dawood	Benjamin	Matthews
Pre-interview duration(min)	26	13	26	17
Lesson 1 duration(min)	45	43	42	33
Lesson 2 duration(min)	33	30	35	28
Lesson 3 duration(min)	45	32	41	46
Lesson 4 duration(min)	40	30	37	45
Lesson 5 duration(min)	30*	30	41*	44
Lesson 6 duration(min)	n/a	n/a	n/a	41*
Video-stimulated interview duration(min)	46	48	45	56
# Post lesson reflections	2	1	2	2
# lesson observations	5	5	5	6

Revision lessons \*