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The Development of Content Knowledge and Pedagogical Content Knowledge in a Professional Learning Community

Jeanette Marchant

Student number: 7538106

Supervisor: Professor Karin Brodie

A research report submitted to the Faculty of Education, University of the Witwatersrand, Johannesburg, in partial fulfillment of requirements for the degree of Master of Education by coursework and research report.

Johannesburg

February 2015

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Declaration

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Education by coursework and research report at the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination in any other university, nor has it been prepared under the aegis or with the assistance of any other body or organisation outside of the University of the Witwatersrand, Johannesburg. All help received with the preparation and/or presentation of this thesis has been clearly acknowledged on the next page.

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Abstract

This study investigates teacher knowledge conversations in one professional learning community which is part of the Data Informed Practice Improvement Project. Conversations where teachers speak about and with their content knowledge and pedagogical content knowledge are analysed. Data are in the form of video and audio recordings of the professional learning community meetings over one year. The study showed that both content knowledge conversations and pedagogical content knowledge conversations did take place, with more time being spent on pedagogical content knowledge conversations than on content knowledge conversations. Furthermore, the type and extent of the teacher knowledge conversations was shown to be related to the design of the project. In terms of level, most of the teacher knowledge conversations took place at level three on a four-level rating scale. Pedagogical content knowledge conversations triggered pedagogical content knowledge conversations, suggesting a close relationship between the two.

Key words

Content knowledge
Pedagogical content knowledge
Professional learning community

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Appendix

A. Code manual

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Chapter 1:

Introduction

1.1 Introduction

South African learners achieve poorly in mathematics in both national and international assessments. The two main national assessments in South Africa are the Annual National Assessment (ANA[1]) and National Senior Certificate (NSC[2]). ANA results for 2014 have showed a general upward trend year-on-year in learner performance in mathematics in Grades 1–6 since the implementation of ANA in 2012. However, learner performance in ANA in Grade 9 mathematics remains dismally poor. According to the Report of the Annual National Assessment of 2014 (p. 9), the average percentage achieved by learners for Grade 9 Mathematics in 2012, 2103 and 2014 was 13, 14 and 11% respectively. Averages achieved by learners in the NSC examinations in mathematics have been low for decades. In 1995, 1999 and 2003 South Africa participated in the Third International Mathematics and Science Study (TIMSS) and the TIMSS-Repeat. Howie (2001) reported that in the 1999 TIMMS study only the most proficient learners in South Africa approached the average of Singapore, the top achieving country, while Reddy (2006) stated that South African learners did not compare well with learners in other African countries.

A result of poor learner performance has been that much time and money has been invested in teacher professional development, under the assumption that such investment of time and money will lead to an improvement in learner performance in mathematics. There is a widespread opinion in South Africa that the main reason for learners' poor performance is teachers' weak content knowledge and so many teacher development programmes focus on giving teachers workshops on content knowledge and aspects of the new curriculum.

A different approach is that of professional learning communities which are seen internationally as a long-term, generative means for teacher professional development and are gaining traction locally (Brodie, 2011). The Data Informed Practice Improvement Project (DIPIP) works with teachers in

1 ANA is the acronym for Annual National Assessment, Department of Basic Education initiative to measure learner achievement in selected grades and subjects, of which mathematics is one.

2 NSC is the acronym for National Senior Certificate, which is the school leaving certificate written at the end of Grade 12 (matric),

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professional learning communities to analyse possible reasons for learners' poor performance, to identify the reasons behind learners' poor performance and to build new knowledge, their own and their learners', on an understanding of learner thinking (Brodie, 2013).

In this research study, I explore teacher development in one professional learning community through the lens of Shulman's construct of pedagogical content knowledge (PCK), (1986a and b). Shulman (1986a, p. 9) described PCK as comprising 'the most useful ways of representing and formulating the subject that make it comprehensible to others'. I describe the extent to which the teachers in one professional learning community talk about content knowledge and pedagogical content knowledge and how such conversation is related to the teacher development project of which the professional learning community is a part. In addition, I investigate the relationships between CK conversations and PCK conversations[3] in the professional learning community under study. In this study I use the term "teacher knowledge conversation" to refer to conversations where teachers talk about their knowledge, or use their knowledge to analyse an aspect of their practice[3].

1.2 Background

Over the past thirty five years I have been involved in both pre-service and in-service teacher education, with a focus on mathematics. In recent years I have become increasingly involved in educational research across all phases of the school system and, through this work, have become aware not only of the need for teacher professional development, but also of the frustration of teachers regarding professional growth, or the lack thereof, experienced in the current workshop approach to teacher professional development. I agree with Wickham and Versveld (1998) that an incremental view of change is more appropriate than expecting a 'workshop conversion'.

An assignment to monitor and evaluate the work being done by the Data Informed Practice Improvement Project (DIPIP) based at the University of the Witwatersrand brought the role that professional learning communities can play in teacher development to my attention. This work, in conjunction with findings in my own field research, prompted me to find out more about the growth of teacher knowledge, particularly in the form of content knowledge and pedagogical content knowledge, in one professional learning community so as to get a better understanding of why professional learning communities are 'increasingly seen as a sustainable and generative method of professional development in mathematics education' (Brodie 2011, p,1).[4]

Added to this is the fact that little research has been done on how teachers develop knowledge. The findings of a study conducted by Ceresto (in preparation) showed that very little of the teacher conversation in professional learning communities was devoted to content knowledge. Another study

3 It should be noted that while content knowledge conversations and pedagogical content knowledge conversations per se do not imply the development of teacher knowledge, they do provide opportunities for learning this knowledge.

4 I note here that my role as project evaluator ended in December 2013 and my work on this study started in February 2014 so there is no conflict of interest.

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(Chauraya, 2013), which looked at mathematics teacher change and identity in a professional learning community, it was found that 'the opportunities for learning which arose in the conversations were distinguishable in terms of focus on a particular domain of the teachers' professional knowledge' (Chauraya, 2013, p.77). This study aims to add to this literature by extending knowledge and understanding of how teacher knowledge in the form of content knowledge and pedagogical content knowledge can be developed in professional learning communities. My research was done in one DIPIP professional learning community. I have been particularly excited about my study because, while other aspects of the DIPIP programme have been the subject of in-depth research, the development of content knowledge and pedagogical content knowledge in DIPIP professional learning communities has not been specifically researched to-date. It is my wish that my research will contribute towards a better understanding of the DIPIP PLC programme of teacher development, and to knowledge of teacher development more generally.

1.3 Research Questions

The main questions framing my study are:

1 To what extent does the professional learning community talk about content knowledge and pedagogical content knowledge and how is this related to the design of the Data Informed Practice Improvement Project?

2 What are the relationships, if any, between content knowledge conversations and pedagogical content knowledge conversations in the professional learning community?

1.4 Teacher knowledge

Since Shulman first spoke of the construct of pedagogical content knowledge, describing it as a 'distinct body of knowledge that differentiates teachers from content specialists' (Shulman (1987, p.15), there has been much debate as to the exact nature of pedagogical content knowledge. Although there is 'no agreed-upon definition of pedagogical content knowledge' (Park, Jang, Chen, 2010), it is recognised that pedagogical content knowledge is 'a crucial element of accomplished teaching' (Park, et al., 2010, p. 246).

As both content knowledge and pedagogical content knowledge are regarded as being important components of a teacher's knowledge repertoire, any programme to develop teacher knowledge should take the development of content knowledge and pedagogical content knowledge into account. My two research questions should help me to better understand two relationships: first, the relationship between content knowledge and pedagogical content knowledge and second, the relationship between these two aspects of teacher knowledge and the design of the DIPIP programme. Brodie (2013, p. 15) argues that professional learning communities (which are fundamental in the DIPIP programme) 'can be sites where deep and powerful learning takes place'. Combining the view that content knowledge and pedagogical content knowledge are important components of teacher knowledge and the goal of

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DIPIP to bring about teacher learning, I look at the content knowledge conversations and pedagogical content knowledge conversations in one DIPIP professional learning community in order to gain a deeper understanding of the development of teacher knowledge in a professional learning community.

Conceptions of the knowledge required by teachers in order to make knowledge accessible to their learners are not only varied, but have also changed over time. My study focuses on two forms of teacher knowledge, namely content knowledge and pedagogical content knowledge. In my study, I have operationalised content knowledge as what Shulman (1986b) described as subject matter content knowledge. Furthermore, I have operationalised pedagogical content knowledge in terms of the description provided by Rollnick et al., (2008, p. 1367):

> *Pedagogical content knowledge can be described as how teachers teach their subject by accessing what they know about the subject, the learners they are teaching, the curriculum with which they are working, and what they believe counts as good teaching in their context.*

My justification for using these descriptions of content knowledge and pedagogical content knowledge in my operationalisation is discussed in detail in Chapter 2. In my study, pedagogical content knowledge is not viewed as a subset of content knowledge, although I do acknowledge that the two constructs are closely interrelated.

1.5 Professional Learning Communities

Professional learning communities (PLCs) comprise a group of professionals "engaged in learning for the benefits of their 'clients'" (Hargreaves 2008). In my study the professionals in the learning community are teachers, their 'clients' are learners and the professional learning community is part of DIPIP. According to Brodie (2013) collaboration, rigorous enquiry, trust, care and a clear focus are crucial elements of a successful professional learning community.

1.6 DIPIP Professional Learning Communities

In the Data Informed Practice Improvement Programme the focus in the professional learning communities is on learner errors (discussed in more detail in Chapter 2). This focus on learner errors provides the opportunity for the community to identify learners' learning needs which, in turn, informs teachers' learning needs (Katz, et al., 2009, Brodie 2013).

The DIPIP project started in 2008 with teachers from various schools meeting at Wits University and working in small groups. From 2011 (with a pilot in 2010, see Chauraya, 2013) the project began to work with professional learning communities located in schools. The DIPIP project consists of a number of activities: test analysis, learner interviews, curriculum mapping; concept identification; readings and discussions; lesson planning and lesson reflections (Brodie, Shalem, Sapire, & Manson, 2010; Brodie and Shalem, 2011; Molefe, Brodie, Sapire, & Shalem, 2010). Each professional learning community is led by a school-based facilitator, supported by a university-based facilitator. Learner

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errors are the central focus of the activities, as teachers analyse, design, present and reflect on lessons. The DIPIP project leaders prepared to hand over leadership of the programme to teachers in the schools, a process which was completed in 2014. It is hoped that the communities will continue with Wits playing a supportive role going forward.

1.7 Structure of the Report

In Chapter 2, I describe the two main theories that frame my research study. I will explain why I use these theories and draw on literature to help me understand why these theories are important for my study. I will present the literature that I draw on to make links to my research questions regarding the extent of content knowledge and pedagogical content knowledge conversations and the relationship between content knowledge and pedagogical content knowledge conversations and the design of the Data Informed Practice Improvement Project.

Chapter 3 focuses on my research design. My research approach is largely qualitative and I explain what makes it qualitative and why I use this approach. I describe participants in the professional learning community being studied and the sources of data, as well as the methods used to collect the data and a justification of the use of these data collection methods. Furthermore, I provide the analytic framework for my study. Since my research focus is primarily on the conversations of teachers in different DIPIP activities, I provide an overview of the DIPIP meeting types, as determined by the different activities planned by DIPIP project team. I provide a detailed description of the content knowledge and pedagogical content knowledge rubrics that I developed and the coding process that I used to analyse teachers' conversations. Chapter 3 also deals with the limitations of my study and the measures I took to ensure rigour and the reliability and validity of the results of my study.

Chapter 4 provides the data analysis that will answer my research questions. I use the data from the coding process described in Chapter 3 as the basis for a detailed analysis of the teacher conversations. My analysis provides details of, and possible explanations for, the relationships between the content knowledge and pedagogical content knowledge conversations and the design of the DIPIP. I refer to the literature described in Chapter 2 to help me make links between content knowledge, pedagogical content knowledge and the DIPIP programme.

I conclude this research report with Chapter 5, where I provide an overview of what I have found in the study with the aim of answering my research questions. I also look at how my research study helped me to understand teacher professional development in professional learning communities and how this can be used to assist others with an interest in teacher professional development in professional learning communities. I will also make recommendations and suggest methods by which the teacher professional development practices that I have analysed in this research study can be disseminated to other teachers, teacher educators and researchers.

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Chapter 2:

Theoretical Framework and Literature Review

2.1 Introduction

Conceptions of the knowledge required by teachers in order to make knowledge accessible to their learners are not only varied, but have also changed over time. As my study focuses on two forms of teacher knowledge, namely content knowledge (CK) and pedagogical content knowledge (PCK), a review of the literature on teacher knowledge, and content knowledge and pedagogical content knowledge in particular, is required. This review of the literature forms the background against which the development of content knowledge and pedagogical content knowledge in one professional learning community is explored. Because my focus is on a professional learning community, a review of the literature on professional learning communities is included. The professional learning community under study is part of DIPIP, so a review of the literature on DIPIP is also provided.

2.2 Teacher knowledge

It was Shulman's interest in conceptions of teacher knowledge and knowledge growth in teaching (1986a; 1986b) that brought the construct of teacher knowledge to the fore in the educational research community about 25 years ago (Shulman, 1987). In order to throw light on conceptions of teacher knowledge, Shulman investigated the contents of teacher tests in terms of teacher competence and pedagogical skills in the United States of America as far back as 1875, and even earlier in European Universities. This historical review of teacher knowledge showed that during these early times there was a heavy emphasis (90–95%) 'on the content, the subject matter' and that 'a knowledge of the theories and methods of teaching' played a decidedly secondary role (Shulman 1986a, p. 10). According to Shulman, the pendulum swung away from the heavy emphasis on content knowledge to a heavy emphasis on 'the capacity to teach' (Shulman 1986a, p. 10) in most states in the USA in the 1980s – a situation which prompted Shulman to ask: 'Where did the subject matter go?' (1986a, p. 10).

Having traced changes in conceptions from a heavy emphasis on content knowledge to a heavy emphasis on pedagogy, Shulman became the first researcher to speak of the construct of pedagogical content knowledge, which he saw as being at the intersection of content knowledge and pedagogical knowledge.

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The literature on these three forms of teacher knowledge, namely content (or subject) knowledge, pedagogical knowledge and pedagogical content knowledge is reviewed in more detail below.

2.2.1 Content Knowledge

Knowledge of subject matter has been variously referred to as Content Knowledge (CK), Subject Knowledge (SK) or Subject Matter Knowledge (SMK), with researchers naming and describing their interpretation of content knowledge slightly differently. Although researchers use slightly different terminology, all list some form of content knowledge as an important component of teacher knowledge. In my study I have used the term content knowledge to describe what Shulman referred to as subject matter content knowledge. Mavhunga (2012) included the concept of topic specific content knowledge.

Shulman's framework for teacher knowledge (1986a) is presented in Figure 2.1 below. Shulman used the construct of content knowledge in a broader sense than I have used it in my study, defining content knowledge as the 'amount and organisation of knowledge per se in the mind of the teacher' (1986b, p. 6). Having listed content knowledge as one of the three general domains of teacher knowledge, the other two domains being pedagogical knowledge and pedagogical content knowledge, Shulman went further to suggest that the content knowledge domain can be categorised as subject matter content knowledge, pedagogical content knowledge[5] and curricular knowledge, adding that the subject matter content understanding of the teacher requires that the teacher 'need not only understand that something is so; the teacher must further understand why it is so' (1986b, p. 9). Shulman saw the construct of content knowledge as encompassing subject matter content knowledge, pedagogical content knowledge and curricular knowledge. I have not operationalised pedagogical content knowledge as a subset of content knowledge.

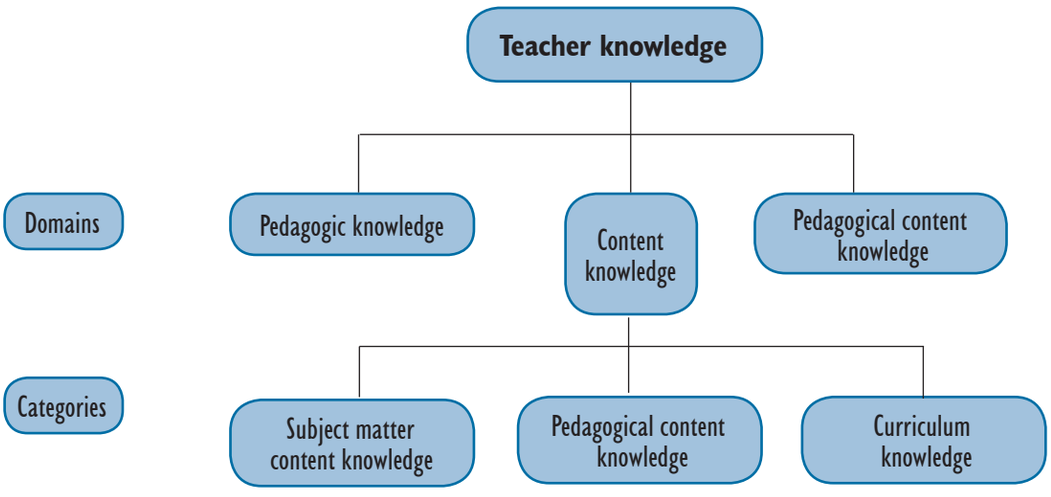


Figure 2.1: Shulman's framework of teacher knowledge (1986a)

5 There is an apparent contradiction here, with Shulman listing pedagogical content knowledge as both a domain of teacher knowledge and a category of content knowledge.

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In addition to presenting a framework for teacher knowledge (1986a), Shulman (1987) presented a framework of the knowledge base for teachers. The knowledge base for teachers consisted of seven categories of knowledge[6]. Shulman's knowledge base for teachers (1987) is presented in Figure 2.2 below. Shulman's seven categories of the knowledge base for teachers are: content knowledge (or knowledge of the subject matter), pedagogical knowledge, pedagogical content knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts and knowledge of educational ends, purpose and values. In his seven category classification of the knowledge base for teachers Shulman positioned content knowledge and pedagogical content knowledge slightly differently from the categorisation of teacher knowledge into three domains as shown in Figure 2.1, in that content knowledge and pedagogical content knowledge are presented as two separate categories, rather than pedagogical content knowledge being presented as a type of content knowledge. This separation of content knowledge and pedagogical content knowledge is how most researchers in the field use the constructs and is closely aligned with the way in which I have operationalised the two constructs in my study. The two categories of teacher knowledge which are pertinent to my study are content knowledge and pedagogical content knowledge and are the two categories which are discussed in depth in this review of the literature.

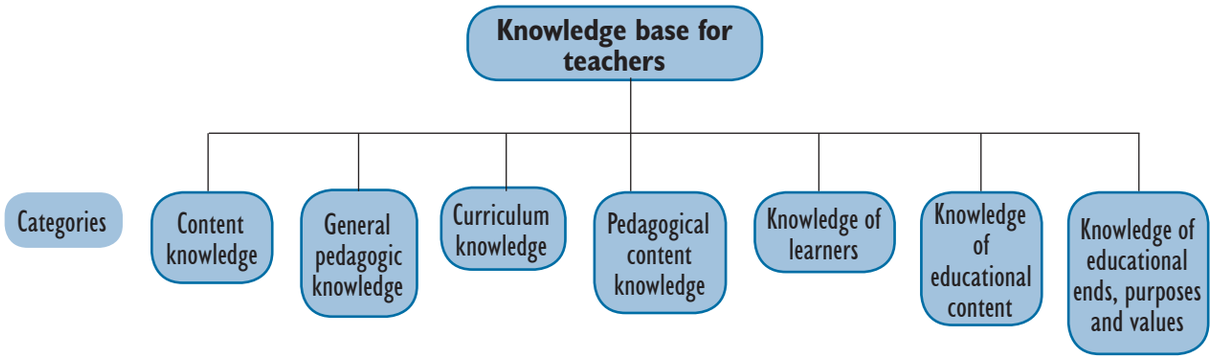


Figure 2.2: Shulman's knowledge base for teachers (1987, p.8)

Following Shulman's categorisation of subject matter content knowledge, various other scholars, for example Marks (1990); Ball and Cohen (1999); and Ball, Thames, and Phelps (2008) added to the debates around teacher knowledge by representing Shulman's categories slightly differently, or by adding new categories. In their framework of content knowledge for teaching, Ball et al., (Ball, Thames & Phelps, 2008, p. 389) describe four domains, namely common content knowledge, specialised content knowledge, knowledge of content and students and knowledge of content and teaching. Of these four domains, it is only the first domain, common content knowledge, that would fit into the way in which I have operationalised content knowledge. By common content knowledge, Ball et al.

6 Shulman differentiated between teacher knowledge (which was further sub-divided into domains and categories, and which was presented in Shulman (1986a), and the knowledge base for teachers (which was categorised into seven components and which was presented in Shulman (1987). Content knowledge and pedagogical content knowledge are included in both of these frameworks.

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meant generic subject knowledge required by everyone (teachers and non teachers alike) who works with the subject. Ball et al's. common content knowledge includes knowledge of concepts and skills; what is right and wrong; the ability to use terms and notations correctly; and the ability to identify inaccuracies in learning materials (p.399). The other three domains of Ball et al's. content knowledge for teaching are more closely aligned with the way in which I have operationalised pedagogical content knowledge and are discussed under the section on pedagogical content knowledge.

2.2.2 Pedagogical Knowledge

Although an in-depth review of the literature on pedagogical knowledge is not required for the purposes of this study, a brief overview of the construct is provided for the sake of completeness as pedagogical knowledge is listed by Shulman (1986a) as one of three domains of teacher knowledge – the other two domains being content knowledge and pedagogical content knowledge. Pedagogical knowledge is also relevant as Shulman places pedagogical content knowledge at the intersection of pedagogy (pedagogical knowledge) and content (1987, p15). In Shulman's seven-point categorisation of the knowledge base required by teachers, general pedagogical knowledge is afforded its own category and is described as the 'broad principles and strategies of classroom management and organisation that appear to transcend subject matter (1987, p. 8). In a similar vein, Koehler, M. and Mishra, P. (2011) speak of pedagogical knowledge as a generic form of knowledge 'about the processes and practices or methods of teaching and learning and how it encompasses overall educational purposes, values and aims.' Pedagogical knowledge can be seen as being specific to teaching but generic across subjects whereas, as will be discussed in more detail below, pedagogical content knowledge is specific to teaching and specific to subjects.

2.2.3 Pedagogical Content Knowledge

In order to address my research question regarding the extent to which teachers in the professional learning community talk about content knowledge and pedagogical content knowledge, as well as the question regarding the nature of the relationship between content knowledge and pedagogical content knowledge, I reviewed the literature on pedagogical content knowledge. In this review of the literature on pedagogical content knowledge. I start with an outline of the construct as described by Shulman and then move on to discuss some of the contributions and elaborations of other scholars.

Shulman is regarded as the father of pedagogical content knowledge. According to Nelson (1992, p. 32) 'in his 1985 presidential address, Lee Shulman tossed off the phrase pedagogical content knowledge and sparked a small cottage industry devoted to the construct'. Shulman (1986a, p. 13 and 1986b, p. 9) categorised pedagogical content knowledge (or subject-matter pedagogical knowledge) as one of three types of content knowledge. Shulman defined the concept of pedagogical content knowledge as a 'distinct body of knowledge that differentiates teachers from content specialists' (1987, p. 15). Shulman (1987) went further to say that 'comprehended ideas must be transformed in some manner if they are to be taught' and to describe pedagogical content knowledge as 'the capacity

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of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful.'

Following Shulman's descriptions of pedagogical content knowledge, there has been on-going debate as to the exact meaning of the construct: according to Kind (2009, p. 171), 'researchers are still arguing about what pedagogical content knowledge is'. The construct of pedagogical content knowledge is still being defined and explored (Abell 2007), and there is 'no agreed-upon definition of pedagogical content knowledge' (Park, Jang, Chen & Jung, 2010). Ball (2008, p. 390) speaks of the meaning of pedagogical content knowledge being 'underspecified', adding that this lack of definition and empirical foundation has limited its usefulness. However, it should be noted that the current debates revolve more around the relationship between content knowledge and pedagogical content knowledge than trying to pinpoint exactly what constitutes what pedagogical content knowledge is and that there is general agreement that pedagogical content knowledge is an important aspect of an effective teacher's repertoire of knowledge. There is, therefore, sufficient clarity to operationalise the construct. Although many scholars have tried to refine Shulman's concept of pedagogical content knowledge, the notion that 'the transformation of subject matter knowledge for the purposes of teaching is the heart of pedagogical content knowledge' (Park et al., 2010, p. 248) is common to the work of most scholars. Bucat (2005, p. 2), amongst others, states that there is a vast difference between content knowledge and pedagogical content knowledge, describing pedagogical content knowledge as consisting of knowledge about the teaching and learning of a topic.

Much of my work is framed on the work of Soonhye Park which, in turn, was structured around the work of Shulman. Although Park focused on pedagogical content knowledge in science teaching, and my study focuses on content knowledge and pedagogical content knowledge in mathematics teaching, I found her work on pedagogical content knowledge sufficiently broad to extrapolate it to frame my study. For this reason, I include a review of the literature on pedagogical content knowledge as presented by Park.

Park (2007, p. 745) presented a pentagonal model of pedagogical content knowledge. Her selection of the five components of pedagogical content knowledge in her model was based on an in-depth literature study in which the components of pedagogical content knowledge from different conceptualisations were identified. While the identification of the components that were deemed most important was nothing new, Park's presentation in a pentagonal shape, the emphasis on the interaction between the components of pedagogical content knowledge and her conclusion that the total pedagogical content knowledge is greater than the sum of the parts (Park, 2014, personal communication) brought new ideas into the pedagogical content knowledge arena.

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Figure 2.3 below shows the five integrated components of pedagogical content knowledge presented by Park (2007): (1) orientation to teaching science, (2) knowledge of student understanding; (3) knowledge of the science curriculum (both horizontal and vertical); (4) knowledge of instructional strategies and representations; and (5) knowledge of assessment of science learning. Although Park's pentagonal model is silent with regard to content knowledge, the placement of pedagogical content knowledge at the centre, with the implication that the 'development of one component may simultaneously encourage the development of others [components], and ultimately enhance pedagogical content knowledge' (Park, 2007, p. 745) aligns with the DIPIP approach that development of pedagogical content knowledge can lead to the development of other components of teacher knowledge, of which content knowledge is one.

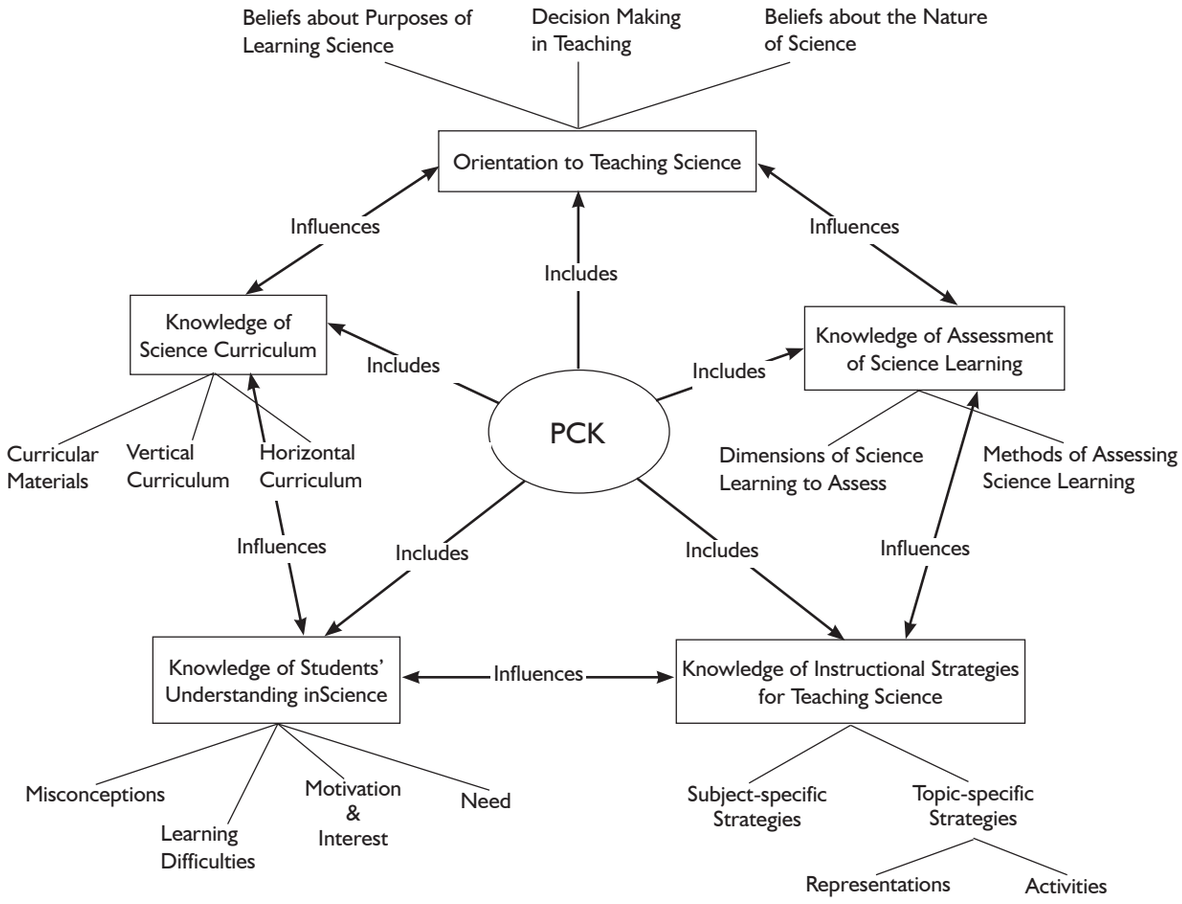


Figure 2.3 Park's pentagonal model of PCK for science teaching (Park 2007, p. 745)

Park (2007) reviewed the components of pedagogical content knowledge listed as key by 13 scholars. Figure 2.4 on the next page summarises the results of this review. Of Park's five components of pedagogical content knowledge, knowledge of student understanding (KSU) and knowledge of instructional strategies and representations of subject matter (KISR) are the two components included as key components of pedagogical content knowledge by all 13 scholars. These two components of pedagogical content knowledge are afforded prominence in my study also. KSU and KISR are

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the two components of the pedagogical content knowledge rubric developed by Park et al., (2010). The pedagogical content knowledge rubric which I developed to analyse the teacher conversations in my study is based on the Park et al., (2010) rubric. As Park is silent on content knowledge in both her pentagonal model and her pedagogical content knowledge rubric, I needed to develop a content knowledge rubric in order to answer my research questions regarding the extent to which the professional learning community talks about content knowledge and pedagogical content knowledge, as well as the relationship between content knowledge conversations and pedagogical content knowledge conversations.

	Knowledge of								
Scholars	Purposes for Teaching a Subject Matter	Student Under-standing	Curriculum	Instruct-ional Strategies and repre-sentations	Media	Assess-ment	Subject Matter	Context	Pedagogy
Shulman (1987)	D	O	D	O			D	D	D
Tamir (1988)		O	O	O		O	D		D
Grossman 1990	O	O	O	O			D		
Marks (1990)		O		O	O		O		
Smith & Neale (1989)	O	O		O			D		
Cochran, DeRuiter & King (1993)		O		N			O	O	O
Geddis, Onslow, Beynon & Oesch (1993)	O	O	O						
Fernandez, Balboa & Stiehl (1995)	O	O		O			O	O	
Magnusson, Krajcik & Borko (1999)	O	O	O	O		O			
Morine-Dershimer & Kent (1999)	O	O	O	N		O	O	O	O
Hasweh (2005)	O	O	O	O		O	O	O	O
Loughran, et. al. (2006	O	O		O			O	O	O

D: Author placed this subcategory outside of PCK as a distinct knowledge base for teaching.
N: Author did not discuss the subcategory explicitly (Equivalent to blank but used for emphasis)
O: Author included this subcategory as a compnoent of PCK

Figure 2.4: Components of pedagogical content knowledge from different conceptualisations (Park 2007, p. 744)

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In the same way that Park elaborated on pedagogical content knowledge by identifying the components of pedagogical content knowledge, many other researchers have done the same. Grossman (1990), identified four central components of pedagogical content knowledge, namely the teacher's knowledge of and beliefs about: (1) the purpose of teaching a subject; (2) learners' understanding, conceptions and misconceptions; (3) the curriculum and instructional strategies; and (4) representations for teaching. As discussed above, Park and Oliver (2008a, 2008b) added a fifth component of pedagogical content knowledge, namely teacher's knowledge of assessment of learner understanding. Mavhunga and Rollnick (2013), building on work done by Grossman (1990) and Davidowitz and Rollnick (2011), identify the influence of four teacher knowledge domains on the development of pedagogical content knowledge. These domains are the teacher's knowledge of context, students, subject matter knowledge and pedagogic knowledge. Mavhunga and Rollnick (2013) refer to 'knowing what makes a topic difficult' as being a component of pedagogical content knowledge, thus agreeing with Park et al., (2010, p. 249) that a knowledge of what concepts learners are likely to experience difficulty with is a component of pedagogical content knowledge.

Geddis (1993) and Geddis and Wood (1997) spoke of the construct of subject matter knowledge. I include their list of the components of subject matter knowledge in this section on pedagogical content knowledge because, in my opinion, their conceptualisation of subject matter knowledge aligns closely with the way in which I have operationalised pedagogical content knowledge. They identified the particular aspects of subject matter knowledge that are relevant to its teachability as '(i) Students' prior knowledge including misconceptions, (ii) Curricular saliency, (iii) What makes a topic easy or difficult to understand, (iv) Representations including analogies and (v) Conceptual teaching strategies'.

Kind (2009, p.171) speaks of pedagogical content knowledge being elusive in nature and as being a 'hidden concept' in two ways. First, pedagogical content knowledge is often tacit and is not used consciously by most teachers. Second, 'pedagogical content knowledge is largely hidden from a professional teacher's view.' However, Mavhunga and Rollnick (2013) are making the concept of pedagogical content knowledge more explicit and include the construct in the training of pre-service science teachers.

In an attempt to frame the 'conceptualisation of the mathematical knowledge and skill required by teachers', Ball et al., (2008, p. 389) built on Shulman's (1986) construct of pedagogical content knowledge. They identified two sub-domains of pedagogical content knowledge, namely knowledge of content and students and knowledge of content and teaching, but hypothesise that there is a third, less recognised domain of content knowledge for teaching, namely specialised content knowledge. Ball et al. do not view specialised content knowledge as a subdomain of pedagogical content knowledge, but rather as a subdomain of 'pure' content knowledge. In Ball et al's. framework of the knowledge needed by teachers, specialised content knowledge is different from the common content knowledge needed by both teachers and non teachers. Ball et al's. specialised content knowledge includes subject knowledge that is unique to teaching; it is knowledge that goes 'beyond that taught to students'

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(2008, p. 400); is used by the teacher to unpack the mathematics for the learner and involves 'making features of particular content visible to and learnable by students' (2008, p. 400). In this study, these aspects of teachers' knowledge are included in pedagogical content knowledge.

Ball et al.'s knowledge of content and students combines knowledge of students and knowledge of mathematics. Ball et al. hold that teachers need knowledge of the 'common conceptions and misconceptions that students bring to the classroom or develop as they learn the subject' (2008, p. 394). This involves teachers being able to anticipate what students are likely to think and what they will find confusing; understand learners' thinking and use of language to express their emerging understanding of mathematical concepts (2008, p. 401). Teachers being able to anticipate what students are likely to think and what they will find confusing are aspects which align closely with the DIPIP focus on error analysis. Ball et al.'s knowledge of content and teaching, combines knowing about teaching and knowing about mathematics. As with specialised content knowledge and knowledge of content and students, knowledge of content and teaching is specific to teaching. It involves knowledge of how to sequence content, select examples and select representations to teach content (2008, p. 401). Knowledge of content and teaching aligns with the way in which I have operationalised pedagogical content knowledge in my study.

In conclusion, this review of the literature on pedagogical content knowledge reveals that a knowledge of learners' understandings, conceptions and misconceptions and knowledge of instructional strategies and representations are the two components of pedagogical content knowledge mentioned by all researchers. In addition, it can be said that, although the construct of pedagogical content knowledge still lacks clear definition, there is general agreement that it represents a 'move away from the notion of pedagogy as a content-free skill' (Rollnick et al., 2008, p.1365). My view of pedagogical content knowledge is that the whole is greater than the sum of the parts, that is, I see pedagogical content knowledge as being more than the sum of pedagogic knowledge and content knowledge. This differs from Schulman's view that pedagogical content knowledge is located at the intersection of content knowledge and pedagogic knowledge.

2.2.4 Relationship between content knowledge and pedagogical content knowledge

There is on-going debate as to whether subject matter knowledge (content knowledge in my study) and pedagogical content knowledge are separate knowledge components or are merged (Kind 2009, p. 180). In integrative models, pedagogical content knowledge is not recognised as a separate knowledge component, whereas in transformative models pedagogical content knowledge is described as 'new knowledge arising from the act of transforming subject matter, pedagogical and contextual knowledge for the purposes of instructing students' (Kind 2009, p. 180). According to Shulman (1986, 1987) pedagogical content knowledge lies at the intersection of content knowledge and pedagogical knowledge.

According to Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu (2008), subject matter knowledge (or content knowledge) is a pre-requisite for the development of pedagogical content knowledge.

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However other researchers, for example Brodie and Sanni (2014) contest the stance that developing subject matter knowledge (or content knowledge) is necessarily primary and that the development of all other forms of teacher knowledge has to be founded on content knowledge. While not disagreeing that the development of teachers' content knowledge is important, Brodie and Sanni argue that 'the relationships between teachers' content knowledge and pedagogical content knowledge are more nuanced.' Brodie and Sanni (2014, p. 3) speak of a two-way relationship between content knowledge and pedagogical content knowledge which they regard as being 'mutually constitutive'. The view that content knowledge is not always primary supports Park's assertion that the development of one component of teacher knowledge may 'simultaneously encourage the development of others, and ultimately enhance pedagogical content knowledge.' (Park 2007, p. 745).

Geddes (1993) pointed out that developing teachers need to transform their subject matter knowledge (or content knowledge) into a version that is suitable for use in teaching learners. I argue that this is part of the process of developing pedagogical content knowledge. Ball et al., (2008) hold that the content-specific components of mathematics are found in the specialised content knowledge of the subject. Marks (1990), who based his pedagogical content knowledge model on data collected from primary mathematics teachers, included subject matter knowledge in the definition of pedagogical content knowledge, adding that 'subject matter knowledge and pedagogical content knowledge were not clearly distinguished knowledge components'.

Following this review of the literature on teacher knowledge, it can be concluded that some form of teacher knowledge beyond content knowledge is essential if teachers are to make knowledge accessible to their learners. I agree with Marks' assertion that subject matter knowledge (content knowledge) and pedagogical content knowledge are not easily distinguishable. Although I have separated content knowledge and pedagogical content knowledge in my study of teacher knowledge conversations in one DIPIP professional learning community in order to make the analysis more manageable, I remain cogniscent of the fact that the separation is not always clear cut. Data need to be (and have been) analysed with this in mind. Having discussed teacher knowledge, I now move on to discuss the Data Informed Practice Improvement Project, an initiative in which content knowledge is seen to develop in tandem with the development of pedagogical content knowledge.

2.3 Data Informed Practice Improvement Project (DIPIP)

The professional learning community under study is a part of DIPIP. A brief outline of DIPIP, particularly DIPIP Phase 3, is provided to enable the reader to understand the context of the study. DIPIP is a project which focuses on the development of mathematics teachers in professional learning communities - which are discussed in more depth in Section 2.4 below. The main aim of DIPIP is to improve teachers' practices through developing pedagogical content knowledge and some content knowledge. This is done by creating a platform for professional conversations in which mathematics teachers, together with university academics or teachers as facilitators, discuss what information test data provide which can be used to think about reasons for learner errors and how these might be

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addressed through collaborative lesson planning, teaching and reflection. The project aims build and sustain professional learning communities in which teachers engage with data from a range of sources and work together to better understand the nature of learners' errors and how they might respond to them' (Brodie, 2013, p.7).

DIPIP was planned from the outset to be a long-term project, based on research which showed that short-term, fragmented seminars and workshops do not work (Borko 2004; Brodie and Shalem 2011). Having distilled the work of several researchers (Borko 2004; Jaworski 2008; Katz, Earl & Ben Jafaar 2009; Kazemi & Hubbard 2008), Brodie (2013) identified six key characteristics of successful teacher development programmes. According to Brodie (2013), DIPIP takes all six of these characteristics into account. The six key characteristics are: 'they are long term and developmental; they focus on artifacts of practice such as student thinking, tasks and instructional practices; they use actual classroom data; they encourage design and reflection on the part of teachers; they are job-embedded (school-based) and therefore blur the boundaries between teaching and learning about teaching; and they promote the development of professional learning communities' (Brodie 2014, p. 5).

According to Brodie (2013) the DIPIP facilitators[7] and team put a lot of time and effort into ensuring that the professional learning communities are sustainable, not only during the set-up phase, but also during the on-going roll-out of the DIPIP programme. This is achieved by respecting the participants' time and knowledge and acknowledging their expertise regarding their schools and learners (Brodie, 2014). In DIPIP, teacher professional development is achieved by supporting teachers to participate in a sequence of activities in which they analyse learners' errors in different teaching contexts. It is the teacher conversations within these planned project activities that form the basic unit of analysis of the development of content knowledge and pedagogical content knowledge in this study.

In light of the fact that the focus of DIPIP is on teachers learning to work with learner errors and consequently the bulk of the teacher conversations under study focuses on learner errors, a review of the DIPIP stance regarding learner errors is provided. Based on the extensive research literature on errors and misconceptions in mathematics, DIPIP regards errors as systematic, persistent and pervasive mistakes performed by learners across a range of contexts (Brodie, 2013, Brodie & Berger, 2010, p. 169). Brodie (2011) goes further to say that, in terms of error analysis, the DIPIP focus is on the reasoning behind the learner errors as the reasoning is often valid. In this way, errors are used as a route to learner thinking (Brodie, 2015, personal communication). This aligns with the view of Borasi (1994) that errors are evidence of reasonable and interesting thinking on the part of the learner. The project distinguishes errors from slips (Olivier 1996) and recognises that 'since errors are systematic and persistent, they are not necessarily responsive to easy correction or re-explanation of concepts' (Brodie 2013, p. 8). In terms of working with learner errors, the DIPIP stance is to encourage teachers to embrace errors, to value learner thinking and to seek to find ways of understanding why learners

7 Two types of facilitators play a role in the DIPIP programme. Both university-based facilitators (part of the project team) and school-based facilitators (teachers) are involved in leading the communities.

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have made errors. Brodie (2013, p. 9) describes the DIPIP approach to errors as being one in which teachers are encouraged not to shy away from errors, but rather to 'search for ways to understand why learners may have made errors' and to find ways to engage their current knowledge in order to create new knowledge', particularly in the light of the DIPIP stance that errors are not a sign of a teaching and/ or learning deficit and are a normal part of learning mathematics.

Since I will argue that the design of the project and, in particular the design of the project activities, plays an important role in the extent to which the professional learning community talks about pedagogical content knowledge and content knowledge, a description of the professional learning community activities in Phase 3 in 2013 is provided. Although nine activity types are specified in the DIPIP framework, only four activity types are pertinent to this study because not all the DIPIP activity types occurred in 2013[8]. The four activity types are error analysis, learner interviews, lesson planning and lesson reflection. During error analysis activities, teachers discuss learners' answers to test items, focusing on common errors and learner thinking behind errors. During the learner interview activities, teachers select and discuss errors which they plan to probe in one-on-one interviews with learners. During lesson planning meetings, teachers work collaboratively to plan and prepare lessons on topics selected by the professional learning community. During lesson reflection activities, teachers reflect on lessons they have taught and which have been video recorded, in order to understand their strengths and challenges in dealing with learner errors in class.

To conclude this section on the Data Informed Practice Improvement Project, I discuss the DIPIP view of pedagogical content knowledge and content knowledge and the way in which the development of these components of teacher knowledge is approached. A clear understanding of the DIPIP approach to the development of pedagogical content knowledge and content knowledge is fundamental to three aspects of my study, namely the ways in which the professional learning community talks about pedagogical content knowledge and content knowledge, the relationship between the way in which the professional learning community talks about pedagogical content knowledge and content knowledge and the design of the DIPIP project, and the relationships between pedagogical content knowledge conversations and content knowledge conversations in the professional learning community.

According to Brodie and Sanni (2014, p. 1) 'much of the work on teacher knowledge suggests that content knowledge shapes pedagogical content knowledge, and in fact is primary in the relationship between the two forms of knowledge'. Brodie and Sanni (2014) challenge this view and contend that 'building teachers' practices and their pedagogical content knowledge can build their content knowledge' (Brodie & Sanni 2014, p. 2). Drawing on evidence from teacher development projects in South Africa and in Nigeria, Brodie and Sanni (2014), argue that constraints arising from teachers' regular practice and pedagogical content knowledge can 'be overcome in professional development programmes designed to take such knowledge relationships into account and that in these contexts

8 In 2013, the year of study, the teachers in this professional learning community had participated in the project for two years and often chose to priortise activities they preferred.

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engagement with pedagogical content knowledge can lead to improvement of content knowledge' (Brodie and Sanni, 2014, pp. 4–5). Based on their arguments and examples, I align with the view of Brodie and Sanni (2014) that pedagogical content knowledge affects content knowledge – that is, that the development of content knowledge does not necessarily have to precede the development of pedagogical content knowledge.

The DIPIP approach to the development of content knowledge and pedagogical content knowledge is that teachers think about what they do in the classroom, that is their practice, first and that the best way of developing teachers' content knowledge is via pedagogical content knowledge. The DIPIP activities are structured in such a way as to promote pedagogical content knowledge conversations, and my study will show that this is, indeed, achieved. Moreover, pedagogical content knowledge conversations often lead to content knowledge conversations. According to Brodie (2012, 2103), the fact that content knowledge is discussed and learned in relation to pedagogical content knowledge makes it more powerful.

Contrary to many other teacher development programmes which start with content knowledge, the DIPIP approach to the development of teacher knowledge is to start with pedagogical content knowledge. The rationale behind this approach is that teachers are most focused on what happens in the classroom and that pedagogical content knowledge is foregrounded in teachers' thinking, and thus the most efficient way of developing teacher knowledge in the form of content knowledge is to access teacher thinking via their pedagogical content knowledge, and their existing knowledge of errors in particular.

The following statement by Brodie (2013, p. 15) encapsulates the DIPIP approach using learner errors as the context for developing content knowledge and pedagogical content knowledge: 'One of the key principles of the DIPIP project is that in coming to understand learner needs, teachers can come to understand their own learning needs: what mathematics they need to learn and how to use this new knowledge to improve their practice'. This statement emphasises the fact that the DIPIP approach is to use learners' errors as a method of bringing teachers' needs to the fore. Once teachers become aware of their needs, a situation which is conducive to the development of content knowledge and pedagogical content knowledge is created. DIPIP activities are designed to support teachers as they learn more about learner errors and learner thinking and, in so doing, develop their content knowledge and pedagogical content knowledge. In addition to creating opportunities for the development teacher knowledge, the focus on learner errors and, in particular, the reasoning behind learner errors creates the opportunity for teachers to use their content knowledge and pedagogical content knowledge in the classroom and thus improve their practices. In terms of the selection of topics for discussion during DIPIP PLC meetings, teachers, under the guidance of the facilitators (school and university), chose the content topics for discussion and lesson plans. In 2013, after a detailed analysis of learner errors in the 2012 Grade 9 ANA, the teachers chose to focus on exponents. Teachers in the PLC discussed the topic, drawing each others' attention to different content and teaching practices that may be required

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in different grades. The discussions focused on errors commonly made by learners with regard to exponents. Teachers worked together to plan lessons on the topic of exponents.

According to Brodie (2013), working in professional learning communities is one of the three key strands of DIPIP. A brief review of professional learning communities in general and the DIPIP approach to professional learning communities in particular, is provided in the next section.

2.4 Professional learning communities (PLCs)

A professional learning community is, or should be, what the name suggests – a group of professionals (in the case of DIPIP the professionals are teachers), who interact collectively (as suggested by the term community) in order to bring about learning. Researchers, including Clarke and Borko (2004), Jaworski (2008) and Brodie (2011, 2012, 2013), view professional learning communities as an effective, lasting and sustainable method of professional development in mathematics education. Brodie (2013, p. 15) holds that 'professional learning communities can be sites where deep and powerful learning among teachers takes place' but cautions that the creation of powerful professional learning communities requires a lot of thought and commitment, from all stakeholders – the teachers involved, professional learning community leaders, principals and departmental officials.

Several researchers have worked to identify features of professional learning communities. Drawing from existing literature, as well as her own research into teacher development programmes, Borko (2004) identified several features of professional learning communities. These features include that a professional learning community should develop a group identity and norms for interaction, a sense of communal responsibility for the regulation of norms and behaviour, and that professional learning community members should show a willingness to assume responsibility for the growth and development of other members of the community. Borko (2004) and Brodie (2011, 2013) emphasise the importance of the collective nature of professional learning communities as they provide a platform for teachers to 'collaborate and learn together about how their learners' needs can influence and improve their practice' (Brodie 2011). Brodie also argues that collectivity extends beyond collaboration because the DIPIP aim of achieving shifts in teacher practice can be achieved through collective shifts of practice. Katz, Earl and Ben Jafaar (2009) identify four key characteristics that a professional learning community needs to exhibit if it is to be successful and, in my opinion sustainable (which is an important element of success). Brodie represents Katz et al.'s four key characteristics of successful professional learning communities as follows: '(1) the professional learning community has a challenging focus; (2) the participants create productive relationships; (3) the participants collaborate; and (4) the participants engage through rigorous enquiry' (Brodie, 2013, p. 6).

I now review each characteristic systematically, with particular reference to the way in which the characteristic is dealt with in DIPIP professional learning communities. I start by discussing the focus of professional learning communities in general and DIPIP professional learning communities

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in particular. According to Katz et al., (2009, p. 23) it is essential that a 'clear, defensible focus' is established in order for a professional learning community to be successful, and that the focus is 'right, shared and understood' (Katz et al., 2009, p. 47). Katz et al. go further to say that the professional learning community focus should have high leverage in enhancing learners' learning and should be concrete, useful, challenging and shared by members of the community and should be appropriate for the context of the community. The professional learning community focus in DIPIP is learner errors from which learners' needs are established, and it is through the process of coming to understand learners' needs that 'teachers can come to understand their own learning needs' (Brodie 2013, p. 13), both in the form of content knowledge and pedagogical content knowledge.

Participants creating successful relationships through trust is the second of the four key characteristics identified by Katz et al., (2009). For Katz et al., professional conflict is encouraged so as to promote rigorous enquiry and growth. However, care must be taken to ensure that professional conflict does not become personal, and DIPIP facilitators go to great measures to ensure that 'we challenge the concept, not the person' (DIPIP facilitator during professional learning community meeting). The DIPIP facilitators 'set an example for building trust and care in the communities' (Brodie 2013, p. 8).

Much has been written about Katz et al.'s third and fourth key characteristics of successful professional learning communities, namely that participants collaborate and that they engage through rigorous enquiry. Jaworski (2006) also proposed enquiry as an important principle of teacher professional development and emphasised the importance of having communities of enquiry in which teachers and researchers work collaboratively on topics identified by the teachers. Brodie (2014, p. 226) contends that the DIPIP facilitators aim to achieve this by positioning teachers in two different ways. Firstly, teachers are recognised as experts – having knowledge of their own schools, classrooms, learners, current teaching practices and some learner errors. Secondly, teachers are recognised as learners with the potential for learning about how to engage with learner errors and the thinking behind learner errors and, in so doing, to improve their practice. Brodie (2013) argues that an aspect of the collaborative nature of the professional learning communities is that they should be supported by departments, schools and principals. Facilitators, in conjunction with the DIPIP project leader, also collaborate with each other in DIPIP. In her discussions of research involving several teacher development programmes in the United States of America, Borko (2004) speaks of the way in which teacher collaboration and mathematical conversations in professional learning communities foster teacher development.

In addition to Katz et al,'s four key characteristics of successful professional learning communities, Jaworski (2006) includes alignment as an essential feature of working in a professional learning community. Jaworski describes alignment as a critical process in which individual members of the learning community align themselves with the conditions and characteristics of the group. In DIPIP,

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the alignment which Jaworski speaks of is achieved, at least in part, by the fact that the teachers in each professional learning community either teach at the same school or, as in the case of the learning community under study, teach at schools that are closely located geographically. In DIPIP, the entire project team works hard to achieve alignment by negotiating with stakeholders and setting up the professional learning communities in such a way as to achieve maximum buy-in; ensuring that every session has a meaningful, learner error-aligned focus; preparing activities carefully; showing respect for teachers' time, knowledge and working conditions; ensuring that all meetings start and finish on time; and that planned meetings that are missed for any reason are made up.

2.5 Summary

Currently, learner performance in mathematics is poor at all levels in the school system. Resulting from this, there has been a proliferation of intervention programmes aimed at improving learner performance. I concur with the view that professional development programmes that focus on long-term teacher learning of content knowledge and pedagogical content knowledge have the potential to bring about lasting changes in teaching practices (Borko 2004; Kazemi & Hubbard 2008). For this reason, my study focuses on understanding the conversations of teachers in one professional learning community, with particular emphasis on development of teacher knowledge in the form of content knowledge and pedagogical content knowledge.

The review of the literature shows that pedagogical content knowledge is broadly accepted as an important component of the knowledge that teachers require in order to make knowledge accessible to their learners. Although there are differing views regarding the positioning of content knowledge in relation to pedagogical content knowledge, the importance of content knowledge in the repertoire of teacher knowledge is acknowledged by most researchers. In addition, evidence provided in the literature provides support for the claim that professional learning communities provide an effective platform for the development of teacher knowledge and that error analysis provides an entry into both learner and teacher learning needs, which can ultimately lead to shifts in teacher practice. The aim of this study is to explore the extent to which the professional learning community talks about content knowledge and how these teacher knowledge conversations are related to the design of the DIPIP project, as well to understand the relationships between content knowledge conversations and pedagogical content knowledge conversations in the DIPIP professional learning community.

In Chapter 3 I discuss my research design and methodology. I discuss my research approach, data collection processes, analytic framework, PCK'and CK rubric and the use of software to code the data in preparation for analysis, rigour and validity and ethical issues considered in the analysis of the data.

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Chapter 3:

Research Design and Methodology

3. 1 Research approach

It is difficult to classify my research approach using the categories of qualitative or quantitative analysis. It is not quantitative in that there are no variables and no statistical analysis. Although the approach makes extensive use of coding and counts of instances and time, the actual process of setting up the codes and the rubrics for codes fits more with qualitative methods than quantitative methods. It should be noted that counting instances is an acceptable methodology used in qualitative analysis. What also makes my research approach largely qualitative is that I have attempted to look for patterns of meaning in data collected mainly in the form of video and audio recordings of meetings of teachers in one professional learning community. My interest is in the teachers' content knowledge conversations and pedagogical content knowledge conversations. This is researched using a case study of a DIPIP professional learning community over a defined period, namely the year 2013.

My research design exhibits three of the nine characteristics of qualitative research, as outlined by McMillan and Schumacher (2010). First, behaviour is studied as it occurs naturally in professional learning community meetings. Teacher behaviour, particularly teachers' utterances, is studied in depth using video and audio recordings, and transcriptions of the professional learning community meetings. Second, the study is process-orientated in that the focus is on how teachers' pedagogical content knowledge conversations and content knowledge conversations occur. Third, the study is done with the belief that the explanations and interactions are likely to be complex and multi-faceted.

3.2 Participants

The participants in this study are the teachers in the DIPIP professional learning community under study. All participants were practising teachers at the time of the study. As is the case in many qualitative designs, the number of participants is small, with a regular core of four teacher participants. The participation of a fifth teacher was sporadic. It was the professional learning community, rather than the participants, that was selected for the study. The professional learning community was selected on the basis of its stability and functionality. Three of the four core participants have participated

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since 2011 and, in fact, have continued into 2014 and beyond. This stability, in association with the commitment of the facilitators and teachers to the project, has contributed to the high level of functionality of the professional learning community. Teachers focus on the tasks at hand and spend a lot of time talking about their work.

The professional learning community under study differs from other professional learning communities in DIPIP as it comprises teachers from three different schools, while in the other DIPIP learning communities the teachers are all from the same school. In the case of this professional learning community, the schools are small and there are not enough teachers to form a professional learning community in each school. Although the schools are in close proximity, the fact that the teachers are from different schools has resulted in some logistical challenges, for example, scheduling meetings at a time suitable for all teachers. In spite of the challenges, the professional learning community has remained stable. Although the professional learning community has been part of DIPIP since its inception, it has undergone some changes over the four-year period of DIPIP's existence. There has been one school change, some changes in teachers and the planned shift from a university facilitator to a school-based facilitator.

The professional learning community draws teachers from three state schools located in the same district in Gauteng Province. For ethical reasons, neither the schools nor the district are named. Table 3.1 shows that two of the three schools are secondary schools, accommodating learners from grades 8 to 12, while one of the schools is a junior secondary school, accommodating learners from grades 7 to 9.

Table 3.1: Schools in the professional learning community under study

	School type	Phase	Grades
School 1	Secondary	Senior and FET	8-12
School 2	Secondary	Senior and FET	8-12
School 3	Junior Secondary	Senior	7-9

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Table 3.2 provides participant information in the form of role played in professional learning community, qualifications, teaching experience, grades taught in 2013 (the year of study) and attendance. For ethical reasons, I have used pseudonyms for the five teachers in the professional learning community under study.

Table 3.2: Participants in professional learning community under study

	Role in PLC	Qualifications	Teaching experience (years)	Grades taught in 2013	Attendance
Chamu	Primary facilitator	Diploma in Education, B Tech Education	18	10, 11	regular
Mapula	Participant	BA Ed	30	8, 9	regular
Funeka	Participant	BA Ed	7	10	regular
Khumo	Participant	PTC SEC and SED	20	7	regular
Mandla	Participant; facilitator	BSc HDE (PG)	19	10, 11, 12	sporadic

3.3 Data

The data were collected by DIPIP before I started my study. As such, the planning for data collection and the actual collection of the data did not form part of my responsibility. All data was made available by DIPIP.

Video and audio recordings of professional learning community meetings

All meetings included in the study were recorded in either video or audio format as part of the planned DIPIP programme. All teacher participants were aware of the fact that they were being recorded and the necessary organisational and participant permissions were obtained, as discussed in Section 3.7 below. As this was not the first year of participation in DIPIP, the teacher participants were quite familiar and at ease with being recorded.

Table 3.3 below shows that 17 professional learning community meetings were included in my study. The distribution of these meetings across the four activity types discussed in Chapter 2 was as follows: two error analysis meetings, two learner interview meetings, five lesson planning meetings and eight lesson reflection meetings. Note that there were more reflection meetings than planning meetings. The spread of the meetings across the four school terms of 2013 was as follows: two meetings in term 1, six in term 2, eight in term 3 and one in term 4. The spread of DIPIP professional learning community activity types across the 17 meetings is relevant to my research findings regarding the relationship between the extent to which the professional learning community talks about content knowledge and pedagogical content knowledge and the design of the project. The spread of meetings

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across the four school terms in 2013 has a bearing on my findings regarding changes in the levels of content knowledge and pedagogical content knowledge conversations over the year.

Table 3.3: Summary of data used in study

Date of meeting	Activity type	Type of data	Duration of meeting	Term
04 March 2013	Error analysis	Audio	01:15	1
13 March 2013	Error analysis	Video	01:09	
15 April 2013	Learner interviews	Video	00:53	2
22 April 2013	Learner interviews	Video	00:16	
29 April 2013	Lesson reflection	Video	00:08	
20 May 2013	Lesson planning	Video	01:27	
03 June 2013	Lesson planning	Video	02:13	
13 June 2013	Lesson reflection	Video	00:45	
22 July 2013	Lesson planning	Audio	00:50	3
29 July 2013	Lesson planning	Audio	00:40	
02 August 2013	Lesson reflection	Video	01:53	
12 August 2013	Lesson reflection	Video	01:06	
19 August 2013	Lesson reflection	Video	01:30	
26 August 2013	Lesson reflection	Video	01:32	
09 Sept 2013	Lesson reflection	Video	00:40	
16 Sept 2013	Lesson planning	Video	01:20	
21 October 2013	Lesson reflection	Video	01:03	4

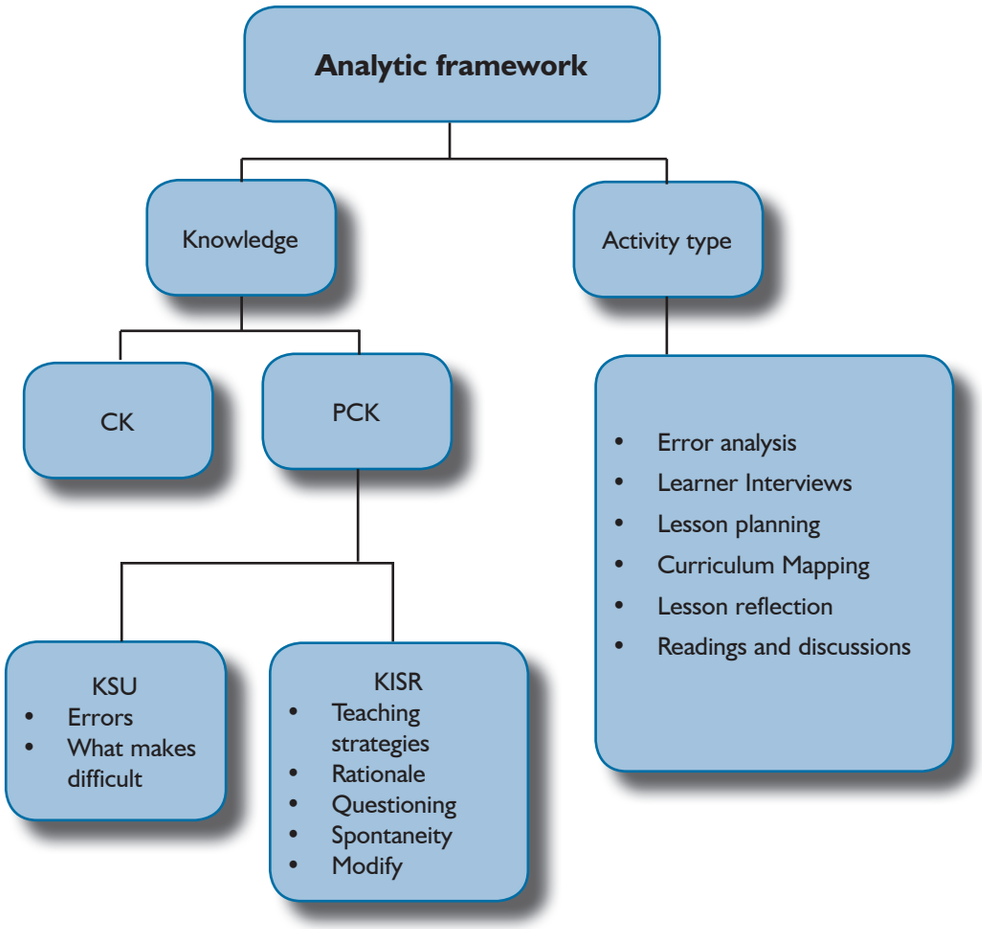
3.4 Data analysis

3.4.1 Analytic framework

Informed by the literature, and based on the DIPIP structure, I developed the analytic framework which I used in my study. The two main categories in my analytic framework, which is represented visually in Table 3.4 on the next page, are knowledge and activity type. The relationship between knowledge and activity type speaks to my first research question and the relationship between different types of knowledge conversations speaks to my second research question.

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Table 3.4: Analytic framework



Knowledge

Knowledge, one of the two main categories in my analytic framework, is categorised into two sub-categories, namely pedagogical content knowledge and content knowledge. The pedagogical content knowledge category is further sub-divided into two sub-categories, namely knowledge of student understanding (KSU) and knowledge of instructional strategies and representations of the subject matter (KISR). As discussed in Chapter 2, both of these categories of teacher knowledge were used in the PCK rubric developed by Park et al. (2010). Knowledge of student understanding is dissected further into the sub-categories of the identification of errors and learning behind errors, and the identification of what makes a topic or concept difficult. Knowledge of instructional strategies and representations of the subject matter is divided into five sub-categories namely, teaching strategies to accommodate errors and misconceptions, the rationale for strategies and representations in connection with learner understanding, the use of questions to probe learner thinking and understanding, teachers' spontaneity to challenge misconceptions or resolve learning difficulties discovered and the teachers' use of new

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understanding of learner understanding to modify instructional strategies and representations. The content knowledge category was not divided into sub-categories.

Activity types

Six activity types are identified in the analytic framework, but only four activity types are pertinent to this study. The six activity types are error analysis; curriculum mapping; learner interviews; readings and discussions; lesson planning and lesson reflection, with curriculum mapping and readings and discussions not being pertinent to this study as there were no meetings of this type in 2013 in the professional learning community under study. The classification of activity types emanated from the activity types as specified in the DIPIP framework. The two error analysis meetings were based on the learner answers to assessment items. The teachers had marked the learner's work ahead of the meetings. As a group, and under the guidance of the school-based facilitator, the teachers discussed learners' answers, focusing on common errors and learner thinking and reasoning behind the errors. The two learner interview meetings comprised the selection and discussion of errors which the teachers planned to probe in one-on-one interviews with learners. During the two lesson planning meetings, the teachers worked collaboratively to plan and prepare a lesson on a topic selected by the professional learning community. During most lesson reflection meetings the teachers reflected on lessons they had taught and which had been video recorded. Teachers prepared for lesson reflection meetings by selecting one 'good episode' and one 'not so good episode' from their lesson. Each teacher showed the video clips of the two episodes to their professional learning community colleagues and a discussion followed. The good and not so good episodes were selected on the basis of the teacher's handling of errors in the classroom. In some of the lesson reflection meetings, teachers reflected on good and not so good episodes that had been presented during a network learning community meeting[9] by their counterparts from other professional learning communities.

Although not DIPIP activity types, episodes during which professional learning community participants were involved in setup, closure or off topic discussions were included under activity in the code window as they formed part of the meeting timeline and thus needed to be coded in some way. The coding process is discussed in more detail in Section 3.4.3 below.

3.4.2 PCK and CK rubrics

The purpose of this study is to explore pedagogical content knowledge conversations and content knowledge conversations in one professional learning community. In order to do this, and on the basis of the theory of teacher knowledge discussed in Chapter 2, I developed research instruments, a PCK rubric and a CK rubric. The PCK rubric developed for use in this study is based on the rubrics developed by Park et al., (2010) and Mavhunga and Rollnick (2011). In Park et al.'s (2008) rubric, evidence of the level of the teacher's pedagogical content knowledge was elicited from observations

9 In DIPIP, a network community meeting consists of a meeting in which teachers from more than one of professional learning community come together to share ideas.

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of the teacher teaching as well as from pre and post observation interviews. Although the PCK rubric used by Park et al. (2008) was theoretically grounded in the pentagon model in which PCK was defined as an 'integral knowledge of five components' (Park and Oliver 2008b), Park et al's. rubric was designed to measure only two of the five key components of PCK, namely knowledge of learner understanding with respect to certain subject matter (KSU) and knowledge of instructional strategies and representations of the subject matter (KISR).

The two components of PCK which Park et al. included in the rubric were found by Park and Oliver (2007) to have been included as components of PCK by all 13 researchers reviewed (see Figure 2.4 in Chapter 2). These two components were initially identified by Shulman (1986) as key components of pedagogical content knowledge. They also fit with the aims of the DIPIP project for teacher learning. For the above reasons these are the two components of PCK which I have included in my rubric. The use of the two components of pedagogical content knowledge, namely KSU and KISR, was based on the Park et al. rubric (2010), while the four level descriptors in my rubric were based on the PCK rubric developed by Mavhunga and Rollnick (2011).

My PCK rubric is provided in Table 3.5. Note that the two main categories are KSU and KISR and that the PCK conversations are ranked on a four-point ranking scale, with a ranking of 1 indicating that the PCK conversations were limited (in terms of depth, not duration) and a ranking of 4 indicating an exemplary conversation.

Table 3.5: PCK rubric

Knowledge of learner understanding with respect to subject matter (KSU)				
	1 Limited	2 Basic	3 Developing	4 Exemplary
1. Identifies errors and reasoning behind errors	• No identification/ • No acknowledgement/ • No consideration of learner prior knowledge or errors	• Identifies errors or prior knowledge • Provides standardised knowledge as definition • Repeats standard definition with no expansion or with incorrect explanation	• Identifies misconception or prior knowledge • Expands and re-phrases explanation correctly • Provides an explanation of the error that takes some account of learner prior knowledge and reasoning behind the error	• Identifies misconception or prior knowledge • Expands and re-phrases explanation correctly • Talk about how they would confront error/ confirms accurate understanding

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2. What makes topic/ concept difficult? (occurs mostly in lesson planning)	• Identifies broad concepts without • specifying the actual sub-concepts that are problematic • Reasons not given	• Identifies specific concepts but provides broad generic reasons	• Identifies specific concepts with reasons related to specified prior knowledge of learners or common misconceptions	• Provides reasons linking to specific leverage concepts that when not fully understood adds to the difficulty of a concept regarded as difficult
Knowledge of instructional strategies and representations of the subject matter (KISR)				
	1 Limited	2 Basic	3 Developing	4 Exemplary
3. Teaching strategies to accommodate errors and misconceptions	• No evidence of acknowledgement of learner prior knowledge and/ or misconceptions • No integration of learner errors into teaching strategies, and no linking explanation • No discussion of representations/ explanations to enforce an aspect of a concept • Activities are largely teacher-centred	• Acknowledges learner misconceptions verbally but no corresponding evidence of confronting misconceptions • Little integration of learner errors into teaching strategies • Limited discussion of representations/ explanations to enforce an aspect of a concept • Limited evidence of efforts to involve learners	• Acknowledges learner prior knowledge and/or misconceptions, with some evidence of confronting misconceptions • Significant integration of learner errors into teaching strategies • Discusses one representation/ explanation to enforce an aspect of a concept • Significant evidence of attempts to encourage learner involvement	• Considers learner prior knowledge and there is evidence of confrontation of misconceptions. Overall , excellent strategy to teach required concept • Excellent integration of learner errors into teaching strategies • Discusses more than one representation/ explanation to enforce an aspect of a concept • Evidence that lessons are largely learning-centred
4. Rationale for teaching strategies and representations in connection with learner understanding (mostly in lesson preparation)	• No rationale for teaching strategies and representations in connection with learner understanding • Lacks aspects of curriculum saliency	• Weak rationale for teaching strategies and representations in connection with learner understanding • Lacks aspects of curriculum saliency	• Adequate rationale for teaching strategies and representations in connection with learner understanding • Considers at least one aspect related to curriculum saliency or sequencing or what not to discuss yet or emphasis of important concepts	• Strong rationale for teaching strategies and representations in connection with learner understanding • Considers at least two aspects related to curriculum saliency or sequencing, what not to discuss yet, emphasis of important conceptual aspects

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5. Questioning to probe learner understanding (mostly in lesson delivery)	No questions to probe learner thinking and understanding	1-2 questions to probe learner thinking and understanding	3-5 Questions to probe learner thinking and understanding	More than 5 questions to probe learner thinking and understanding
6. Spontaneity to challenge misconceptions or resolve learning difficulties discovered	No recognition and/or no attempt to challenge learner errors or resolve learning difficulties discovered during instruction	1-2 attempts to challenge learner errors or resolve learning difficulties discovered during instruction	3-4 attempts to challenge learner errors or resolve learning difficulties discovered during instruction	More than 4 attempts to challenge learner errors or resolve learning difficulties discovered during instruction
7. Use of new understanding of learner understanding to modify instructional strategies and representations	No attempt to change instructional strategies and representations based on new understanding of learner understanding	Few attempts to change instructional strategies and representations based on new understanding of learner understanding	Some attempts to change instructional strategies and representations based on new understanding of learner understanding	Many attempts to change instructional strategies and representations based on new understanding of learner understanding

My CK rubric is provided in Table 3.6. Note that there are no sub-categories for CK and that the levels and descriptors are similar to the PCK rubric.

Table 3.6 CK rubric

CK				
	1 Limited	2 Basic	3 Developing	4 Exemplary
Content knowledge	No discussion	Limited discussion	Discussion of CK leads to some new understandings for participants	Discussion of CK is appropriate and leads to substantial new understandings for participants

It is acknowledged that measuring only two components of pedagogical content knowledge is a limitation of my rubric. A second limitation of the rubric developed for use in this study is that the rubric is generic in that it is developed for use across topics and, as such, and does not accommodate the topic-specific nature of pedagogical content knowledge, as described by Mavhunga and Rollnick (2013). It should be noted, however, that the topic-specific nature of pedagogical content knowledge is embedded to some extent in the construct of KSU.

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3.4.3 The coding process

The next step was to code the data. Using the meeting transcriptions[10], in conjunction with the video or audio recordings, I followed a structured process to divide the discourse into conversation units. Conversation units were demarcated on the basis of shifts in the conversation – that is, when there was a change in topic and/or conversation type (PCK or CK). Conversation shifts can be triggered by the facilitator or a participant and a shift does not necessarily occur when the speaker changes; shifts can occur within the narrative of one speaker.

Once the teachers‘conversations had been demarcated into conversation units, each conversation unit was coded according to activity, knowledge and level. As discussed above, nine activity types were coded but the activities of set up, closure and off topic were not coded any further and were not used in the analysis of data. It is of interest to note that setup, closure and off-topic conversations occupied only 3% of the total conversation time, meaning that the teachers spent 97% of the conversation time discussing PCK and CK.

Conversation units involving PCK were coded as KSU or KISR and their respective sub-categories. All conversation units involving CK and PCK were coded according to the level of the discussion. The levels as defined in my rubric for quantifying PCK and CK were used to identify the level at which the discussions took place. A coding manual was developed and used in conjunction with the rubric for quantifying PCK and CK. The coding manual is found in Appendix I.

The coding was done using a software programme called Studiocode™. The Studiocode™ software allows the video footage and audio recordings to be plotted along a timeline, which could then be divided into conversation units as described above. Each conversation unit was then coded using the code window as shown below. The development of the code window was based on the PCK and CK rubrics developed for use in my study and the standardised activity codes used in the DIPIP programme.

Figure 3.1 on the nex page shows the code window which I used in my study. A code window is a Studiocode™ feature which is used to code each conversation unit in each meeting.

10 In this study the term transcription is used in two different ways. First, meeting transcriptions are the transcriptions of the utterances of participants during professional learning community meetings. Second Studiocode™ transcriptions are the matrices of conversation counts and types developed using Studiocode™ software.

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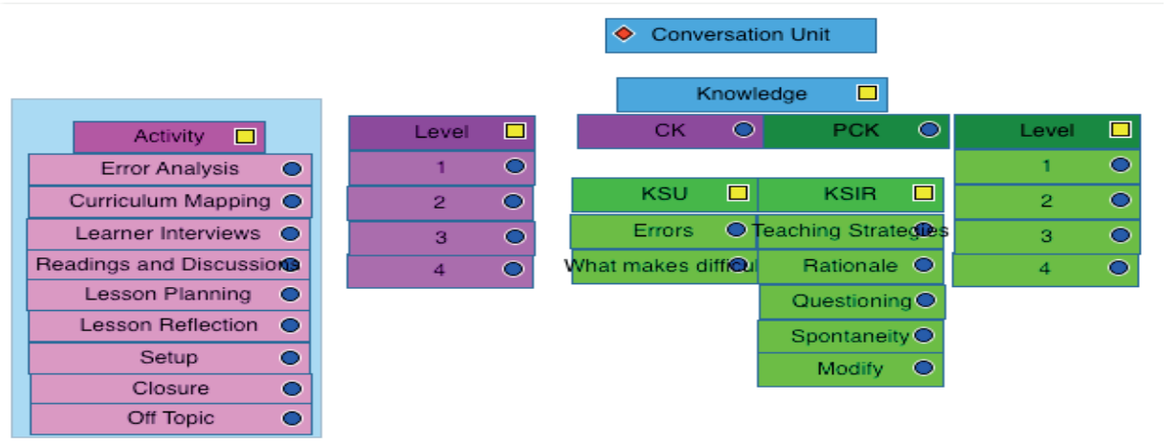


Figure 3.1: Code window

Once all 17 professional learning community meetings had been coded using Studiocode™, the Studiocode™ programme was used to generate the matrices and code reports which form the basis of the data analysis in this study. Each code report was scripted in such a way that the required information was included in the code report.

Figure 3.2 shows a code report in which both the count and time for each level of each category of CK and PCK are reported. This code report combines the data for all 17 meetings. For example, this code report shows that there were 29 instances of a Level 3 KSU-errors conversations, and Level 3 KSU-errors conversations occupied 1 hour and 17 minutes of the total 9 hours, 9 minutes and 30 seconds of the total PCK time (see blocked part of report).

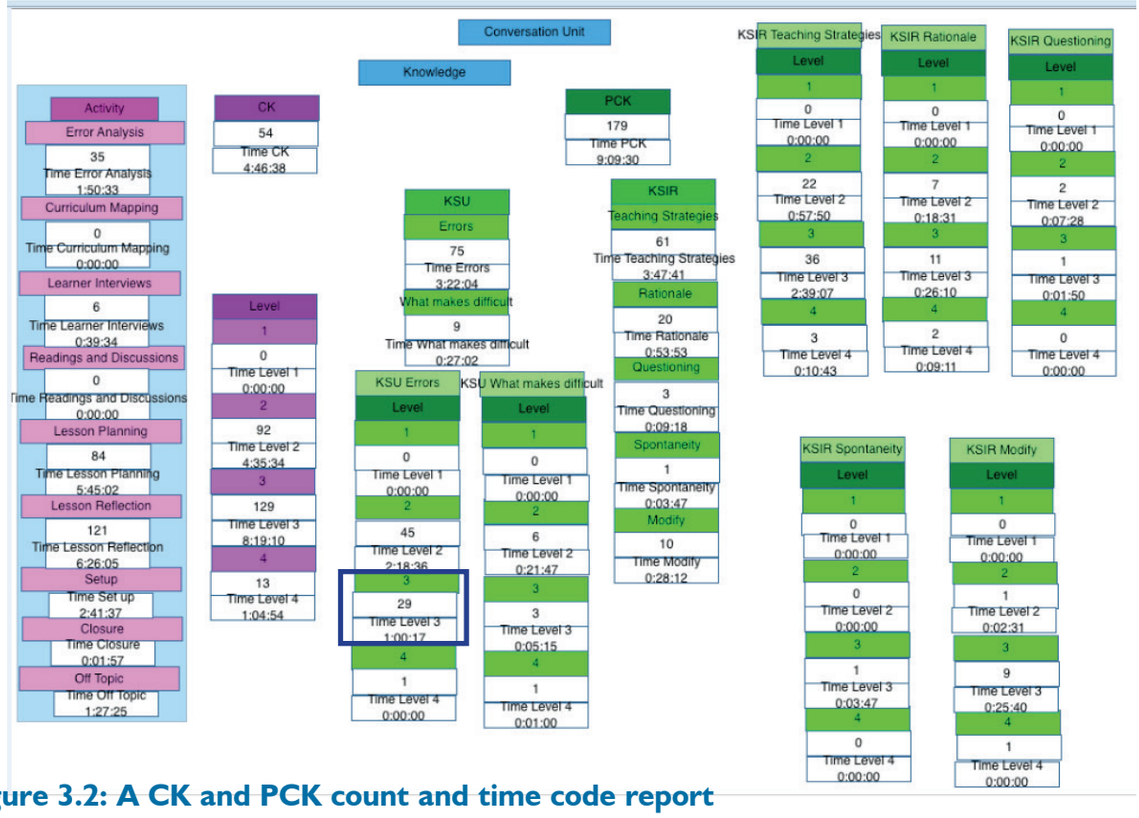


Figure 3.2: A CK and PCK count and time code report

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3.5 Limitations

A drawback of qualitative research is that it can present challenges in terms of validity, reliability and the extent to which conclusions can be generalised. This limitation can be exacerbated when, as is the case in this study, a single entity (case) is studied. There is also the risk of findings being affected by conscious or unconscious researcher bias. I have remained cogniscent of these limitations and, through my research design and methodology, have attempted to reduce these limitations as far as possible. To achieve this, I have constantly returned to the evidence when making claims and I have been ever cogniscent of the fact the intention of this study is not to provide broad, generalisable findings, but rather to analyse the specific circumstances in which CK and PCK were developed in one DIPIP professional learning community.

3.6 Ensuring rigour in my research

Historically, reliability and validity have not been regarded as being as important in qualitative research as in quantitative research. My interpretation of the concept of validity is aligned with that of Bassey (1999), who claims that validity is the extent to which a research finding is what it is claimed to be. My research findings are particular to the development of pedagogical content knowledge and content knowledge in one specific professional learning community and validity is ensured by not making any claims beyond this. Validity is further enhanced through the use of the case-study approach, a close analysis of the data by the researcher herself and the use of video or audio recorded data which allows the researcher to constantly re-visit the data and confirm findings.

I have used counts of events to support my findings. This is in the endeavour to address the criticism that in a qualitative study anecdotes are often selected to support the writer's argument, and thus introduce an element of researcher bias, by. In an attempt to further strengthen the rigour of my study, I used the Studiocode™ computer software programme in my data analysis as a way of ensuring that conversation units are systematically analysed. The presentation of counts is used to provide information on the representivity, spread and depth of instances of PCK and CK in teacher conversations during professional learning community meetings. The counts were done using a systematic coding system in conjunction with a detailed rubric, thus reducing the impact of researcher bias.

A second strategy used to improve the validity of the study was the use of detailed transcription techniques when the professional learning community conversations were transcribed. The transcriptions were done in such a way as to reveal subtle features in the conversations. This means that non-verbal cues such as pauses and hesitations were also noted in the transcript. This enabled the researcher to pick up fine nuances in the conversations. The validity of judgments based on the conversations was further strengthened by the Studiocode™ software.

Reliability refers to the extent to which similar results can be produced under "constant conditions on all occasions" (Bell, 1999 in Opie, 2004). The strategies I have used to strengthen the reliability,

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and thus the rigour, of my study included dong both intra- and inter-reliability checks on the coding of CK and PCK in professional learning community conversations. In the intra-reliability checks, I checked the consistency of my coding over time by re-coding the same three conversations two weeks after I had coded them the first time and then comparing the results. I found my intra-coding reliability to be above the acceptable standard of 95%. In the inter-reliability checks, my coding was compared to that of my supervisor and one fellow researcher and found to be acceptable. The major cause of differences between my coding and that of my supervisor emanated from ambiguities in the rubric used to do the coding. The rubric, as well as the Coding Manual (See Appendix 1), were further strengthened on the basis of the results of the coding reliability checks.

I have endeavoured to ensure rigour in my research through the use of self-questioning and have at all times focused on getting it right and being accurate (McMillan & Schumacher, 2010:333).

3.7 Ethical considerations

I was granted approval from the School of Education Ethics Committee of the University of the Witwatersrand (Protocol number: 2014ECE026M). As no new data needed to be collected, this approval fell under the approval granted to the Data Informed Practice Improvement Project, Protocol number: 2010ECE189C. Organisational Consent to conduct research in specified secondary schools in Gauteng was granted to DIPIP by the Gauteng Department of Education.

Participants' Informed Consent was obtained from teachers, learners and parents. Teachers granted permission and consent for participation, recording and use of recordings. Learners and parents granted permission for participation in the research project.

As a fellow human being, I owe it to the participants in my study, to respect and protect their dignity, confidentiality and anonymity at all times. All data, including videotapes, audiotapes and transcripts are stored under password-protected conditions. Anonymity has been achieved through the use of pseudonyms for teachers and schools.

In Chapter 4 I present my analysis of the data which serves to answer my research questions regarding the extent to which the professional learning community talks about content knowledge and pedagogical content knowledge; the relationship between the extent of the teacher knowledge conversations and the design of the project; and the relationships between content knowledge and pedagogical content knowledge in the professional learning community under study.

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Chapter 4:

Results and findings

4.1 Introduction

In this chapter I present my analysis of the conversations of the teachers during the 17 professional learning community meetings in my study. The data were analysed using the processes described in Chapter 3, focusing on teacher knowledge in the form of content knowledge and pedagogical content knowledge, as well as the levels at which the conversations were conducted. The primary argument that I make is that it is the type of professional learning community meeting activity that is the main determining factor in the type and depth of teacher knowledge in the discussions. It is the activity in the professional learning community meeting that triggers content knowledge and pedagogical content knowledge conversations and is the primary determinant as to whether the conversation will focus largely on content knowledge or pedagogical content knowledge. I also show that most of the conversation time for both content knowledge and pedagogical content knowledge took place on Level 3, but that while the level of conversation increased over the year for pedagogical content knowledge, the level of conversation declined over the year for content knowledge.

This chapter starts with a discussion of my results and findings. The general discussion on pedagogical content knowledge is followed by a more detailed elaboration of the pedagogical content knowledge conversations. Finally, the levels at which the conversations took place, and findings regarding changes in the levels of conversation over the year under study are presented and analysed.

4.2 CK and PCK in the conversations

I start by showing that both CK and PCK conversations did take place during the professional learning community meetings. I do this by looking at both the number (count) of each conversation type and the time spent on each conversation type.

The count and time for CK and PCK conversations are shown in Tables 4.1 and 4.2 on the next page. As explained in Chapter 3, the count and time for each type of teacher knowledge conversation was obtained by scripting a combined code report for the 17 meetings. When analysing the data, I decided that the count of the instances was not a valuable indicator of the extent of the different teacher

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knowledge conversations because, as will be shown later, the CK conversations were generally longer than the PCK conversations, but there were fewer of them.

Table 4.1: Count of CK and PCK conversations

Type of conversation	Count	Percentage of total teacher knowledge conversation count
CK	54	23
PCK	179	77
Total	**233**	**100**

Table 4.2: Time spent on CK and PCK conversations

Type of conversation	Time*	Percentage of total teacher knowledge conversation time
CK	04:47	34
PCK	09: 10	66
Total	**13:57**	**100**

* All times are rounded to the minute.

The data in Tables 4.1 and 4.2 show that CK and PCK conversations did take place during professional learning community meetings. In total, CK and PCK conversations occupied 97% of the professional learning community conversation time under analysis. The other 3% of the time is accounted for in set up, closure and off topic conversations.

It is evident from Tables 4.1 and 4.2 that PCK conversations outweighed CK conversations in both count and time spent. There were considerably fewer CK conversations than PCK conversations, with 54 CK conversations and 179 PCK conversations. There are at least three possible explanations for this. First, CK conversations tended to be longer than PCK conversations. Once a CK discussion on a particular mathematical concept was initiated, the professional learning community took a significant amount of time to work through the concept so as to ensure new understanding for teachers, leaving little time for pedagogical content knowledge conversations during the meeting. Second, the professional learning community activities were designed for the purpose of developing teacher knowledge in the form of PCK in particular. This design is the result of the DIPIP philosophy regarding the relationship between PCK and CK, which is that where teachers have CK learning needs, CK teacher knowledge conversations will arise out of PCK conversations. This means that all DIPIP activities in the cycle target PCK conversations first and foremost. It is thus not unexpected to find more PCK than CK teacher knowledge conversations. Third, the methodology for demarcating conversation units might account for some short CK conversation being ‘lost’ in PCK conversations. Although not substantial, this could account for CK conversations having a lower count than PCK conversations.

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Teacher conversations that were classified as CK occupied approximately 34% of the total teacher knowledge conversation time, while PCK conversations occupied approximately 66% of the total teacher knowledge conversation time. The fact that CK conversations are generally longer than PCK conversations becomes evident when comparing the data in Tables 4.1 and 4.2. Although 23% of the total teacher knowledge conversations were CK conversations, 34% of the teacher knowledge conversation time was spent on CK conversations. Once again, the fact that PCK conversations occupy more of the teacher knowledge conversation time aligns with the design of the DIPIP activities, as well as the DIPIP philosophy on the relationship between PCK and CK. Taking account of the fact that the DIPIP approach to the development of teacher knowledge prioritises PCK, the percentage of CK conversation time is, perhaps, higher than expected.

Table 4.3 shows the total amount of time spent on each activity. Data are listed for the four DIPIP activities pertinent to my study and as identified from the analytic framework. Note that the total meeting time analysed and discussed excludes setup, closure and off topic discussions. This applies to all analysis from this point onwards.

Table 4.3: Conversation time for each activity

Activity type	Total time	Percentage of total conversation time
Error analysis	01:51	13
Learner interviews	00:40	5
Lesson planning	05:45	41
Lesson reflection	06:26	44
Total	**14:46**	**103**[11]

The amount of professional learning community conversation time allocated to the different DIPIP activities is also a contributing factor regarding the amount of CK and PCK conversation time in total. Table 4.3 shows that lesson planning and lesson reflection account for a combined total of 85% of professional learning community conversation time. The reader is reminded that Table 3.3 in Chapter 3 showed that eight of the seventeen professional learning community sessions under study were lesson reflection activities and five were lesson planning activities.

4.2.1 CK, PCK and activity types

An overview of the four activity types pertinent to my study, namely error analysis, learner interviews, lesson planning and lesson reflection was provided in Chapter 2. My primary argument is that the amount of time the professional learning community spends talking about CK and PCK is closely related to the design of the activities, In spite of the fact that all DIPIP project activities are designed

11 The minor errors in the data are the result of the rounding process.

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to focus on PCK, Tables 4.4 and 4.5 below show that different activity types do, in fact, support both CK and PCK conversations, and that the percentage of CK and PCK conversation time varies significantly across the four activity types.

Table 4.4: CK conversation time by activity type

Activity type	Time	Percentage of CK conversation time	Percentage of total conversation time
Error analysis	00:31	11	4
Learner interviews	00:25	9	3
Lesson planning	02:47	58	20
Lesson reflection	01:03	22	8
Total	**04:46**	**100**	**35**

Table 4.5: PCK conversation time by activity type

Activity type	Time	Percentage of PCK conversation time	Percentage of total conversation time
Error analysis	1:19	14	9
Learner interviews	0:02	<1	<1
Lesson planning	2:57	32	21
Lesson reflection	4:51	53	35
Total	**9:09**	**99**	**65**

In terms of time, there was more CK conversation during lesson planning activities than in any other activity type, with 58% of the total CK conversation time occurring during lesson planning of professional learning community meetings (Table 4.4), in spite of the fact that lesson planning activities accounted for 40% of the professional learning community meeting time under study (Table 4.3). A possible reason for such a high amount of CK conversation time occurring during lesson planning meetings is that it is during lesson planning meetings that teachers attempt the examples themselves and, when they encounter difficulties, they are supported by their colleagues and the facilitator. A possible reason for the second highest amount of CK conversation time occurring during lesson reflection meetings (22% of total CK conversation time) is that it is during lesson reflection meetings that teachers' analyses of learner errors provide the stimulus for CK conversations.

In terms of time, there was more PCK conversation during lesson reflection activities than in any other activity type, with 53% of the total PCK conversation time occurring during lesson reflection professional learning community meetings (Table 4.5). A possible explanation for this is that during lesson reflection meetings teachers are required to identify 'good' and 'not so good' episodes in terms of the way in which they dealt with learner errors during the lesson. As a professional learning

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community, the teachers view video clips of these episodes and discuss what makes them good or not so good. Apart from some discussion which could constitute CK conversation – 22% of total CK conversation time (Table 4.4), the discussions during lesson reflection meetings are PCK conversations because they are about teaching and its relationship to learning and mathematical thinking.

Error analysis and lesson reflection activities elicit more PCK conversation than CK conversation time. This aligns with the DIPIP view of PCK and CK and the way in which the development of these components of teacher knowledge is approached. As discussed in Chapter 2, and based on the work of Brodie (2013) and Brodie and Sanni (2014), the DIPIP approach to the development of teacher knowledge is to develop CK via PCK. If PCK is the trigger which leads to the development of CK, then it is not unexpected to find that, overall, there is more PCK conversation than CK conversation. Overall, PCK (66%) accounted for nearly double the amount of conversation time, when compared with CK (35%).

The findings regarding the duration of CK and PCK conversations in this study differ from the findings in other studies. For example, results in a study by Ceresto (in preparation) showed that in both professional learning communities under study, CK conversations occupied very little of the total conversation time, whereas the results in my study indicate that about one third (35%) of the conversation time was devoted to CK conversations. While it is premature to draw strong conclusions, the results here suggest that the DIPIP design may be a reason.

The analysis thus far shows that CK and PCK conversations did take place in the professional learning community meetings, that there was more PCK conversation time than CK conversation time and that the amount of CK and PCK conversation time varied across the DIPIP activity types, with PCK conversation time being highest in lesson reflection and lesson planning activities, and CK conversation time being highest in lesson planning activities.

In order to give the reader some insight into typical CK and PCK conversations, I include excerpts from a CK conversation and a PCK conversation.

4.2.2 Examples of teacher knowledge conversations

I operationalised CK and PCK as separate forms of teacher knowledge, and have shown that CK and PCK times and counts vary across DIPIP activity types and that, overall, more time is spent on PCK conversations than on CK conversations. However, I do acknowledge that CK and PCK are closely linked and that the separation can be restrictive at times as CK and PCK discussions are often closely interlinked. I am cogniscent of the fact that there is divided opinion on the relationship between CK and PCK. For example, Kind (2009) speaks of integrative models of PCK in which PCK is not recognised as a separate knowledge component, and transformative models of PCK where PCK is recognised as a separate knowledge component. In this section, I provide an example of a CK and a PCK conversation, as well as the reasons why the conversations were classified as such.

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Example of a CK conversation

As stated above, CK conversations are, by nature, very long. It is thus not possible to include an entire CK conversation as an example. The excerpts below are from a typical CK conversation, which took place during the lesson reflection meeting of the 26 August 2013. The CK conversation, which was one of 17 conversation units in the meeting, lasted 12 minutes and 15 seconds.

In this example the teachers, with the guidance of the facilitator, worked through two different methods of simplifying an expression involving exponents. It is an example of a CK conversation because the discussion focuses on developing new understanding for participants (teachers). The teachers' CK is developed as they are exposed to a variety of ways of simplifying an expression involving exponents. This conversation was identified as a CK conversation because, through their discussions of mathematics, participants develop their own knowledge of strategies to simply fractions involving exponents. Although Chamu (the facilitator) dominates the conversation, the responses from Funeka and Mapula indicate that they are participating in the conversation, and are following his explanations.

This was the expression under discussion:

$$\left(\frac{2a^3.3a^2}{6(a^3)^2}\right)^2$$

Funeka starts by grappling with how to simplify the numerator of the expression, where she needs to raise a power to a power: Chamu, the facilitator, supported Funeka as follows:

Chamu	Right, take us through.
Funeka	…Okay and then I will say two multiply by three, I'll get six and then *a* will be raised, three *a*, this number must be multiplied by the number that is outside the bracket which is three, two – sorry – three multiplied by two will be six and then because I've already multiplied the base and then I'll say, I'll have my *a* which is two to the exponent two which it will give us, I think it will give us four. Okay, just because we said, okay, before I continue with this, the brackets I think, no, they are not there but I should think; Meneer, I forgot.
Chamu	Do you want me to help you?
Funeka	Wait a bit. This one multiply. There is one that is raised to the exponent two. This one is also raised to the exponent one multiplied by two. Okay, I should think they raised one with this one – can I go back a little bit? Okay, let me just say number two and *a*, three by two, three one by two, then a two by two, okay and then six one by two into a three by two. Okay, one by two is two to the two and three by two is six, three by two is two and *a* to the four and then it will be a to the six, three is *a* to the exponent of six. ..

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Later in the conversation, when Funeka seems to be at a loss regarding what to do, Chamu offered CK support by suggesting that they use the BODMAS[12] rule in order to deal with the inner and outer brackets in the expression. Chamu goes further by reminding teachers to use a law of exponents when they multiply to raise a power to a power. Note the way in which the facilitator used questioning and provided examples so that Funeka (and the rest of the professional learning community) can develop their CK.

Chamu	Maybe I can assist you or are you still fine, ma'am or do you need assistance?
Funeka	No, I need assistance.
Chamu	Okay. Alright, myself I would do it slightly differently. First of all, if there are brackets, I usually think of BODMAS to say, 'What does BODMAS say? Brackets first.' So, I will deal with the brackets first, inside the brackets, then the last thing will be the square. Inside, is it allowed to say two times three? Can I multiply like this inside the brackets? Is it fine? I get six. Then this one maybe I can use the laws of exponents. What is it? It's *a* to the power …
Funeka	Five.
Chamu	Three plus two is five. Then here, there's six. What is here? Again, we're using the laws of exponents; *a* to the exponent what? It will be *a*, let's say *x* to the exponent *a* raised to the power *b*; what is the answer? Do you remember something?
Funeka	It's *ab*…

In the next part of the conversation, teachers grapple with one strategy for dealing with the numerator and the denominator together. The participants' CK is developed as they work through two different methods of dividing fractions involving exponents. Chamu reminds them that they are dividing and demonstrates that the five numerator *a*'s can be cancelled against five of the six denominator *a*'s (division), leaving one a in the denominator. In the second strategy, the participants use BODMAS and the laws of exponents to simplify the expression.

Chamu	Mathematically? Then this one, you have five of them here, you have six here. If I cancel, what am I left with? Five on top dividing here, where they use laws, five minus six or this idea of cancelling. Are we still together?
Funeka	…The law is what?
Chamu	One, two, three, four, five.
Funeka	Five *a's*, six *a's*.
Chamu	And the bottom, I have six. Ah-ha, so if I divide five of them by another five…
Mapula	You are left with one.
Chamu	One over?

12 BODMAS is an acronym for Brackets, Of, Division, Multiplication, Addition and Subtraction. It lists the sequence of operations in which multi-operation expressions should be computed.

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Funeka	*a*
Mapula	*a*
Chamu	*a,* still inside the brackets.
Funeka	Mhm.
Chamu	If I square this one by this, same as one over *a* times one over *a,* which is one over *a* squared. Okay, let's do it using that method. Two *a* cubed multiplied by three *a* squared all over six *a.* Allow me to simplify this one like this. Are you happy? Squared means repeat the bracket. Two *a* what?
Mapula	Two *a* cubed and three *a* squared.
Chamu	Cubed divided by three *a* squared.
Mapula	Divided by six *a* to the six.
Chamu	*Six a to the six…*
	It will still be the same as this one but as I'm suggesting that we use BODMAS just in this, try to simplify as much as… Someone can quickly do this; two here, two here, then three if you are doing it very fast there. I mean, these a's, this is six, that is five; already one is remaining at the bottom. I square it, I get that. You can do it very fast. Always do your brackets first then other things later. I don't know, there are a lot of shortcuts that you can do, as long as you… The long-cut, yes, I mean the long way of doing it. Yes but let's remember to simplify...These are the aims of DIPIP. We help one another…

Example of a PCK conversation

This excerpt from a conversation during a lesson planning professiomal learning community meeting is typical of the PCK conversations which took place across the meetings. The meeting was held on 29 July 2013 and teachers were planning a Grade 9 lesson. Mandla was the facilitator and the teachers were anticipating the errors learners would make.

This conversation is classified as a PCK conversation because it focuses on knowledge of learner understanding with respect to subject matter which, in this conversation, is exponents. I have identified this as an example of a PCK conversation because teachers work systematically through a process of anticipating the errors that learners might make when solving an equation involving an exponent containing a variable. In order to anticipate the errors learners might make, teachers needed to draw on their knowledge of student understanding with respect to subject matter (KSU), focusing particularly on identifying reasoning behind errors and what makes a concept difficult. As discussed in Chapter 2, Park (2007) identified KSU as one of the five components of the pentagonal model and included it in her PCK model. The discussion was developmental in that teachers shared their views regarding the errors learners might make. In terms of levels, this conversation would be classified as a Level 2 (Basic) PCK-KSU conversation because it does not go beyond identifying the anticipated error and does not provide an explanation of the error that takes some account of learner prior knowledge and the reasoning behind the error.

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The conversation starts with the teachers confirming what they were expecting to do, namely to check mistakes or anticipate learner errors, as well as confirming the actual question.
The mathematical equation being discussed was $2^{x+1} = 32$
In this equation, the value of x is 4.

Mandla	…we are going to check the possible mistakes or anticipate the possible mistakes from the learners.
Mapula	Anticipate their errors, yes.
Mandla	Ja, the exponent you are going to use is what? Two to the exponent *x*..?
Mapula	Two to the exponent *x* plus one.
Khumo	Add one.
Mandla	Plus one is equal to thirty two.
Mapula	Is equal to thirty two.

Next, the teachers anticipate the errors learners might make. The first error the teachers anticipate is that learners will ignore the fact that the x+1 is an exponent and that they will solve the equation as if the question read:

$$2x+1 = 32$$

In this equation, with learners ignoring the fact that the $x + 1$ is an exponent, the value of x is 15,5. Put differently, the teachers anticipate that learners will calculate the value of x to be 15,5 because they will ignore the fact that $x + 1$ is an exponent. Once they had discussed the anticipated error, the eachers went on to discuss how they thought learners would solve the equation as if it read:| $2x + 1 = 32$. Mandla suggested that learners would eliminate the constant 2 from $2x$ by dividing the $2x$ and the 32 by 2*, to get* $x + 1 = 16$.

Mandla	Yes, ja, and what is the first thing that learners might do with this equation instead of solving for *x*? When they're trying to solve for *x*, they will try to do what? Personally, I think they'll divide by two both sides. For me, I think they will say two into two, one; two into thirty two.
Khumo	Sixteen.
Mandla	Sixteen.

It is interesting to note that in the conversation excerpt above, none of the participants discussed the fact that the + 1 on the LHS of the equation had not been divided by 2.

Funeka agreed with Mandla in anticipating that learners would ignore the fact that $x + 1$ is an exponent, but suggested that they would transpose the 1, to get the equation $2x = 31$, and then divide each side of the equation by 2 in order to remove the constant from the $2x$. Using this process, learners would find $x = 15,5$.

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Funeka	I should think because they will be solving for *x*, they will bring the *x down because the x*, there is the exponent.
Mandla	The *x* plus one.
Funeka	*x* plus one, they will bring it down to be two *x* plus one and then start by dividing or expose, transpose one.
Mandla	What they are saying…is two *x* plus one.
Funeka	Yes, plus one is equals to thirty two.
Mandla	Is equal to thirty two and then expand and transpose what?
Funeka	One.
Mandla	One, so it's going to be negative one and two *x*.
Funeka	Ja and then they'll solve for *x*.
Mandla	*x* will be..?
Mapula	They divided that by itself, fourteen.
Mandla	Fifteen comma five.
Mapula	Which is sixteen.
Funeka	It's fourteen comma five, I think so.
Khumo	Fifteen comma five, ja.
Funeka	It's fifteen comma five? Okay, ja, fifteen comma five.
Mandla	They are ignoring it. They don't even see that.
Funeka	Ja, they don't want to see the exponents. It's difficult for them.

Having provided an example of a content knowledge conversation and a pedagogical content knowledge conversation, in the next section I discuss two different relationships between content knowledge and pedagogical content knowledge conversations, namely content knowledge conversations triggering pedagogical content knowledge conversations – which is the standard view, and pedagogical content knowledge conversations triggering content knowledge conversations – which is the DIPIP approach to the relationship between the development of content knowledge and pedagogical content knowledge

4.3 The relationship between Content Knowledge and Pedagogical Content Knowledge

As discussed in Chapter 2, there is debate regarding the nature of the relationship between the development of content knowledge and pedagogical content knowledge. According to Brodie and Sanni (2014, p. 2) 'much of the work on teacher knowledge suggests that content knowledge shapes pedagogical content knowledge, and in fact is primary in the relationship between the two forms of knowledge', a stance which Brodie and Sanni (2014) challenge. In this section I will show that in the community meetings, conversations about pedagogical content knowledge can lead to both content

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knowledge learning and pedagogical content knowledge learning. This aligns with the DIPIP approach to the development of teacher knowledge and supports the argument of Brodie and Sanni (2014). I add to the argument by claiming that the development of content knowledge and pedagogical content knowledge is often iterative, as conversations, and thus the potential for the development of content knowledge and pedagogical content knowledge, switch between pedagogical content knowledge and content knowledge. In my study of the DIPIP professional learning community conversations, I found examples of examples of content knowledge conversations leading to pedagogical content knowledge conversations (the standard view), as well as examples of pedagogical content knowledge conversations leading to content knowledge conversations (the DIPIP view). It needs to be emphasised that the existence of a particular conversation type (pedagogical content knowledge or content knowledge) does not guarantee the development of that form of teacher knowledge, but rather creates a platform for the possible development of that type of teacher knowledge.

The professional learning community meeting which took place on 4 March 2013 provides an example of a situation in which PCK conversations triggered CK conversations. As the whole conversation is too long to reproduce here, I base the discussion on evidence provided in a transcription[13] generated using Studiocode™ software. The transcription is shown in Table 4.6. The reader is directed to the knowledge column of the transcription in particular. In this column, the type of conversation (CK or PCK is indicated) for each of the 19 conversation units coded for the professional learning community meeting which had a duration of 75 minutes.

13 In the Studiocode™ software programme, a transcription is a table which shows a count of the type of conversation (CK or PCK), the sub-type of the PCK conversation, and the level at which the conversation took place.

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Table 4.6 Transcription of 4 March error analysis professional learning community meeting

Conversation unit	Activity	Knowledge	KSU	PCK Level	CK Level
1	Error analysis	PCK	Errors	3	
2		PCK	Errors	2	
3		PCK	Errors	2	
4		CK			3
5		PCK	Errors	3	
6		PCK	Errors	3	
7		PCK	Errors	3	
8		CK			4
9		PCK	Errors	3	
10		CK			4
11		PCK	Errors	2	
12		PCK	Errors	2	
13		PCK	Errors	2	
14		PCK	Errors	3	
15		CK			4
16		PCK	Errors	3	
17		PCK	Errors	2	
18		CK			3
19		PCK	Errors	3	

During this professional learning community meeting the conversation starts with teachers looking for common learner errors. The test items involved changing decimals to scientific notation (which requires an understanding of the use of exponents) and simplification of expressions containing exponents. The first PCK conversation led to the conclusion that many learners made errors when simplifying the following expression:

$3 \times 3 + 2 \times 3$

The meeting started with a PCK conversation in which teachers identified common learner errors provided the opportunity for the facilitator to realise that some of the teachers needed CK support. The PCK conversation was thus was followed by a CK conversation (conversation unit 4 in Table 4.6)

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in which the facilitator led the teachers through two different methods of simplifying the expression. One of the teachers followed the two methods easily, while the facilitator needed to use questioning to guide another of the teachers through the two methods, meaning that there was an attempt to develop the CK of at least one of the participants. The other two participants were silent during this conversation. This is an example of a situation in which a PCK conversation triggered a CK conversation.

Another PCK conversation followed (conversation units 5–7) as the teachers continued to look for common errors in other test items. This PCK conversation was, however, not triggered by the preceding CK conversation. Instead, the PCK conversation was triggered by the DIPIP activity type, namely error analysis. Although PCK conversations followed CK conversations five times during this professional learning community meeting, in no instances were the PCK conversations triggered by the preceding CK conversations. This professional learning community meeting thus presents a clear case of PCK conversations triggering CK conversations and, perhaps, the development of content knowledge.

An example of a relationship between CK and PCK, in which a CK conversation triggered a PCK conversation, is found in the professional learning community lesson planning meeting which took place on 29 July 2013. Following a lengthy CK discussion in which the reasons why $2^5 = 32$ were clarified for some of the teachers, the conversation shifted to a PCK conversation on when and how to teach the concept.

The line below is the end of a CK conversation. What makes it a CK conversation is that the teachers discuss the mathematics of $2^5 = 32$, not the strategies and representations they could make the concept accessible to their learners.

Mandla Thirty two. So, that means thirty two is written in two ways there. One is thirty two as it two as it is, is, ne, and the other one, in terms of exponent, is two to exponent five.

The extract below is the start of the PCK conversation. What makes it a PCK conversation is that the teachers discuss strategies they could use to make the concept accessible to their learners. The first strategy suggested by Mandla, the facilitator, is to use questioning to guide learners to think about a way of representing 32 ‘as an exponent or a power’.

Funeka But if the learner asks, “Why are we writing two to the exponent five? Why can’t we just solve it as it is?”

Mandla How? …I think the follow-up question would be, “What will be your other method of solving it?”

Mapula Of solving it.

Mandla Yes but that’s for me. I would ask them, “What do you think we can do to solve that again if we do not change the thirty two and write it as an exponent or as a power in fact?”

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The next strategy suggested by the facilitator is to explore alternative methods or representations and to probe to find out how learners came to their answer:

Mandla If the learner can come up with an alternative way and it works, it's even better. Then you, I think, at the end of the day, you say, "We want the skill here. We want the skill of what?" If there's a mixed thing, like there's a whole number and the exponents. Maths is about getting an easier and a better way of trying to a particular problem. So, if you've got a better way than this one, show us. We are actually trying to give you a better way of solving this because we have an exponent on the left-hand side. We prefer that everything must look the same. If we are doing exponent, exponent; if it's whole numbers, let it be whole numbers all the way, you see? I think I'm – one way or another – answering that question.

Mapula Yes.

Mandla So things look easier to deal with otherwise, as it is there, would that learner be able to solve?
If the learner can say, "Yes." then you find out how. If he can come up with a better method, that is the best, then, ja.

Thirty two. So, that means thirty two is written in two ways there. One is thirty two as it is, ne, and the other one, in terms of exponent, is two to exponent what?

Group Five.

Table 4.7 on the next page shows counts of teacher conversation units, activity type, conversation unit switches, CK conversations triggering PCK conversations, and PCK conversations triggering CK conversations. The data were extracted from a transcription which was a composite of the 17 professional learning community meetings. The count of teacher conversation units was restricted to teacher knowledge conversations, meaning that setup, closure and off topic conversations were excluded. The count of conversation unit switches was restricted to switches between CK and PCK. As the sequence of the teacher knowledge conversations does not, on its own, indicate a relationship between the conversation types, data are provided regarding the number of conversation switches in which one conversation type triggered another conversation type. This data is provided in Columns 7 and 8 of Table 4.6. It should be noted that the count of conversation units does not necessarily equate to the sum of the CK triggering PCK conversations and PCK conversations triggering CK conversations because not all teacher knowledge conversations are triggered by CK or PCK. In other words, KSU conversations usually triggered KISR conversations.

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Table 4.7: Summary of transcriptions of all 17 PLC meetings[14]

Date of meeting 2013	Activity type	Count					
		Teacher knowledge conversation units	CK	PCK	Conversation unit switches	CK triggering PCK	PCK triggering CK
04 March	Error analysis	19	5	14	10	3	5
13 March	Error analysis	16	3	13	2	1	1
15 April	Learner interviews	1	1	0	0	0	0
22 April	Learner interviews	5	3	2	1	1	0
29 April	Lesson reflection	2	1	1	1	0	1
20 May	Lesson planning	17	4	13	7	2	3
03 June	Lesson planning	22	7	15	9	2	5
13 June	Lesson reflection	16	0	16	0	0	0
22 July*	Lesson planning	30	10	20	18	7	7
29 July							
02 August	Lesson reflection	22	3	19	2	1	0
12 August	Lesson reflection	6	0	6	0	0	0
19 August	Lesson reflection	16	4	12	2	1	1
26 August	Lesson reflection	11	2	9	3	0	2
09 Sept	Lesson reflection	11	2	9	2	1	1
16 Sept	Lesson planning	15	11	4	5	2	3
21 October	Lesson reflection	10	2	8	3	2	1
Total		**219**	**58**	**161**	**65**	**23**	**30**

An analysis of Table 4.7 provides information on the relationship between content knowledge conversations and pedagogical content knowledge conversations. Of the 58 content knowledge conversations across the 17 meetings, 30 (52%) were triggered by pedagogical content knowledge conversations. This leaves 28 content knowledge conversations (48%) which did not arise out of pedagogical content knowledge conversations. The bulk of the content knowledge conversations (55%) took place during lesson planning meetings. During lesson planning meetings teachers attempt to solve the mathematics problems themselves and this sometimes leads to content knowledge conversations. In such cases, it is to be expected that the content knowledge conversation need not necessarily have been triggered by a pedagogical content knowledge conversation. In this situation, new content knowledge conversations started as teachers worked through the examples they planned to include in the lesson.

14 The data for meetings of the 22 and 29 July have been combined as the 29 July meeting was a continuation of the 22 July meeting.

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Of the 161 pedagogical content knowledge conversations, 23 (14%) were triggered by content knowledge conversations. This relatively low CK-PC trigger rate could be ascribed, at least in part, to the fact that there were many more pedagogical content knowledge conversations (by count) than content knowledge conversations and that the focus of the DIPIP activities was to start with PCK.

This section adds to the previous analysis which shows a substantial amount of time given to content knowledge conversations in this professional learning community. Here I have shown that many content knowledge conversations are triggered by pedagogical content knowledge conversations and so can suggest more strongly that the DIPIP project design does support both PCK and CK conversations. My argument here is that teachers feel more comfortable talking about pedagogical content knowledge, as this is close to what they do in their classrooms, and that teachers are more reluctant to engage in content knowledge conversations. Thus, starting the conversations with pedagogical content knowledge discussions gives teachers an opportunity to gain confidence and this, in conjunction with the deficits in teachers' own content knowledge that may be revealed in the pedagogical content knowledge conversations, provides a platform for the initiation of content knowledge conversations. I argue further that starting professional learning community meetings with pedagogical content knowledge conversations provides facilitators with rich opportunities to show respect for the teachers' knowledge and so gain the trust of teachers (Brodie 2013).

4.4 Elaborating PCK

While CK conversations were not differentiated into sub-categories, PCK conversations were further categorised into conversations about knowledge of students understanding (KSU) and knowledge of instructional strategies (KISR).

It is evident from Table 4.8 that more PCK conversation time was spent on KISR than on KSU. This is an unexpected finding, given the fact that DIPIP prioritises understanding learner thinking (KSU) ahead of practice (KISR). The fact that there was more KISR conversation time than KSU conversation time can be explained, at least in part, by the fact that most conversations around errors (the kernel of KSU conversations) quickly led into KISR conversations which centre on instructional strategies for dealing with the errors. In other words, KSU conversations usually triggered KISR conversations.

Table 4.8: KSU and KISR in professional learning community conversations

	Time spent	Percentage of PCK time	Percentage of total conversation time
KSU	03:49	42	27
KISR	05:22	58	38
Total PCK time	**09:11**	**100**	**66**

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Teacher's knowledge of learner understanding (KSU) was differentiated into two components, first knowledge of errors – identification of errors and learners' reasoning behind the errors; and second knowledge of what makes a topic or concept difficult. As is evident in Table 4.9, significantly more KSU conversation time (88%) was spent identifying errors and discussing the reasoning behind the errors than on discussing what makes a concept difficult (12%).

Table 4.9: Time spent on each category of KSU conversations

	Time spent	Percentage of KSU time	Percentage of PCK time	Percentage of teacher knowledge conversation time
Identifies errors and reasoning behind errors	03:22	88	37	36
What makes topic/ concept difficult?	00:27	12	5	<1
Total	**03:49**	**100**	**42**	**37**

Teachers' knowledge of instructional strategies and representations of the subject matter (KISR) was differentiated into five sub categories, namely teaching strategies to accommodate errors and misconceptions, rationale for teaching strategies and representations in connection with learner understanding, questioning to probe learner understanding, spontaneity to challenge misconceptions or resolve learning difficulties discovered and, finally, the use of new understanding of learner understanding to modify instructional strategies and representations.

Table 4.10 on the next page shows that the majority of KISR conversation time (71%) was spent discussing teaching strategies to accommodate errors and misconceptions. As was shown in Table 4.9, the bulk of the KSU time was spent identifying errors and reasoning behind errors. It is thus reasonable to find that most of the KISR time was spent discussing teaching strategies to accommodate the identified errors and misconceptions as teachers discuss ways of implementing their learning and findings. The professional learning community spent a relatively low percentage (17%) of KISR conversation time discussing rationale for teaching strategies and representations in connection with learner understanding. This could be due, at least in part, to the fact that teachers are more comfortable discussing what they do in the classroom than discussing the reasons for what they do (Brodie, personal communication). The amount of time spent discussing rationale for teaching strategies and representations in connection with learner understanding might have been higher had facilitators probed for this. Only 13% of KISR conversation time was spent in conversations on the other three sub-categories of KISR, namely questioning to probe learner understanding, and use of new understanding of learner understanding to modify instructional strategies and representations.

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Table 4.10: Time spent on each category of KISR conversation

	Time spent	Percentage of KISR time	Percentage of PCK time	Percentage of teacher knowledge conversation time
Teaching strategies to accommodate errors and misconceptions	03:48	71	41	27
Rationale for teaching strategies and representations in connection with learner understanding	00:54	17	10	6
Questioning to probe learner understanding	00:09	3	2	1
Spontaneity to challenge misconceptions or resolve learning difficulties discovered	00:04	1	<1	<1
Use of new understanding of learner understanding to modify instructional strategies and representations	00:28	9	5	3
Total	**05:23**	**≈ 100**	**≈ 59**	**≈ 38**

Tables 4.11 and 4.12, show KSU and KISR conversations as a percentage of PCK in each activity type and provide evidence to support my argument that the professional learning community activity type is a determinant in the type of teacher knowledge conversation. I have shown that lesson planning and lesson reflection are the two activity types that elicited the most CK conversation and PCK conversation, 28% of total conversation time and 56% of total conversation time respectively. An analysis of Tables 4.11 and 4.12 reveals that the activity type has some influence on the type of PCK conversation. Error analysis and lesson reflection are the two activity types during which there is most KSU discussion, while lesson planning and lesson reflection are the two activity types during which there is most KISR discussion.

Table 4.11: KSU conversations as a percentage of PCK in each activity type

	Activity type			
	Error analysis	Learner interviews	Lesson planning	Lesson reflection
Identifies errors and reasoning behind the errors	14	<1	3	20
Identifies what makes topic/ concept difficult	0	0	4	0
Total	**14**	**<1**	**7**	**20**

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Table 4.12: KISR conversations as a percentage of PCK in each activity type

	Activity type			
	Error analysis	**Learner interviews**	**Lesson planning**	**Lesson reflection**
Teaching strategies to accommodate errors and misconceptions	0	0	20	22
Rationale for teaching strategies and representations in connection with learner understanding	1	0	5	5
Questioning to probe learner understanding	0	0	0	2
Spontaneity to challenge misconceptions or resolve learning difficulties discovered	0	0	0	1
Use of new understanding of learner understanding to modify instructional strategies and representations	0	0	0	5
Total	**1**	**0**	**25**	**35**

In summary, my findings show that lesson planning and lesson reflection meetings create the most opportunities for the development of teachers' PCK and that the activity type has some influence on the type of PCK conversation. In addition, I have argued that more PCK conversation time was spent on KISR than on KSU and that KSU conversations usually triggered KISR conversations. My findings in terms of the sub-categories of KISR and KSU are that the majority of KISR conversation time was spent discussing teaching strategies to accommodate errors and misconceptions and that significantly more KSU conversation time was spent identifying errors and discussing the reasoning behind the errors than on discussing what makes a concept difficult.

4.5 Levels of CK and PCK conversations

I move on to show that CK conversations and PCK conversations occurred at different levels. The levels referred to here are the levels from the PCK and CK rubrics, discussed in Chapter 3 and summarised in Table 4.13 beow:

Table 4.13: Levels from CK-PCK rubric

Level	**1**	**2**	**3**	**4**
Descriptor	Limited	Basic	Developing	Exemplary

Table 4.14 shows the levels at which CK and PCK conversations took place. In both CK and PCK, the bulk of the conversations took place at Level 3, which is described in the CK rubric as 'discussion which leads to some new understanding for participants'. The percentage of Level 3 conversation was 76% and 51% for CK and PCK respectively. There was only one, very short PCK Level 4 conversation, which was a KSU conversation on what makes a concept difficult. There was also

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limited CK Level 4 conversations (14% of total CK time) which, by definition, led to significant new understanding for participants. In general, the CK conversations took place at a higher level than the PCK conversations. This is might be ascribed to the fact that the facilitator, who has strong content knowledge, talked more during CK conversations than during PCK conversations. Differences in descriptor levels in the CK and PCK rubrics, making it marginally easier to achieve higher levels in CK than in PCK might also have had some impact on this finding. Table 4.14 shows that there was no Level 1 CK or PCK conversation. This is ascribed to a limitation in the rubrics, where the descriptors for Level 1 (Limited) indicate that there was no evidence of the criterion being discussed.

Table 4.14: Levels of CK and PCK conversations

		Time (percentage of total conversation time)	
Level	Description	CK	PCK
1	Limited	0	0
2	Basic	10	45
3	Developing	76	51
4	Exemplary	14	4

4.5.1 Changes in levels of conversations over the course of the year

I now discuss how the levels of CK and PCK conversations changed during the course of the year. As the bulk of CK conversation took place on Level 3, this level of CK conversation is discussed in more detail.

Table 4.15 shows the distribution of the DIPIP professional learning community activity types across the year. This distribution is of significance when considering changes in the levels of conversation over the course of the year because I argue that the level of conversations is linked to the activity type.

Table 4.15: Number of each type of DIPIP professional learning community activity across the four terms

	Error analysis	Learner interviews	Lesson planning	Lesson reflection	Total
Term 1	2				2
Term 2		2	2	2	6
Term 3			3	5	8
Term 4				1	1
Total	**2**	**2**	**5**	**8**	**17**

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An analysis of Tables 4.16 and 4.17 should take account of the spread of DIPIP professional learning community activities across the year as indicated in Table 4.15. The meetings are not evenly spread across the four terms. Some form of grouping of meetings was required to accommodate a longitudinal analysis of conversation level changes over the year, and it was decided to use the four school terms as the criterion for grouping the meetings. With hindsight, this was possibly not the best criterion to use – this limitation is discussed in more detail in Chapter 5. In particular, it should be noted that there were two DIPIP professional learning community meetings, both error analysis meetings, in Term 1; and only one DIPIP professional learning community meeting, a lesson reflection meeting, in Term 4.

Table 4.16 shows how the percentage of CK conversation time on Levels 2-4 changed over the course of the year. The percentage of Level 3 conversation time started high (70%) and increased during the course of the year, while the percentage of Level 4 conversation time declined over the year.

Table 4.16: Percentage of CK conversation time on Levels 1–4

Conversation	Term 1 %	Term 2 %	Term 3 %	Term 4 %	Whole year %
CK conversation time: Level 1	0	0	0	0	0
CK conversation time: Level 2	0	7	14	10	10
CK conversation time: Level 3	70	79	80	90	76
CK conversation time: Level 4	30	14	6	0	14
Total CK time	**0:13**	**1:44**	**2:18**	**0:14**	**4:47**

The decrease in Level 4 conversation time could be partly due to the increase in Level 3 conversation time. I also argue that, with CK in particular, the level of conversations is linked to the activity type. A possible reason for this is that for a CK conversation level to be at Level 3 or 4, the discussion needs to lead to some (Level 3) or substantial (Level 4) new understanding. In order for this to happen, a fairly lengthy CK discussion needs to take place. CK discussions, particularly lengthy CK discussions, tend to occur in Lesson Planning and Lesson Reflection professional learning community meetings because that is when teachers work through the examples themselves.

Another factor which may contribute to the decline of CK Level 4 conversation time, particularly in Term 4, is the DIPIP programme of activities over the four terms. There was only one DIPIP professional learning community meeting during Term 4 (refer to Table 3.3 in Chapter 3), and that was a lesson reflection meeting. As discussed in Section 4.2.1, lesson reflection activities do not elicit much CK conversation and, as explained earlier, a CK conversation needs to be fairly lengthy if it is to achieve the substantial new understanding required of a Level 4 conversation. It would be interesting to investigate changes in conversation levels over the four years of DIPIP Phase 3, not just over the course of one year, as has been done in this study.

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Table 4.17 shows that over the whole year the highest percentage of PCK conversation time (50%) took place at Level 3, closely followed by Level 2, which accounted for 45% of the PCK conversation time. Only 4% of the PCK conversations took place at Level 4.

Table 4.17: Percentage of PCK conversation time on Levels 1–4

Conversation	Term 1 %	Term 2 %	Term 3 %	Term 4 %	Whole year %
PCK Level 1	0	0	0	0	0
PCK Level 2	76	35	46	32	45
PCK: Level 3	24	61	47	68	50
PCK: Level 4	0	4	7	0	4
Total PCK time	**0:30**	**2:35**	**4:31**	**1:26**	**100**

Looking at changes in PCK conversation levels over the course of the year, there is evidence to show that the percentage of PCK Level 2 discussion decreased from 76% of the total in Term 1 to 32% in Term 4 (however, it should be borne in mind that there was only one professional learning community meeting in Term 4). This decrease in Level 2 conversation time was paralleled by an increase in PCK Level 3 conversation time, from 24% in Term 1 to 68% in Term 4. In terms of time, most PCK conversation time was at Level 3. Although the highest percentage of PCK Level 3 conversation time (68%) took place in Term 4, this data is only based on one meeting and is thus possibly not a true reflection of the situation. The percentage of PCK Level 4 conversation time peaked in Term 3 (7%), but it should be noted that overall, there was little Level 4 PCK conversation so it would be unwise to place any significance on this. Based on the fact that most PCK conversation time was at Level 3 and that the percentage of Level 3 conversation time showed a general increase over the year, I conclude by saying that overall the level of PCK conversation increased over the year.

To summarise my findings on levels of conversation, most of the conversation time for both CK and PCK took place on Level 3. Levels of conversation changed over the year, with the level of conversation increasing over the year for PCK and decreasing over the year for CK.

4.6 Conclusion

In this chapter I looked at content knowledge conversations and pedagogical content knowledge conversations in 17 DIPIP professional learning community meetings. I found that:

1. Pedagogical content knowledge conversations outweighed content knowledge conversations in time spent, although there were a significant number of content knowledge conversations;
2. There was a relationship between the DIPIP activity type and the type of teacher knowledge conversation;

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3. A substantial number of content knowledge conversations were triggered by pedagogical content knowledge conversations;
4. Most conversations took place at Level 3 and the level of pedagogical content knowledge conversation started high and increased slightly over the year, while the level of content knowledge conversations decreased over the year.

These findings have implications for the design of projects involving teacher knowledge development and for research. Implications of the findings and recommendations arising from the study are discussed in Chapter 5.

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Chapter 5:

Conclusions, Implications and Recommendations

5. 1 Summary of findings

The data analysed in my study show that both content knowledge conversations and pedagogical content knowledge conversations took place during the professional learning community meetings, with pedagogical content knowledge conversations outweighing content knowledge conversations in time spent. In light of the DIPIP approach which prioritises pedagogical content knowledge, this finding is to be expected. However, the significant amount of content knowledge conversation time was not entirely expected and differs from initial findings in other South African professional learning communities. In a study of two school-based professional learning communities in the Gauteng Province, Ceresto (in preparation) found that teacher conversations 'focused mainly on practical knowledge and gave much less attention to content knowledge'.

The primary argument that I make is that it is the type of professional learning community meeting activity that is the main determining factor in the type and depth of teacher knowledge and learning discussions that take place. I found that the percentage of both content knowledge conversation time and pedagogical content knowledge conversation time varies significantly across the four activity types, with content knowledge conversations being most prominent in lesson planning and error analysis activities, and lesson reflection activities generating the highest percentage of pedagogical content knowledge conversation time. An in-depth analysis of the sub-types of pedagogical content knowledge revealed that activity type was a determining factor in the type of pedagogical content knowledge conversation which took place, with most KSU and KISR conversations taking place during lesson reflection meetings. Given the fact that DIPIP prioritises understanding learner thinking (KSU) ahead of practice (KISR), a somewhat unexpected finding regarding pedagogical content knowledge conversation time was that more pedagogical content knowledge conversation time was spent on KISR than on KSU. An in-depth analysis of the pedagogical content knowledge conversations revealed that the bulk of the KSU time was spent identifying errors and reasoning behind errors and the bulk of KISR conversation time was spent discussing teaching strategies to accommodate errors and misconceptions.

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My analysis relating to the levels of content knowledge and pedagogical content knowledge conversations led to the finding that the bulk of the conversations in both content knowledge and pedagogical content knowledge took place at Level 3. However, there was a difference in the way in which the levels of two types of teacher conversations changed over the course of the year, with the amount of pedagogical content knowledge Level 3 conversation level starting high and increasing slightly over the year, and the amount content knowledge Level 4 conversation decreasing over the year. The implications of this relationship between conversation type and level, and activity type are discussed in detail in Sections 5.3 and 5.5 below.

The standard view of the relationship between the development of content knowledge and pedagogical content knowledge is that is that the development of content knowledge precedes the development of pedagogical content knowledge. My findings differ from the standard view in that they show that more content knowledge conversations were triggered by pedagogical content knowledge conversations than pedagogical content knowledge conversations triggered by content knowledge conversations. I also found that the conversations often switched back and forth several times during the same meeting. Ceresto (in preparation), found there was very little content knowledge conversation in the professional learning communities she studied. In the light of this, it might have been surprising to find that there was a high level of content knowledge conversation in the DIPIP professional learning community under study and, furthermore, that 52% of the 58 content knowledge conversations that took place were triggered by pedagogical content knowledge conversations. This finding aligns with the DIPIP approach to teacher knowledge development that, because teachers are most focused on what happens in the classroom (what they do), the most effective way of developing content knowledge is to use pedagogical content knowledge conversations to initiate content knowledge conversations (Brodie 2014, personal communication). Interestingly, the finding that there are examples of content knowledge conversations triggering pedagogical content knowledge conversations is also to be expected as it aligns with the DIPIP strategy of using learner errors to access learner thinking – the implications of which are discussed in detail in Section 5.4 below.

5.2 Answering my Research Questions

My first research question:

> To what extent does the professional learning community talk about content knowledge and pedagogical content knowledge and how is this related to the design of the project?

My research shows that the professional learning community spent more time on pedagogical content knowledge conversations than on content knowledge conversations; that more time was spent on PCK KISR conversations than on PCK KSU conversations, and that most of the content knowledge and pedagogical content knowledge conversations took place at Level 3. Taking the DIPIP focus on accessing content knowledge via pedagogical content knowledge, the finding that more time was spent on pedagogical content knowledge conversations than content knowledge conversations was

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not unexpected. However, the amount of content knowledge conversation - 34% of teacher knowledge conversation time – was higher than expected, particularly in light of the findings of Ceresto (in preparation) that in all the professional learning communities in her study, content knowledge conversations occupied very little of the total teacher conversation time.

My research shows that each of the two conversation types is linked to the design of the project in at least three ways. First, the extent of each type of conversation is related to the professional learning community meeting activity type, with the highest percentage of content knowledge conversation occurring during lesson planning meetings, and the highest percentage of pedagogical content knowledge conversation occurring during lesson reflection meetings. Second, the extent of each type of conversation is related to the DIPIP design which uses error analysis as the vehicle for accessing both learner and teacher thinking, which resulted in 13% of the conversation time being spent on error analysis. In total, 4% of the conversation time during error analysis meetings was spent on content knowledge conversations, and 9% of the conversation time during error analysis meeting was spent on pedagogical content knowledge. Third, the extent of the conversations is related to the DIPIP philosophy on the relationship between content knowledge and pedagogical content knowledge which is that, while the development of content knowledge is best accessed via pedagogical content knowledge, teacher conversations will switch between content knowledge and pedagogical content knowledge.

My second research question:

> What are the relationships, if any, between content knowledge and pedagogical content knowledge conversations in the professional learning community under study?

My analysis shows that the relationship between content knowledge conversations and pedagogical content knowledge conversations was that pedagogical content knowledge conversations triggered content knowledge conversations and content knowledge conversations triggered pedagogical content knowledge conversations, with 23 of the 58 content knowledge conversations (40%) being triggered by pedagogical content knowledge conversations and 30 of the 161 (19%) pedagogical content knowledge conversations being triggered by content knowledge conversations. As the design of the DIPIP project was based on the view that conversations about pedagogical content knowledge can lead to learning about content knowledge and pedagogical content knowledge, it is to be expected that conversations would shift from pedagogical content knowledge to content knowledge. However, my analysis shows that there were also instances of content knowledge conversations triggering pedagogical content knowledge conversations, a finding which is contrary to the general view that content knowledge needs to precede pedagogical content knowledge.

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5.3 Limitations of my study

In this study I analysed the teacher knowledge conversations which took place over the course of one year in one DIPIP professional learning community. The findings of my study cannot be generalised to other professional learning communities within DIPIP, or to any other professional learning communities in the broader education sphere. In addition, the findings of the study cannot be generalised to any other year in this DIPIP professional learning community.

There is a limitation in the content knowledge and pedagogical content knowledge rubrics used to analyse the data. This limitation exists in the descriptions of the categories in Level 1 (Limited), where many of the descriptions refer to there being no evidence of conversation in the category. This resulted in no conversations being coded at Level 1. In addition, the DIPIP professional learning community meetings were divided into terms in order to do a longitudinal study of changes in conversation level over the course of the year. As there was only one meeting in Term 4, it might have been better to divide the meetings into time-units with the number of meetings spread evenly across each unit, My study is also limited in that there was a heavy emphasis on the analysis of the time spent on the teacher conversations, without a systematic, simultaneous analysis of more qualitative aspects of the conversations. This limits the data that can be provided to the reader.

5.4 Implications and Recommendations

For programme designers

There is much to learn from the teacher knowledge conversations which took place in the DIPIP professional learning community under study. The relationships as shown between content knowledge, pedagogical content knowledge and activity type and conversation level are of significance in the design of programmes which have the development of teacher knowledge as an outcome. The way in which the design of the project in terms of the focus activities in the DIPIP professional learning community meetings influenced the type of teacher knowledge conversations could be informative for other professional teacher development programme designers, regardless of whether the project includes professional learning communities.

The finding that pedagogical content knowledge conversations can stimulate content knowledge conversations; and that content knowledge conversations can lead to pedagogical content knowledge conversations could inform the selection of the overall focus of a teacher professional development programme, as well as the foci of programme activities.

For DIPP

My analysis shows that a number of DIPIP aims were achieved in this community. The community spent most of their time on task in relation to the activities, and pedagogical content knowledge conversations did lead to content knowledge conversations. So the focus on error analysis did lead to opportunities for learning both content knowledge and pedagogical content knowledge. There is

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one finding, which the analysis of this community's conversations suggests the DIPIP team should take note of. There was more KISR conversation time than KSU conversation time as discussions quickly moved from identifying errors and reasoning behind errors (KSU) to teaching strategies to accommodate the errors (KISR). As a DIPIP goal is to use error analysis to get teachers to develop a deeper understanding of learner thinking, the project team should investigate ways of achieving deeper levels of conversations in KSU.

For research

A deeper understanding of the development of content knowledge and pedagogical content knowledge in DIPIP professional learning communities could be achieved if the following research studies are undertaken: (1) teacher knowledge conversations in the same professional learning community are investigated over the four years of DIPIP Phase 3; (2) the extent and nature of teacher knowledge conversations in other DIPIP professional learning communities in all three phases of the project; (3) the role of the facilitator in determining the extent and nature of teacher knowledge conversations in DIPIP professional learning communities and (4) the frequency of pedagogical content knowledge to content knowledge shifts and content knowledge to pedagogical content knowledge shifts.

5.5 Final conclusion

Teacher knowledge and the development thereof is complex. I have learned that teacher knowledge development is not haphazard and that any programme which has teacher knowledge development as its goal needs to be carefully conceptualised and meticulously planned. In spite of its narrow focus, this research has shown me that the designers of teacher professional development programmes can do a lot of planning and monitoring work in order to create situations which are conducive to the development of teacher knowledge, but that in order to do this, programme developers need to have a sound understanding of the constructs of content knowledge and pedagogical content knowledge.

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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: Erlbaum.

Ball, D., & Cohen, D., (1999). Developing Practice, Developing Practitioners. In Darling-Hammond, L. and Sykes G. (1999). *Teaching as the learning profession: handbook of policy and practice*. San Francisco: Jossey-Bass.

Ball, D., Thames, M., & Phelps, G. (2008). Content Knowledge for Teaching: What makes it special? *Journal of Teacher Education*, 2008, 59–389.

Bassey, M. (1999). *Case Study Research in Educational Settings*. Open University Press: Buckingham.

Borasi, R. 1994. Capitalizing on errors as 'Springboards for Inquiry': A teaching experiment. *Journal for Research in Mathematics Education* 25(2),166–208.

Borko, H. 2004. Professional development and teacher learning: Mapping the terrain. *Educational Researcher* 33(8), 3–15.

Brodie, K. & Sanni, R. (2014). 'We won't know it since we don't teach it': Interactions between Teachers' Knowledge and Practice. *African Journal of Research in Mathematics, Science and Technology Education,* 1–10.

Brodie, K. & Shalem, Y. (2011). Accountability conversations: Mathematics teachers learning through challenge and solidarity. *Journal for Mathematics Teacher Education* 14, 419–439.

Brodie, K. (2011). Teacher Learning in professional learning communities. In H. Venkat & A. Essien (Eds.), *Proceedings of the Seventeenth National Congress for Mathematics Education of South Africa (AMESA)* (Vol. 1, 25–36). University of Witwatersrand: Johannesburg.

Brodie, K. (2012). Learning about Learner Errors in Professional Learning Communities. In T. Nampota & M.Kazima (Eds.), *Proceedings of the Twentieth Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE)* (Vol. 2, pp. 117–121). University of Malawi: Lilongwe.

Brodie, K. (2013). The power of professional learning communities. *Education as change*, Volume 17, No. 1, July 2013, 5–18.

Brodie, K. (2014). Learning about learner errors in professional learning communities. *Educational Studies in Mathematics* (2014). 85:221–239.

Brodie, K., & Berger, M. (2010). *Toward a discursive framework for learner errors in mathematics*. Paper presented at the Proceedings of the Eighteenth annual Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) conference, Durban.

Brodie, K., Shalem, Y., Sapire, I. & Manson, L. 2010. Conversations with the mathematics curriculum: Testing and teacher development. In V. Mudaly (Ed.), *Proceedings of the eighteenth annual meeting of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE)* (182–191). University of KwaZulu-Natal, Durban.

Bucat, R., 2005. Pedagogical content knowledge as a way forward: Applied research in chemistry education. Chemistry education: research and practice, Volume 5, No.3, pp. 215–218.

JM Research Report final.indd 63 2015-05-18 12:57:38 PM

Ceresto, A. (in preparation) Choosing a knowledge focus in a Professional Learning Community: What do teachers focus on?

Chauraya, M., (2013) Mathematics Teacher Change and Identity in a Professional Learning Community. PhD Thesis. University of Witwatersrand, Johannesburg.

Davidowitz, B. & Rollnick, M. 2011. What lies at the heart of good undergraduate teaching? A case study in organic chemistry. *Chemistry Education Research and Practice.* 12: 355–366.

Geddis, A. & Wood. E. (1997). Transforming subject matter and managing dilemmas: A case study in teacher education. *Teaching and Teacher Education*, Vol. 13, No. 6, 611–626.

Geddis, A. (1993). Transforming subject-matter knowledge: the role of pedagogical knowledge in learning to reflect on teaching. *International Journal of Science Education,* 15(6), 673–683.

Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. New York: Teachers College Press.

Hargreaves, A. 2008. Sustainable professional learning communities. In L. Stoll & K. S. Louis (Eds.), *Professional learning communities: Divergence, depth and dilemmas*, 181–195. Maidenhead: Open University Press and McGraw Hill Education.

Howie, S, (2001). Mathematics and Science performance in Grade 8 in South Africa 1988/ 1999. Pretoria: HSRC.

Innovative Solutions for information Intensive Environments (n.d.). Retrieved from http://www.studiocodegroup.com/

Jaworski, B. 2008. Building and sustaining enquiry communities in mathematics teaching development: Teachers and didacticians in collaboration. In K. Krainer & T. Wood (Eds.), *Participants in mathematics teacher education: Individuals, teams, communities and networks*, 309–330. Rotterdam: Sense Publishers.

Katz, S., Earl, L. & Ben Jaafar, S. 2009. *Building and connecting learning communities: The power of networks for school improvement*. Thousand Oaks, CA: Corwin. *Technology Education (SAARMSTE)*, 182–191). Durban: University of KwaZulu-Natal.

Kazemi, E. & Hubbard, A. 2008. New directions for the design and study of professional development. *Journal of Teacher Education* 59(5): 428–441.

Kind, V. (2009). Pedagogical content knowledge in science education: perspectives and potential for progress. Studies in Science Education Volume 45, Issue 2, 2009, 169–204.

Koehler, M., & Mishra, P., (2011). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers' College Record*, Volume 108, Number 6, June 2006, 1017–1054.

Marks, R. (1990). Pedagogical content knowledge: from a mathematical case to a modified conception. *Journal of teacher education*, 41(3), 3–11.

Mavhunga, E., & Rollnick, M. (2011). The development and validation of a tool for measuring topic specific PCK in chemical equilibrium. Paper presented at the ESERA Conference, Lyon, France.

Mavhunga, E., & Rollnick, M. (2013). Improving PCK of chemical equilibrium in pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education*, 17(1–2), 113–125.

Mavhunga, M. E. (2012). *Explicit inclusion of Topic Specific Knowledge for Teaching and the Development of PCK in Pre-service Science Teachers*. PhD Thesis. University of Witwatersrand, Johannesburg.

McMillan, J., & Schumacher, S. 2010. *Research in Education: Evidence-based inquiry*. New Jersey: Pearson.

Nelson, B. (1992). Teachers' special knowledge. Educational Researcher, 21(9), 32–33.

Nesher, P. 1987. Towards an instructional theory: The role of students' misconceptions. *For the Learning of Mathematics* 7(3):33–39.

Olivier, A. 1996. Handling pupils' misconceptions. *Pythagoras* 21:10–19.

Opie, C. (2004). Research procedures. In C.Opie (Ed), *Doing Educational Research* (pp. 95–129). Los Angeles: Sage.

JM Research Report final.indd 64 2015-05-18 12:57:38 PM

Park, S. (2007) Teacher Efficacy as an Affective Affiliate of Pedagogical Content Knowledge. *J Korea Assoc. Res Science Education*. Volume 27, No. 8, 743–754.

Park, S., & Oliver, J. S. (2008a). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, 38(3), 261–284.

Park, S., & Oliver, J. S. (2008b). National Board Certification (NBC) as a catalyst for teachers' learning about teaching: the effects of the NBC process on candidate Teachers' PCK development. *Journal of Research in Science Teaching*, 45(7), 812–834.

Park, S., Chen, Y-C., & Jang, J. (2008). *Developing measures of teachers' pedagogical content knowledge for teaching high school biology*. International conference of the Association for Science Teacher Education, St. Louis, MI. January.

Park. S, Jang, J, Chen. Y-C., & Jung. J. (2010). Is Pedagogical Content Knowledge (PCK) necessary for Reformed Science teaching?: Evidence from an Empirical Study. DOI 10.1007/s11165-009-9163-8.

Reddy, V. (2006). Mathematics and Science Achievement at South African Schools. Cape Town: HSRC.

Report of the Annual National Assessment. Department of Basic Education (2014).

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.* Vol. 30, No. 10, 13 August 2008, 1365–1387.

Shulman, L. (1986a). Those who understand: A conception of teacher knowledge. *American Educator, 10*(1), 9–15, 43–44.

Shulman, L. (1986b). Those who understand: Knowledge growth in teaching. *Educational Researcher*. 15 (2), 4–14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the New Reform. *Harvard Educational Review*. 57 (1), 1–22.

Wickham, S, & Versveld, R (1998) Investigating and establishing best practices in the teaching of English as a second language in under-resourced and multilingual contexts. *Joint Education Trust Report 2,* January – July 1998.

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Appendix

A. Code manual

Note: this code manual should be read in conjunction with the code window provided in Section 3.4.3.

This manual outlines the process followed and the basis for decisions taken.

<table>
<tr><th>Process</th><th>Further clarification</th></tr>
<tr><td>1. Divide meeting into conversation units.</td><td>• A conversation unit consists of a ‘packaged unit’.
• Where possible, identify several shorter conversations rather than one long conversation unit.</td></tr>
<tr><td>2. Decide whether the conversation deals with content knowledge or pedagogical content knowledge.</td><td>• Content knowledge conversations focus on teachers learning more about the subject matter.
• Pedagogical content knowledge focus on the ways in which teachers make learning accessible to learners</td></tr>
<tr><td>3. If the conversation is a PCK conversation, decide whether it is a KSU conversation or a KISR conversation</td><td>• KSU conversations deal with knowledge of learner understanding
• KISR conversations deal with knowledge of instructional strategies and representations of the subject matter</td></tr>
<tr><td>4. If the conversation is KSU, decide which of the two sub categories of KSU is appropriate.</td><td>• Identifies errors and reasoning behind errors
• What makes topic/ concept difficult? (occurs mostly in lesson planning)</td></tr>
<tr><td>5. If the conversation is KISR, decide which of the two sub categories of KSU is appropriate.</td><td>• Teaching strategies to accommodate errors and misconceptions
• Rationale for teaching strategies and representations in connection with learner
• understanding (occurs mostly in lesson preparation meetings)
• Questioning to probe learner understanding
• (occurs mostly in lesson delivery)
• Spontaneity to challenge misconceptions or resolve learning difficulties discovered
• Use of new understanding of learner understanding to modify instructional strategies and representations</td></tr>
<tr><td>6. Decide on the level at which the conversation took place. Use the four level rating scale:<table><tr><td>1</td><td>Limited</td></tr><tr><td>2</td><td>Basic</td></tr><tr><td>3</td><td>Developing</td></tr><tr><td>4</td><td>Exemplary</td></tr></table></td><td>• Start with the two ‘extremes’ – Limited and Exemplary. Note that for a conversation to be Exemplary, the discussion needs to show in-depth understanding.
• Most conversations are likely to be Level 2 or 3 conversations. The difference here is the depth of the discussion – is it quite superficial (Level 2) or are some insights, understandings or teacher knowledge development evident?</td></tr>
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