EXPLORING TEACHERS' IMPLEMENTATION OF KNOWLEDGE AND SKILLS BEYOND A SCHOOL-UNIVERSITY PARTNERSHIP

by

PAKISO JAMES MOETI

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BLOEMFONTEIN

PROMOTER: Dr N.J. Ramohai

CO-PROMOTER: Dr A. Stott

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DECLARATION

I, Pakiso Moeti James, declare that the thesis, **Exploring teachers' implementation of knowledge and skills beyond a school-university partnership**, hereby handed in for the qualification of Philosophiae Doctor at the University of the Free State, is my own, independent work, which I have not previously submitted for a qualification at any higher education institution or publication house. I hereby cede to the University of the Free State the copyright of this work.

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P.J. MOETI **Date**

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DEDICATION

I dedicate this work to my late grandfather, Molefe Moeti, who supported me from childhood, and my grandmother Mamokgele Moeti, who encouraged me to focus on education from my adolescence.

This work is also dedicated to my parents Mahlomola Moeti and Limakatso Mosebo.

Most importantly, this work is dedicated to my beautiful children Phoebe Maya and Buhle Maya, who inspire me and make life worth living.

ABSTRACT

School–university partnerships have been shown to be effective in developing the knowledge and skills of participating teachers. Understanding what teachers do in classrooms with these knowledge and skills, including after the end of the partnership, and factors that affect this, is vital in the assessment of the long-term impact and sustainability of such partnerships, but is largely unexplored. This qualitative case study describes the experiences of 16 participants who taught mathematics and physical sciences within a school–university partnership, ways in which they implemented the knowledge and skills they gained through this partnership, and their perceptions of threats to, and conditions for, successful implementation of this knowledge and skill beyond the partnership period. The investigation drew data from two sources: semi-structured interviews and focus group discussions. The data were analysed using an interpretivist paradigm that allowed for a iterative and process-oriented research approach. The knowledge produced was analysed and interpreted using Kram's framework of mentoring and complex systems theory. The findings suggest that the teachers developed content and pedagogical knowledge, and curriculum management and assessment skills, and are using a variety of approaches to implement these beyond the partnership period. Certain individual and institutional factors that threaten, and teacher traits and school conditions that are conditional for this implementation, were identified. Based on the findings, the study makes several recommendations for future school–university projects.

KEYWORDS: teachers, knowledge and skills development, knowledge and skills implementation, mathematics and science, school–university partnership, SPP

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ACRONYMS AND ABBREVIATIONS

CAPS	- Curriculum and Assessment Policy Statement
CPD	- Continuous professional development
DBE	- Department of Basic Education
DHET	- Department of Higher Education and Training
DOE	- Department of Education
IBP	- Internet Broadcast Project
ICT	- Information communication and technology
OECD	- Organisation for Economic Co-operation and Development
PCK	- Pedagogical content knowledge
SPP	- School Partnership Project
SUP	- School–university partnership
TSCK	- Topic-specific content knowledge
TSPK	- Topic-specific pedagogical knowledge
TSPCK	- Topic-specific pedagogical content knowledge
TTSPCK	- Technological topic-specific pedagogical content knowledge

CHAPTER 1: INTRODUCTION

1.1 POSITIONING THE THESIS

School–university partnership (SUP) is not a new concept in higher education, it is a form of in-service continuing professional development (CPD) for teachers. In recent times, globally and in the South African context, approaches to knowledge and skills development for teachers are slowly moving away from traditional approaches, such as once-off workshops, seminars, and conferences. School-university partnership appears to be a contextualised CPD that aims to equip teachers with new knowledge and skills (Hawkins & Rezazade, 2012; Mitchell, Eby & Ragins, 2010; Wang & Wong, 2019; Xu, 2009). Teachers participate in SUP with the primary purpose of developing their knowledge and skills. Studies have shown that individual teachers develop their own experiences by participating in SUP, and that these programmes have relevance for their classroom teaching practice (Mokhele, 2013; Ndlovu, 2011a). However, it is uncertain whether mathematics and science teachers who participate in a SUP continue to apply what they learned through the SUP even after such a programme has ended.

While participating in a SUP seems to be a solution to decontextualised knowledge and skills development CPD (Ono & Ferreira, 2010; Tsotetsi & Mahlomaholo, 2015) for teachers to translate what they learn into practice, little is known about how teachers implement the knowledge and skills they acquire in SUP beyond the partnership. This study aims at contributing knowledge into the implementation of the knowledge and skills teachers acquire in SUP beyond partnership within South Africa.

In recent times, globally and in a South African context, approaches to teacher learning are slowly moving away from traditional approaches, such as once-off workshops, seminars, and conferences. In some countries, policies mandate universities and schools to work collaboratively for different purposes (DHET, 2013; Education Bureau, 2003; European Commission, 2007; US Department of Education, 2010). There are several conundrums associated with the traditional approaches to teacher learning. Ono and Ferreira (2010) explained that one of the challenges is the exclusion of teachers in the

design of these programmes, since teacher learning programmes often exclude experiences and knowledge of teachers. Teachers are more likely to become absorbers of knowledge when knowledge is delivered with a top-down approach and, thus, teachers are not afforded the opportunity to construct their own knowledge based on their experience. Another challenge is that these approaches happen outside the classroom, a distance away from the classroom reality as experienced by the concerned teachers (Ono & Ferreira, 2010). The disconnection of these traditional teacher learning approaches from teachers' classroom reality makes it challenging for teachers to "translate and contextualize the CPD programme into the classroom, particularly in rural schools with their own characteristics" (Tsotetsi & Mahlomaholo, 2015:47). Against this background, it is worth investigating the type of knowledge and skills mathematics and science teachers develop by participating in SUP and how they implement the knowledge and skills independently beyond SUP.

1.1.1 About the School Partnership Project in this study

It is important to note that the School Partnership Project (SPP) is a form of SUP implemented by one university in South Africa. According to Jacobs (2018), the SPP that this study focuses on was launched in mid-2012 under the stewardship of Professor Jonathan Jansen, a former University of the Free State vice chancellor. Towards the end of 2019, after seven years of its existence, the SPP concluded its mission in chosen partnered schools across in the Free State province. According to Jansen (2011, cited in Jacobs 2018), key problems are highlighted in the summative foundational document of the SPP; these problems threaten sustainable change at schools. These challenges include,

- Learners not receiving the required teaching time;
- Teachers' shortcomings regarding knowledge of content and pedagogy;
- Failure by principals to provide instructional leadership;
- Lack of parental involvement in schools; and
- Shortages of essential resources and inconsistent investment by external stakeholders.

To address the above-mentioned conundrums, the SPP adopted a mentoring approach, in which mentors – former teachers and principals – visited teachers weekly for the purpose of teacher empowerment and leadership management (Van der Walt, 2016). Through collaboration between the education department and teacher unions, agreement was reached that mentors from the university would empower teachers regarding their own work through weekly visits (Van der Walt, 2016). The weekly visits culminated in social interaction – mentoring relationships, to be precise – between school-based teachers and university-based mentors.

Mentoring, as a social practice adopted in the SPP, has the potential to produce diverse types of learning experiences for the individual teachers involved in the project (Whitworth & Chui, 2015). This suggests that different teachers can have different knowledge experiences through their participation in the SPP, and this can yield differing perspectives in relation to the implementation of the acquired knowledge and skills. Thus, mentoring is a pedagogical encounter that develops mentee who participate in it, irrespective of their prior knowledge (Bransford, Darling-Hammond & Lepage, 2005). This social practice of the SPP means that, "not only does the project contribute to the advancement of quality education in the project schools, whilst opening up access to higher educational institutions, it touches the lives of individual teachers and learners" (Jacobs, 2018:43). During its implementation, the SPP, which was aimed at lower quintile schools, based its operations on four fundamental goals,

- To increase the pass performance of the secondary-school learners particularly in mathematics, physical sciences, accounting, and English (the language of teaching and learning) through empowerment of teachers;
- To develop robust, sustainable management leadership at these schools;
- To provide guidance to the schools to strengthen the social fibre of the schools and the communities in which the schools are embedded; and
- Create optimum opportunities for learners at selected schools to access universities after Grade 12.

This study confined itself to the first goal.

1.1.2 My positionality

This section will provide an explanation of how I developed a research interest in conducting this study, and the reasons for the questions posited in this research report. According to Leedy and Ormrod (2014), a researcher might have had a personal experience associated with the phenomenon that is under consideration. By being embedded in the SPP, the researcher may be stimulated to understand how other teachers have experienced this phenomenon. In the case of this study, my personal and professional experience played a pivotal part in the selection of this research topic. I personally experienced the SPP between 2016 and 2019, as a science teacher at one of the schools that partnered with the project. According to its format and content, the SPP provided teachers with mentors who conducted weekly classroom visits to ensure that teachers at quintile 1 to 3 schools were empowered. Through the process of mentoring, mentors of the SPP provided teachers with ready-made content documents, some in the form of CDs and Internet Broadcast Project (IBP) videos, that teachers could utilise during their classroom teaching. The significance of these resources was their alignment with the Curriculum and Assessment Policy Statement (CAPS) – they were not topics arbitrarily chosen by the SPP coordinators.

Wang and Wong (2019) agree that mentors can provide teachers with useful written learning materials that contain relevant information on teaching and learning in schools. Another aspect of the SPP mentoring programme was that mentors conducted classroom visits, especially for mathematics and science teachers. During the visits, my allocated mentor occasionally engaged in classroom observations – I was observed while I presented lessons. After lessons, I engaged in reflection discussions with the concerned mentor, and these sessions led to constructive feedback. This confirms the suggestion by Nel and Luneta (2017) that mentors should observe teachers during lesson presentations, and then give feedback and engage in reflection sessions. Mentors' classroom observations can lead to a co-teaching activity. This practice suggests that the mentor participated in the lesson presentation by providing their knowledge and expertise on the lesson being presented.

The social interactions between myself and my mentor during classroom visits and utilisation of learning resources enhanced my knowledge and skills for teaching physical sciences. Firstly, I had access to content documents, such as CDs containing, for example, prepared PowerPoint presentations in accordance with science CAPS curriculum. These resources enhance my technological skills, as some of the science lessons were conducted by using PowerPoint presentations. Secondly, the content documents and reflection sessions between myself and mentor enhanced my content knowledge, especially in curriculum realms that I found challenging to teach. Lastly, my pedagogical knowledge was enhanced by watching the IBP videos that were provided. In these videos, experienced teachers with knowledge of and expertise in mathematics and science do live and recorded presentation of various topics contained in the CAPS; the IBP videos also enhanced my pedagogical content knowledge (PCK).

The knowledge and skills acquired through participation in SPP significantly affected how I conducted classroom teaching practice and, consequently, I made changes to the way I planned lessons and assessment for learners. The impact of engaging in the activities of the SPP contributed to an exponential improvement in learners' performance in physical sciences at my school between 2017 and 2019, which confirms Van der Walt's (2016:140) claim that the SPP programme, through "mentoring of accounting, mathematics and physical sciences teachers had a large positive impact on the student achievement in these subjects". One of the critical phases of enhancing knowledge and skills of teachers is related to improving academic performance (Halai, 2006). My personal experience of implementing the knowledge and skills gained from the SPP did not only have an impact on my CPD, but it was reflected in learners' performance.

Although many positives can be articulated about the SPP, what lingers is a primary apprehension about the implications of the SPP for the independence and autonomy of teachers in relation to their implementation of the acquired knowledge in practice once the project ceases to exist. The literature contains abundant evidence of the antecedents and consequences of projects of this nature when they are functional (Mokhele, 2013; Ndlovu, 2011b). However, there is less information on what happens post mentoring (Erdem & Omuris, 2014), especially when these projects no longer exist and teachers are

faced with implementation on their own, without the support and guidance of their mentors. The challenge for this study was to determine how teachers continued to make use of allocated resources and implemented the acquired knowledge and skills in their classrooms. The objective of this study was to understand teachers' experiences in relation to knowledge and skills implementation from the broader perspective of their everyday lived experiences beyond the SPP.

1.2 PROBLEM STATEMENT

Numerous studies have examined SUPs as a CPD approach for experienced teachers in a South African context (Fricke, 2008; Ndlovu, 2011a; Silbert, Clark & Dornbrack, 2015). For example, Fricke (2008) focused on the effects of a mentoring for science and mathematics teachers and concludes that using teachers' and mentors' voices provides a way to propose a model for teacher professional development that has potential for both broad and deep sustainable change. Mokhele (2013) examined the perspectives of teachers of a professional development project in a rural context. Drawing from an already established professional development model, Mokhele focused on the extent to which this model is implementable for teacher CPD. Mokhele concluded that her study was not sufficient to bring to the fore the voices of teachers who participate in projects aimed at CPD, in terms of the benefits and empowerment they gain from the projects.

This study manoeuvred into this need to probe further into the lived experiences of teachers who participated in the SPP, but also broadened the scope by seeking out the everyday lived experiences of teachers while they implemented the knowledge and skills they had acquired from the SPP beyond its existence. The assumption, backed by insights from Wang and Wong (2019), is that teachers develop knowledge by crossing boundaries in an SUP. However, it is important to ascertain how empowered teachers are once they are left to face skills and knowledge implementation on their own, and the extent to which this is evident from their classroom teaching practice.

Against this background, this study aimed to respond to this main question: What are teachers' experiences regarding the implementation of the skills and knowledge attained in an SPP?

1.2.1 Research questions

From the above discussion, the central research question was the following: **What are teachers' experiences regarding the implementation of the knowledge and skills they attained in an SPP?** The answers to the research problem highlighted in this section were obtained by getting answers to the following secondary questions:

1. What knowledge and skills did teachers involved in an SPP gain as part of CPD?
2. How do teachers implement the knowledge and skills they attained in the project?
3. What threats (if any) are related to successful implementation of the knowledge and skills attained?
4. What are the conditions for success regarding implementation of the knowledge and skills gained during the project?

1.2.2 Research aim and objectives

The main aim of the study was to understand how mathematics and science teachers implemented the knowledge and skills they have acquired in SPP. Aligned to the questions above, the following objectives were explored:

- To identify the knowledge and skills that teachers obtained through their involvement in the SPP programme;
- To provide an understanding of how teachers are implementing the knowledge and skills independently and beyond the project's existence in their classrooms;
- To identify the encounters that affect successful implementation of the acquired knowledge and skills in the classroom; and
- To identify the indicators that prompt the implementation of knowledge and skills in teachers' classroom practice.

1.3 THEORETICAL FRAMEWORK

Several theories articulate how mentoring teachers can have implications for teaching practice. The theoretical lens in this study placed the problem in consideration in a

framework that enabled the study to interrogate the relationship between concepts (Cohen, Manion & Morrison, 2018) of knowledge and skills implementation. Therefore, this study used Kram's framework of mentoring, and complex systems theory as foundations for gaining insight into teachers' experiences and perceptions of the implementation of the knowledge and skills they had acquired in the SPP. In this section, the rationale for adopting these two theories will be provided.

The adoption of Kram's framework of mentoring as a primary theoretical framework provided the study with a theoretical lens through which empirical data could be analysed. The framework recognises a mentor as someone outside mentees' organisation or in a different chain of command, who is responsible for the development of the mentee and with whom the mentee can discuss work-related issues (Israel, Kamman, McCray & Sindelar, 2014; Kram, 1983; Ragins & Kram, 2007). A theory of mentoring emphasises the mentor–mentee relationship, which is to a master–pupil dyad relationship. Individuals who are proactive tend to deliberately seek mentors from whom they can learn (Sugimoto, 2012). It is necessary to understand that a chosen mentor may seem imposed, whereas a self-selected mentor may not be forthcoming, as every teacher is passive to pick a mentor. The SUP under investigation selected mentors – teachers could not directly decide who they wanted as their mentor. Thus, all the mentors in the SPP were imposed on participating teachers. The role that a mentor plays is to ensure the comprehensive development of the teacher, whether the mentor is imposed or self-elected (Aspors & Frasson, 2015; Israel *et al.*, 2014).

Establishing mentoring relationships between teachers and mentors marked the commencement of a developmental relationship that was aimed at developing and guiding teachers towards growth in teaching profession. This is the initiation of mentoring, which is regarded as the inception of mentoring relationship (Kram, 1983). In this study, this phase started the social interaction that allowed teachers and mentors to project their qualities on each other when they crossed the knowledge boundary zone.

Mentoring is often oriented to an interchange of knowledge, support, or learning for the purposes of career growth, though, sometimes, mentoring is used to achieve strategic organisational goals (Ragins & Kram, 2007). Mentoring is a talent management activity

that organisations employ in to identify and develop teachers, to retain and deploy the most talented individuals in an organisation (Beardwell & Claydon, 2007). Mentoring is a developmental process, a skilful and knowledgeable mentor works with a less experienced person to teach, sponsor, and counsel amongst other. This is done to promote the less experienced individual for personal growth. The above-mentioned functions represent the activities that members in a dyadic relationship should implement when they interact; these are the activities undertaken during the cultivation phase (Ragins & Kram, 2007; Sugimoto, 2012). The cultivation phase is an important phase, and this study considered this phase as a developmental phase in which teachers developed knowledge and skills in relation to mathematics and science through mentoring activities.

In this study, the issue of the separation of teachers and mentors took centre stage during the discourse. This study considered how teachers established their independence and autonomy from their mentors when the partnership ceased to exist. Doing so called for inclusion of a separation phase for the mentoring relationship (Kram, 1983; Ragins & Kram, 2007), which provided a theoretical lens to understand the implications of the knowledge and skills teachers had acquired in mathematics and science teaching practice. This study was based on the belief that mentoring enriches teachers' content and pedagogical knowledge; teachers acquire new knowledge, skills, and values that improve their practice (Mokhele, 2013; Ndlovu, 2011a; Wang & Wong, 2019). This phase helped the study to consider how teachers had established their autonomy and independence from their mentors. It also assisted in understanding the implications of practice in classrooms, and whether teachers were successful or not in the implementation of their newly acquired knowledge and skills.

Kram's framework offered a platform to generate self-reflection knowledge, which could guide both understanding and explanation of knowledge and skills implementation when two socially interacting systems terminate their relationship, thereby advancing teachers' independence and autonomy in the teaching profession.

However, Kram's theory of mentoring could not provide a better understanding of the complex process associated with the implementation process. Although the theory was

instrumental in identifying the typologies of knowledge and skills teachers acquired from the SPP, it fell short in considering the different systems that could affect implementation of the knowledge and skills in classrooms. Against this background, this study adopted a secondary theory, complex systems theory, to provide a theoretical lens for understanding the implementation.

The adoption of complex systems theory was done with the view that knowledge and skills implementation in mathematics and science classrooms takes place in a web of subsystems that interact with each other to influence the outcome. In complex systems theory, systems, such as macro-, exo-, meso-, and microsystems interact with each other (Ettekal & Mahoney, 2017). In this study, sources such as policy documents for mathematics and science (e.g., CAPS and CPD), which are components of macrosystems, were considered to exert a monumental influence on what happens in the classroom (the microsystem). Similarly, school leadership (the exosystem) and school infrastructure (the mesosystem) were considered as elements that could affect implementation in the classroom (the microsystem) (Yoon, Goh & Park, 2018). The adoption of complex systems theory for this particular study was foregrounded by the intention to study knowledge and skills implementation in classrooms, the classroom is one of the components of a complex web of other systems (Bronfenbrenner, 2005).

The main aim of this study was to have a better understanding of teachers' experiences in the implementation of their acquired knowledge and skills in mathematics and sciences. The appropriateness of Kram's phases of mentoring indicate that this theory is not only important in management, but it can also be applied in education, including in mathematics and science. Kram theory and complex systems theory were, therefore, suitable as theoretical frameworks, as they focus on investigating and scrutinising the role of mentoring in knowledge and skills implementation.

1.4 RESEARCH DESIGN

Research design in this study encompasses a framework for translating research objectives (*cf.* 1.2.2) into a detailed data generation plan, analysis and interpretation, and lastly reporting of the empirical findings (Cohen *et al.*, 2018). The framework enabled the

study to choose an appropriate design on which the study was underpinned, this enabled the study to respond to the research objective and all secondary research questions (*cf.* 1.2.1). The framework also assisted the study to choose a specific methods and methodology (Cohen *et al.*, 2018). It is against this background that this section will elucidate the methodology, methods, participant selection and data analysis, interpretation, and reporting.

1.4.1 Methodology

Education research is pluralistic, and it is characterised by methodology and methods that help to understand a phenomenon under consideration (Hammersley, 2013). It is crucial to outline the research design, as it serves as a ground plan for procedures of inquiry that are developed in a bid to respond to the issue under discourse. Hence, the methodology describes the design, methods, sources of data and instruments that were used. This study had a case study design, and it was informed by a qualitative methodology and couched in an interpretivist paradigm. The succeeding section (*cf.* 1.4.2) outlines the details of these aspects.

Framed within the experience of teachers to implement of the knowledge and skills they acquired in a professional development project, this study was informed by a qualitative research methodology. Qualitative studies attempt to gather rich and informative data of a specific phenomenon with the intent to develop a better understanding of that phenomenon (Maree, 2007). This opinion concurs with Hammersley's (2013) definition, qualitative research is a process that make use of less organised data, which stresses subjectivity in the research process, it studies a lesser number of occurring cases in detail by focusing on verbal rather than statistics in the analysis. This study aimed to investigate the experiences of mathematics and science teachers while they implemented the knowledge and skills they had gained from participating in an SPP. This suggests that a qualitative research approach gives voices to the participants of a study, as it probes what lies behind the participants' actions.

Researchers regard the case study as a type of qualitative study that focuses on a particular single instance of a bounded system, such as a project (Cohen *et al.*, 2018;

Merriam, 2002; Yin, 2012). Therefore, a case study was adopted to investigate the experiences of teachers in the implementation of their knowledge and the skills beyond the SPP. Yazan (2015) describes a case study as an investigation that allows for an in-depth comprehension of the phenomenon under consideration.

A case study could be useful for examining a project such as an SPP. This suggests that this was a single case study of the SPP. Therefore, a single case study methodology was adopted because it was anticipated that it would enable and in-depth investigation with multiple perspectives investigated at a particular time (Simon, 2009). This study investigated a single case of a SUP, namely the SPP, for several mathematics and science teachers at several schools. The investigation centred on their lived experiences of implementing the knowledge and skills developed from the project and involved an attempt to analyse and interpret their experiences and perceptions.

In this context, this study was grounded in the interpretivist paradigm. With an interpretivist paradigm, an “emphasis is placed in understanding the individual and their interpretation of the world around them” (Kivunja & Kuyini, 2017:33). According to Cohen *et al.* (2018), an interpretivist paradigm attempts to comprehend the subjective world of individuals who have experienced a particular phenomenon. Teachers who participated in the SPP have their own subjective meaning as a result of being part of mentoring relationships; they can make these meanings knowledge. The subjective reality is socially constructed, and therefore, knowledge and skills development in an SPP was socially constructed by the participating teachers.

1.4.2 Methods

1.4.2.1 Semi-structured interviews

Interviews in this study are a dialogue between two participants (researcher and a teacher) to learn about their opinions and behaviours (Cohen *et al.*, 2018; Creswell 2012). These scholars suggest that an interviewer initiate an with the purpose of eliciting information. The value of interviews is that they generate data that cannot be gathered when one is doing direct observation. Semi-structured questions are posed to implore

rich and valuable data from participants (Cohen *et al.*, 2018). Interviews are a well-planned, extendable dialogue, with the intention to generate opinions of the participants' experiences; their experiences comprise in-depth data from which can be used to derive meanings. Interviews are a well-planned, extendable dialogue, with the intention to generate narratives of the participants' experiences and memories; their experiences contain in-depth information from which meanings can be derived.

Participants who had experienced the SPP were given an opportunity to share their experiences of the knowledge and skills development in mathematics and science truthfully and subjectively and face-to-face. The semi-structured interviews were conducted with teachers who had participated in the SPP, and information provided enriched the process of developing a better understanding of teachers' knowledge and skills development and its impact on their implementation. The data collected from the interviews form the basis of discussions around "professional development dedicated to specialised knowledge and skills" (Betlem *et al.*, 2018:327–346).

1.4.2.2 Focus group discussions

Focus groups are a collective interview which comprises of multiple participants to share or interaction on a specific area of interest supplied by the researcher (Cohen *et al.*, 2018). Focus group discussions were used to substantiate evidence obtained from the semi-structured interviews, to show similarities and differences in the comprehension of how knowledge and skills were developed, and implemented, and what challenges were experienced in the implementation in classrooms. After the interviews, focus group discussions were conducted, so that teachers had the opportunity to share their experiences and perceptions with each other. This activity provided a suitable platform for teachers to distribute their knowledge, skills, and expertise of teaching mathematics and science. The focus group discussion solicited participation from participants and focused on their understanding (Denscombe, 2014) of knowledge and skills relating to mathematics and science, and detailed and rich information was generated.

I am persuaded that the methods discussed in this section would make it possible to generate multiple realities. The iterative corroboration of data from the multiple data

sources discussed in this section validated and provided rigor for the collected data (Denscombe, 2014).

1.4.3 Participants

The selection of teachers as participants for this study was based on a purposive technique, through which information-rich individuals who were knowledgeable and had experienced the phenomenon being studied, were identified and selected (Flick, 2009; Patton, 2002; Suri, 2011). For Cohen *et al.* (2018), these participants would yield the most relevant, plentiful, and broad range of information. In this study, participants who had experienced the SPP were identified to provide rich information about their experiences of gaining knowledge and skills on subjects of mathematics and science. Sixteen participants who voluntarily participated in the study were purposively chosen to be interviewed and participate in the focus group discussions.

1.5 DATA ANALYSIS

Data analysis in a qualitative study relates to how the raw data is translated to understand, explain, and interpret the phenomenon in question (Taylor & Gibbs, 2010). In this context, data analysis explores raw data, gathered from as many different views as possible, in a well-planned manner, in a bid to find out what the inherent facts about the issue under investigation are (Pandey & Pandey, 2015). The study employed focus group discussion and semi-structured interviews for data generation about the experiences of teachers. The interviews and focus group discussions were recorded, it was done with the permission of the teachers involved and were transcribed following the interviews. Data were segmented, coded, and categorised in order to analyse transcribed data (Creswell, 2012). The transcribed data were divided into meaningful units according to themes or segments, to understand its meaning. A segment can be a word, phrase or a sentence that is relevant to the study and is segregated with the intention of highlighting or bracketing. Segments that describe teachers' experiences in the context of knowledge and skills development for mathematics and science were demarcated. Lastly, the data

was coded by means of categories which were assigned units of meanings of the descriptive data (Cohen *et al.*, 2018; Creswell, 2012).

1.6 RELEVANCE AND SIGNIFICANCE OF THE RESEARCH

SUPs continue to be an essential mechanism for classroom-based intervention, with a key focus on teachers' CPD. The investigation into how teachers implement the skills and knowledge acquired in an SUP aims to:

- Provide a new viewpoint of CPD in an SUP experience;
- Expose SUP as a critical model or approach for creating sustainable teacher continuing development in South Africa; and
- Inform policymakers about the long-term implementation of a classroom-embedded professional development approach to teacher learning.

1.7 LIMITATIONS

The study was restricted to mathematics and science teachers that participated in SPP in Botshabelo and Thaba Nchu. In this study, eight schools that formed part of SPP were included, and sixteen teachers from these schools participated in the study. The number of teachers that participated in each school ranged from one to three, not necessarily two teachers from each school were included. Although SPP offered mentoring in subjects such as English, accounting, mathematics and physical/natural sciences, this study excluded English and accounting teachers and only mathematics and sciences teachers were selected. As Creswell (2012) puts it, information rich participants are required in qualitative research. Therefore, teachers were purposively sampled to include mathematics and science who experienced the SPP. Due to ethical and time constraints, this study could not include classroom observations as an additional data collection method to complement the data emanating from semi-structured interviews and focus group discussion, particularly on knowledge and skills implementation. These forms of data would have enhanced this study, as would inclusion of the perceptions of mentors to express their experiences when they conducted classroom visits. This could have

contributed to a better understanding on how teachers implement the acquired knowledge and skills, and used the resources provisioned by SPP mentors.

1.8 DEFINITION OF KEY CONCEPTS

School-university partnership – The social connection between universities and schools is a boundary area where regular interchange of miscellaneous perspectives and practice takes place and constitutes what has come to be known as SUPs (Bain, Bruce & Weir, 2017; Ng & Chan, 2012; Tsui & Law, 2007).

School Partnership Project – A project established by UFS to respond to educational challenges that are pervasive in underprivileged and under-resourced schools. In this project, external stakeholders come on board in an attempt to improve the situation (Jacobs, 2018).

Knowledge – The concept of knowledge is related to human actions, such as producing and using knowledge, which constantly involve a communication process (Papadouris, Hadjigeorgiou & Constantinou, 2013).

1.9 THESIS STRUCTURE

This section will present the layout of this thesis, which comprises six chapters, as outlined below.

Chapter 1 *Introduction*

This chapter laid out the general outline of this thesis, it identified the research gap that motivated the investigation into teachers' skills and knowledge implementation. This chapter also set out the general aims and objectives and outlined the relevance of this study.

Chapter 2 *Literature review on school–university partnerships*

This chapter will discuss the contribution of the literature, with a key focus on SUPs and professional development. The definition of professional development, CPD and mentoring will be provided in this chapter. Policy informing SUPs, different school-university partnership models and the ways in which they influence classroom teaching, are explored in this chapter.

Chapter 3 *Theoretical framework*

The chapter will provide a discussion of the two theoretical frameworks that guided the identification of key concepts in data analysis and interpretation of data relating to the everyday lived experiences of teachers when they implement knowledge and skills they had gained during their participation in an SUP. This chapter will conclude by presenting a unit of analysis tool from the adopted theoretical frameworks, that will be used to analyse and interpret data emanating from participants' responses.

Chapter 4 *Research design and methodology*

Chapter 4 will present the methodology that was used in this research. To be specific, the research approach, design, paradigm, participants, data collection instruments, analysis techniques will be discussed.

Chapter 5 *Data analysis and findings*

In this chapter, a qualitative analysis of the data collected from schools around Botshabelo and Thaba Nchu in the Free State province will be documented. The case study will present a thick explanatory summary of the data and will also outline major themes emanating from the analysis.

Chapter 6 *Discussions and conclusion*

This chapter will present the findings of this study and discuss the implications of the findings on teaching practice. This chapter will explain the significance of these findings and provide the conclusion of the study into teachers' CPD, in general, in other countries and South Africa, in particular.

1.10 SUMMARY

This chapter provided the background of the study, it focused primarily on knowledge and skills development in SUP and its implementation beyond SUP. In this chapter, I argued that SUP equip teachers with novel knowledge and skills and this knowledge is essential as it affect teaching practice within the classrooms. However, there is a gap in the literature on the implementation of the knowledge and skills teachers acquire in SUPs that needs to be explored or investigated. Most of the studies focus on how mathematics and science teachers develop the knowledge and skills in SUP. In this chapter, I have indicated that this study contributes insights into knowledge and skills implementation in mathematics and science teaching. The chosen theoretical frameworks, research aim and objectives, research methodology together with data analysis procedure were discussed. This chapter also indicated that qualitative research approach and case study design were chosen, and an interpretivist paradigm to interpret the experiences of mathematics and science in implementing the knowledge and skills. Study limitations were provided. In the next chapter, the literature review is presented.

CHAPTER 2: LITERATURE REVIEW OF TEACHERS' KNOWLEDGE AND SKILLS DEVELOPMENT AND IMPLEMENTATION

2.1 INTRODUCTION

This study intends to understand teachers' implementation of the knowledge and skills beyond SUP. The chapter starts with SUP and its models, it also reviews the policies that regulate formation of SUP globally, in Africa and in a South African context. The chapter discusses teachers' CPD as an essential component of knowledge and skills in mathematics and science teaching. In the previous chapter, an introductory part of the research was provided, and stated the main aim and research questions that guided the study. In this chapter, I will review the literature on teachers' knowledge and skills development in SUPs, and the implementation of the acquired knowledge and skills in practice. I will also discuss the factors that affect implementation at schools. The chapter concludes with the summary of the chapter.

2.2 SCHOOL–UNIVERSITY PARTNERSHIPS

The social connection between universities and schools is a boundary area where regular interchange of miscellaneous perspectives and practice takes place, and constitutes what has come to be known as SUPs (Bain, Bruce & Weir, 2017; Ng & Chan, 2012; Tsui & Law, 2007). A boundary zone between university academics and teachers exists because schools and universities are different. In this context, teachers and university experts are different in the ways they conceptualise a problem and solve it, they have different antecedence, responsibilities, and visions (Cochran-Smith & Lytle 2009; Mitchell, Hayes & Mills, 2010). A boundary zone that exists between different professional domains – including schools and universities – creates ample chances for participants to stimulate self-reflection about their practice, to approach new knowledge, and explore potentially innovative ideas in practice (Wenger, 1988). This suggests that a boundary zone that teachers and university academics need to cross to relate to each other is rich with knowledge and expertise. Schools and universities could use this knowledge and expertise for their own advancement. Therefore, SUPs can be viewed as a cross-institutional zone for learning, it is an

practice in which knowledge could be created, distributed, and acquired between partners (Fenwick, 2007).

In the past, university experts crossed boundaries to enable teachers to expose prospective teachers to the practical site of teaching. The research literature reports that university academics partnered with schools to place preservice teachers when they attend teaching practicum so that preservice teachers could acquire a practical knowledge of teaching while teachers served as mentors (Ambrosetti & Dekkers, 2010; Mutemeri & Chetty, 2011; Zeichner, 2010). This mode of partnership provides a linkage between higher education's theoretical knowledge, and field experience in preservice teacher education during teaching practicum. This link between theoretical and practical knowledge in teacher education expands learning prospects for prospective teachers, so that they are better prepared to successfully enact complex teaching practice (Zeichner, 2010). In recent years, however, a wider recognition of the needs of teachers and schools has started to surface. Universities are increasingly recognising their social responsibility agenda as members of the community, also in South Africa (DHET, 2013). University experts attempt to use higher education knowledge and expertise, as well as their social capital, to solve a wide range of social problems – of which education is one – by forming partnerships.

Given the extent to which SUPs are functioning, it can be argued that they are formed on the basis of three major domains of schooling: school leadership, curriculum, and student support. Jacobs (2018) argues that SUPs enacted in schools empower teachers in lower quintile schools, support school leadership, and improve learners to gain access in higher education. In the context of leadership, SUPs can provide ongoing support for new school principals, to a point where they can run a school independently. Fahey (2011) argues that newly appointed school principals should be moulded on the type of culture they should build in their own schools. The development of successful principals requires a collaboration in which members are committed to ensuring that newly appointed principals have the necessary skills and proficiencies to lead schools (Browne-Ferrigno & Barber, 2010).

Higher education forms partnerships with schools to combine critical domains phrased as teaching, research, and service to their surrounding communities (McLaughlin & Black-Hawkins, 2004). Teachers tend to seek help from universities to improve on

their instruction, content and pedagogical knowledge, school leadership, or learner support (Yuan & Burn, 2016). Universities on the other hand tend to respond to these issues by providing novel approaches stemming from theoretical epistemology, universities also evaluate innovative ideas in practice. Higher education appears to be a relevant institution that can interconnect with the educational needs of schools by identifying new instructional strategies generated through empirical research (Causton-Theoharis, Theoharis, Bull, Cosier, Dempf-Aldrich, 2011). Thus, schools assist higher education to understand the classroom reality and serve as research sites for universities in relation to education research. The empirical research conducted by higher education could, in turn, inform teaching practice at schools. Therefore, SUPs represent a symbiotic relationship that has the potential to bridge the theory–practice gap for in-service teachers. Researchers such as Yuan and Burn (2016) and Avalos (2011) agree that teachers are encouraged to take part in action research that could inform school improvements; both institutions benefit reciprocally by acquiring a new type of knowledge and skills. Teachers acquire knowledge through academics' expertise and resources, in return, schools are fieldwork areas in which the practicality of research is executed by universities. Butcher, Bezzina and Moran (2011) emphasise that such relationships are necessary for effective operation of schools and higher education.

2.3 SCHOOL–UNIVERSITY PARTNERSHIP MODELS

2.3.1 Equitable models

Schools and higher education institutions enter into collaborative agreements as distinct institutions. In these partnerships, equitability remains an important concept, one that is characterised by partners having equivalent authority regarding their involvement in a partnership. The development of relationships between higher education and primary and/or secondary schools culminates in a multifaceted collaborative environment that displays distinct institutional boundaries (Chan & Clarke, 2014; Tsui & Law, 2007). Researchers such as Chan and Clarke (2014) report that, although schools and universities may appear to share similar objectives of teaching and learning, they are different in terms of institutional culture. Another distinct feature is that schools are sites where higher education conducts education

research, while universities are knowledge hubs. Crawford, Killingsworth Roberts and Hickmann (2008:95) state that:

> *It is only under these circumstances that schools and universities can come together as equal partners and work towards a simultaneous renewal of their joint responsibilities of creating educational systems of excellence.*

This quote indicates that equitable SUPs affect stakeholders in two ways. One, equality implies that the stakeholders in an SUP are on equivalent footing on issues such as decision-making, planning and implementation of partnership activities. This implies that the institutional differences are suppressed, and the boundaries are crossed (Tsui & Law, 2007) for the development of equitable partnerships, and each stakeholder is an active participant in all the processes. Second, the quote highlights that SUPs can promote education systems of excellence (Crawford *et al.*, 2008) phrased as “simultaneous renewal”. It is through equality that the partnership can manifest successes pertaining to its mandate and produce excellence in terms of professional development of teachers (Mansour, EL-Deghaidy, Alshamrani & Aldahmash, 2014); learners’ performance (Maheady, Mageira & Simmons, 2016) and university excelling through research and theory practice at schools (Segedin, 2011).

Equitabilities symbolise a democratic, professional relationship between partners. Zeichner (2010) argues that the shift towards more democratic ways of higher education working with schools is needed for universities to fulfil their vision and mission regarding the education of teachers. SUPs bring together practitioners and academics in a less hierarchical way to produce new learning opportunities for teachers. Creation of the partnerships involves an equal and a more systematic relationship between academics and practitioners in support of teachers’ learning and knowledge development. This kind of democratic principle eliminates a hierarchical relationship and invigorates a less hegemonic partnership in which participants are equal (Mockler, 2013; Zeichner, 2010). Democratic partnership suggest that a professional dialogue is necessary between teachers, academics, and members of other education-related associations. This dialogue ensures that teachers express their perspective about how an SUP should contribute to their professional knowledge.

Since relationships are built between people and not institutions, there should be trust and reciprocal relationship as explained by Jeffery and Polleck (2010) to build authentic SUPs. A professional dialogue between teachers and academics fosters teacher autonomy, through which teachers can express their perspectives with regard to their learning needs without being marginalised (Wang & Zhang, 2014). This kind of professional dialogue also ensures that teachers become responsible partners in identifying key areas of their professional needs (Allen, Howells & Radford, 2013). According to Judyth Sachs (2003), a professional dialogue reorganises professional roles of teachers, it also modifies their political role. The modification of professional and political roles provides a conceptual and political platform to reconsider teachers' activities in collaborations.

An equitable SUP prioritises elimination of hierarchies amongst participants and allows partners to express their voices to stablish reciprocal relationships (Miller, 2015). The social interaction of school and higher education leads to the creation of a third culture that requires a true reciprocal relationship in which neither party bows to the authority of either individual institution (Arhar *et al.*, 2013; Beck, 2016; Tsui & Law, 2007). The concept of the "third culture" has also been proposed to describe the learning that takes place at the intersecting boundaries of both institutions when ideas from different cultures meet and form new meanings and understandings. However, Bartholomew and Sandholtz (2009) argue that SUPs inevitably encounter challenges due to these distinct cultures, and, consequently, a new culture of learning and knowledge creation is promoted by social interaction. Gutiérrez (2008) argues that a third culture is a changing endeavour and can lead to an extended form of teacher learning and, subsequently, the development of teachers' new knowledge.

2.3.2 Inequitable models

Relations between higher education and school participants have come under scrutiny. Schools and higher education are unstable organisations, and they bring to the partnership their distinct cultures to which the partnership is insignificant; both institutions come from diverse cultures in terms of knowledge, interest, and prospects (Bartholomew & Sandholtz, 2009; Hamel & Ryken, 2010). There is growing concern that relationships in SUPs are skewed. In this case, SUPs are typically organised by

university personnel together with the school management team and it is only much later that representative teachers from schools may be involved (Bartholomew & Sandholtz, 2009). Segedin (2011) explains that university-based partners bring an authoritative figure to the partnership and organise it in a top–down hierarchical structure, and only later recruit teachers. This kind of inequity increases teachers' responsibility; teachers could feel a high degree of accountability to universities, and also to their peers, schools, learners, and government in relation to student performance (Walsh & Backe, 2013). The contention that could be made in this regard is that SUPs should move away from being led by higher education experts, and should be teacher-driven, particularly when they aspire to contribute to teachers' professional knowledge and skills development.

Many scholars have referred the disparities in power relations between schools and universities. According to Botha and Beets (2016), the issues related to the interplay of power and authority indicates unequal membership, which causes a struggle for superiority between institutions, instead of focusing on what each institution can bring to the collaboration to achieve shared goals. For Mutemeri and Chetty (2011), the relationship between institutions is one-sided: Schools remain as passive recipients of knowledge, and universities are the producers of such knowledge. This one-sided partnership ensures that universities maintain superiority and hegemony over the development and dissemination of knowledge, while schools remain passive recipients of, and implementers of that knowledge. The kind of partnership represented here also deviates from a marriage metaphor (partnership, in this context) involving compatibility, attraction, respect and love, with concomitant problems that embrace unity in diversity.

Imbalance of authority exists between higher education and schools despite all attempts at achieving parity (Barnett, Anderson, Houle, Higginbotham & Gatling, 2010). Achieving relationship equality in university and school relationships may be challenging, because teachers might not view themselves as equal partners. However, university staff and researchers possess superior academic knowledge expertise, and teachers inevitably perceive university staff as superior. Regrettably, this kind of situation, due to the knowledge–power differential, does not foster the creation of equitable relationships (Primavera, 2004), and it impedes the formation of partnership based on the principles of equality. Teachers can create a climate of discomfort that

could culminate in their unwillingness to share their honest thoughts and perspectives. The development of SUPs involves the investment of time, resources, funds and energy, and a lack of equality certainly inhibits these valuable assets that can make partnership a success. A study conducted by Fisler and Firestone (2002) reports that trust emerged as an issue regarding partnership activities. Fisler and Firestone (2002) claim that partners should work towards building trust in order to interact productively. It is argued that schools and higher education institutions should contribute to the establishment of a shared vision and sense of trust among the partners (Allen *et al.*, 2013). The kind of mistrust reported on here contradicts the claim by Fisler and Firestone (2002), it does hamper partnerships from flourishing in relation to their mandate, but teachers lose hope in the university's role in sustaining professional development programmes, thereby impeding teachers' professional learning and development. Tsotetsi and Mahlomaholo (2013) argue that professional development programmes inevitably exclude teachers on various aspects, including decision-making. Grau, Calcagni, Preiss and Ortiz (2017) contend that SUPs successfully address this shortcoming by encouraging teachers to reflect on their practice. It would appear that – by encouraging teacher reflection – SUPs promote professional dialogue between partners to convey information regarding their learning.

2.4 POLICIES FOR SCHOOL–UNIVERSITY PARTNERSHIPS

Higher education is on a continuous trajectory of transformation, and several policies impact its management. Transformation of higher education – globally and in South Africa – is influenced by policies that govern transformation of higher education. From a global policy perspective, the concept of SUPs is one of higher education's transformative agendas of the 21st century, which mandates higher education institutions to form partnerships with communities such as schools (Department for Education, 2015; DHET, 2011; Education Bureau, 2003; US Department of Education, 2010). The general aim of these policies is to foster collaborative relationships between schools and universities, and they are based primarily on the reform agenda of education systems. This reform agenda compels universities and schools to form collaborations to achieve teacher CPD.

In the case of Hong Kong, for example, SUPs are promoted as one way to achieve CPD of teachers and which involves higher education institutions working in

partnership with schools (Education Bureau, 2003). The policy states that universities around Hong Kong should form partnerships with schools; the policy further state that school and universities should collaboratively plan and design CPD programmes. It is through this policy that Chinese schools occasionally seek professional support from university academics who are perceived by school-based teachers as knowledge providers (Education Bureau, 2003). There is a belief that learning permeates through various stages of a teacher's career, from initial teacher education to in-service teacher education. Therefore, in-service teachers should constantly participate in CPD programmes to refine their knowledge and skills for teaching.

The United States government, in turn, highlights that transformation of schools is not only the responsibility of teachers and principals; instead, it should be a shared responsibility (US Department of Education, 2010). The US policy aims to foster school environments where teachers have the time to collaborate, and this policy extends support to innovative approaches to teaching and learning to transform low-performing schools. In the US, schools and universities have historically partnered with each other to attain educational objectives. SUPs were fast-tracked by the 2001 No Child Left Behind legislation, this legislation highlighted vast inequity regarding education outcomes in the US (US Department of Education, 2010).

The European Commission policy states similar beliefs and states, furthermore, that the school environment should be encouraged to engage in collaboration that involves teachers interacting with external agencies, such as universities (European Commission, 2007).

The United Kingdom on the other hand has mandated universities to make a meaningful impact in communities through research and beyond academic services. In response to government mandate, universities have formally and informally partnered with schools to promote evidence-informed practice. The Department for Education in England published a document that was revised in 2015 to include case studies of six SUPs (Department for Education, 2015). In one type of partnership, schools form partnerships with organisations such as universities to "exchange information and expertise among teachers and others" (OECD, 2009:49). The document explicitly states that a variety of stakeholders such as schools and universities could benefit by knowledge that is shared amongst stakeholders.

Furthermore, it claims that benefits could include better school leadership, equipped teachers with better teaching practice, and an improved curriculum (Department for Education, 2015).

Drawing on the above discussions, it can then be argued that governments in China, the United States and Europe consider SUPs to be capillaries that stimulate teacher learning and improve skills and knowledge. These policies can be conceptualised because higher education institutions have similar educational responsibilities as schools, and this positions higher education as knowledge hubs for CPD of teachers' skills and knowledge. Through social interactions between participants, SUPs accelerate teacher learning, as SUPs are embedded in schools to address a plethora of teachers' educational needs (OECD, 2009).

Given policy directives for in-service teachers to focus on the topics of collaborative relationships, SUPs appear to be a relevant approach to strengthen these relationships (OECD, 2009). Accounts of the rightfulness and outcomes of partnerships have continuing relevance to teachers, schools, and the higher education sector. It implies that information and expertise could be shared and exchanged between teachers and academics, thereby fostering a unique form of reciprocal relationship between individuals representing distinct institutions (OECD, 2009).

Due to South Africa's complex history, transformation of higher education in the country is well documented in the literature (Badat, 2013; Davids, 2016). Without considering history, universities are by their constitutions expected to symbolise and enact transformation as a redress mechanism for education challenges that are inherent in lower-quintile schools (DOE, 1997). The *White Paper for Post-Schooling Education and Training*, for example, mandates universities to contribute to their surroundings as part of a redress mechanism, by being more proactive through community engagement programmes (DHET, 2013). The *National Plan on Higher Education* policy also recognises community engagement as part of three central functions of universities, alongside with research and teaching (DOE, 2006). The community engagement agenda assigns higher education institutions the task to form "partnerships with civil society organisations" (DHET, 2013:39). However, community-engagement initiatives in higher education are circumscribed to programmes "linked directly to the academic programme of universities, and form part of the teaching and

research function of these institutions" (DHET, 2013:39). One of these restrictions is the continuation of professional development of in-service teachers beyond initial teacher education. Hence, the SSP that this study focused on was aimed at empowering teachers in previously disadvantaged, lower-quintile schools through mentoring. This suggests that the contribution of higher education institutions to society is based primarily on the development of society in general and schools in particular. It is through connection that carefully conceptualised, mutually planned, and reciprocal partnerships between higher education and communities have the potential to create opportunities for economic and social advancement, while simultaneously enriching research, teaching, and learning.

In light of the discussions above, it is clear that, for universities to remain relevant in society, they should extend their application of knowledge and expertise to humane ends in the service of the common good. In South Africa, the DHET (2013) policy directs universities to be reflective and pragmatic practitioners, and to make their knowledge and expertise useful, so that they build both material and metaphorical bridges to better lives for people in disadvantaged communities. This obliges higher education to create collaborative partnerships, to improve all forms of scholarship so as to solicit and foster the support of stakeholders, such as schools, to contribute to the common good. This debate brings this thesis to a discussion of SUPs in a broader context and, most importantly, in a South African context.

2.5 SCHOOL–UNIVERSITY PARTNERSHIP AS A PROFESSIONAL DEVELOPMENT APPROACH

Internationally, SUPs are being implemented in various contextual settings to develop, address, and enhance diverse educational needs of teachers. The literature review shows that teachers participate in SUPs mainly to be inducted as new teachers and to attend a CPD activity for knowledge and skills development (Hartman, Kennedy & Brady, 2016; Gut, Wan, Beam & Burgess, 2016; Moss, 2010). Scholars have argued that SUPs are essential for promoting teacher autonomy at schools (Mockler, 2013; Wang & Zhang, 2014). It is important to discuss these aspects, so that the reader can understand how SUPs are enacted globally for the benefit of in-service teachers.

Novice teachers exiting higher education institutions enter the schooling system with anxiety about how they should navigate the tricky teaching profession (Moss, 2010). One of the setbacks associated with teacher attrition is loss of good teachers from the schooling system (Kelchtermans, 2017). SUPs provide a way to alleviate novice teachers' anxiety and turn around teacher attrition. Literature reports that induction of novice teachers in SUPs and providing them with mentoring in their early years of teaching, increases teacher self-efficacy (Hartman *et al.*, 2016). This suggests that SUPs are fundamental to curbing teacher attrition, especially for retaining good teachers to impart their knowledge and expertise to learners in schools.

Traditional approaches to professional development of teachers are characterised as teacher-centred, as they focus on the transmission of knowledge to teachers. The assumption is that individual teachers can learn, and there is a belief that teachers' learning can lead to an instantaneous change in teaching practice and make it possible for teachers to apply newly acquired approaches in diverse contexts (Bausmith & Barry, 2011). However, research reports otherwise (Girvan, Connelly & Tangney 2016). A professional development approach that takes place outside the classroom is insufficient – teachers will find it difficult to translate what they learn in episodic CPDs into the actual teaching practice. Teachers in different contextual settings experience diverse professional development needs and having a single coordinated type of professional development is unlikely to address these diverse needs.

Higher education institutions in certain parts of Africa recognise the implementation of SUPs as a professional development approach. In Uganda, for example, Makerere University formed partnerships with schools in four different ways (Opolot-Okurut & Bbuye, 2015). One of these avenues was that in-service teachers were tasked to work on projects at the schools at which they teach. Key findings of this study indicate that schools have an interest in working collaboratively with institutions of higher education. The study concludes that a school–university collaboration "enhances closer working relationship between institutions [for] teachers to practice new ways of working" (Opolot-Okurut & Bbuye, 2015:848). By working collaboratively with university academics, teachers could learn new curriculum and different pedagogy.

Bhengu and Svosve (2019) conducted a study that was aimed at transforming rural schools through a school–community partnership in Zimbabwe. They report that

school leadership is a pivotal element that can turn schools around to produce desirable outcomes. The findings reiterate the findings of the literature, that leadership has a fundamental role to play in providing vision and direction and building a conducive environment that is supportive to learning (Browne-Ferrigno & Barber, 2010; Fahey, 2011). Thus, if teachers perceive SUPs as providing new ways of working in schools, then it is worth investigating how teachers, independently, are applying these new ways in their practice.

In South Africa, SUPs continue to be used extensively for the professional development of in-service teachers. Academics and teachers are committed to SUPs, as can be seen from the many universities that have formed partnerships with schools in different contextual settings (Fricke, 2008; Jacobs, 2018, Myende & Chikoko, 2014; Silbert *et al.*, 2015). In the context of rurality, the manifestation of social ills, such as poverty and low levels of education including low levels of learner achievement, are pervasive among the people who live in rural areas (Chikoko & Khanare, 2012; Hlalele, 2012), and this makes rurality complex and difficult to describe. Against this background, rural contexts experience massive encounters that adversely affect the achievement of better quality education. This is the reason why Hlalele (2012) agrees that rural education generally requires specialised support to address low learner achievement. Scholars argue that the concept of SUPs is usually adopted as one of the interventions in South Africa in response to education challenges in rural settings (Myende & Chikoko, 2014). Building on the previous discussion on SUP policies, the establishment of SUPs supports the Higher Education Act, which expects universities to “demonstrate social responsibility of institutions and their commitment to the common good by making available expertise and infrastructure for community service programmes” (DOE, 1997:11).

A socially responsive institution is seen by one university in the Free State province of South Africa, which formed a partnership with the provincial Department of Basic Education (DBE), with rural schools, in particular. This partnership was designed primarily to address learners’ and teachers’ educational needs in rural settings through mentoring (Jacobs, 2018). The university-based partners appointed mentors to visit school-based teachers at least once a week to support teachers professionally in classrooms. Van der Walt (2016) reports that this partnership improved the academic achievements of learners in lower quintile schools in mathematics, science and other

subjects. The project contributed immensely to advancing quality education in lower-quintile schools, while it provided opportunities for learners to access universities after completing matric. Additionally, it contributed substantially to the social well-being of teachers and learners (Jacobs, 2018).

Ndlovu (2011a) reports on a university in the Western Cape province which designed and implemented an SUP for the purpose of revisiting teachers' professional development needs in mathematics and science. The partnership compelled university-based partners to visit schools on multiple occasions and, in the process, identify teachers' professional development needs and offer professional support. Through school visits, the purpose of this kind of a project was to facilitate co-teaching, as school-based teachers and university-based partners ventured into classroom teaching. Ndlovu (2011a) concludes that SUPs are responsive to teachers' professional development needs and can achieve great impact when they are sufficiently funded and efficiently facilitated.

From the above, it can be concluded that SUPs are embedded in classroom reality, as opposed to once-off CPD workshops detached from classrooms. The use of SUPs as a classroom-embedded CPD is advocated by Ndlovu (2011a), who argues that class visits by university-based partners are beneficial to meeting teachers' professional needs. Classroom visits, through the activity of observation and co-teaching, allow university-based partners to identify critical curriculum areas in which teachers require professional support (Graven, 2013; Siyepu, 2013). They improve teachers' knowledge and skills, "so they could develop positive feelings of professional self-efficacy in handling their lessons" (Ndlovu, 2011a:430).

2.6 TEACHERS' CONTINUOUS PROFESSIONAL DEVELOPMENT

The term teacher CPD is ubiquitous in the literature (Mokhele & Jita, 2010; Steyn, 2008; Tsotetsi & Mahlomaholo, 2015). It is frequently used reciprocally with terms such as staff development, in-service training on skills, and continuing education. A learning process that emanates from social interaction and that can result in knowledge transformation in teachers to enrich their practice is what has become to be known as CPD (Avalos, 2011; Kelchtermans, 2004; Mtetwa, Chabongora, Ndemo & Matuture, 2015; Zide & Mokhele, 2018). This suggests that teachers' CPD is a continuation of

their learning process beyond initial teacher education training, and might enhance content knowledge and instructional strategies. In a South African context, the DBE and South African Council of Educators collaborate and broaden views professional development of teachers as activities undertaken by individual or collaborative teachers in their careers. The aim of continuous participation in CPD is enhance knowledge and understanding of teachers, their competence and school leadership (DOE, 2007). Teachers registered with the Council are required to earn CPD points by participating in CPD activities that meet their developmental requirements. According to Desimone, Smith and Ueno (2006), accumulating professional development points is an accepted technique, internationally, to recognise teachers' CPD.

In their study on exploring strategies to strengthen teachers' CPD, Tsotetsi and Mahlomaholo (2015) report that involving partners at schools is one of the strategies to implement effective CPD programmes. Additionally, they believe that the inclusion of multiple partners in CPD programmes is a worthwhile technique, as it promotes multiple perspectives. A consultative democratic mechanism has to be followed for partners to reach a common vision that promotes ownership. This implies that communication about classroom experiences enable university partners to consider teachers' experience when they design and implement partnership activities (Grau *et al.*, 2017; Ndlovu, 2011a). Teachers can make sense of their own practice when SUPs consider their classroom experience prior to the implementation of partnership activities (Borko, Jacobs, Eiteljorg & Pittman, 2008; Butler, Novak, Lauscher, Jarvis-Selinger & Beckingham, 2004; Hennessy, Mercer & Warwick, 2011; Van Es & Sherin, 2008). Centralising teachers' experiences in SUPs allows teachers to have their theories and pedagogies considered, they can make the partnership a learning community.

From the above, it emerges that a classroom-embedded CPD can be a highly contextualised practice that is driven by the needs of teachers involved. This undertaking might imply that context-specific mentoring through an SUP can be a solution to off-site workshops or seminars, which supports the argument made by other scholars about detaching CPD from classroom reality (Steyn, 2008; Tsotesti & Mahlomaholo, 2015; Zide & Mokhele, 2018). Off-site professional development approaches tend to address the needs of teachers generally, without considering

individual teachers' needs, and are therefore not context driven, and they have a more simplistic and technical view of teachers' knowledge and skills. There is general criticism that traditional approaches are not offering teachers adequate time, and the content to improve their knowledge and skills (Mokhele, 2013; Tsotetsi & Mahlomaholo, 2015). This suggests that off-site approaches are ineffective since they cannot adequately enrich teachers' content knowledge or pedagogical skills. According to Ramnarain and Ramaila (2012), involving mentors in schools can yield better equipped teachers, as mentoring develops the personal and professional domain of individual teachers. Thus, mentoring works differently to workshops and seminars, which are detached from the classroom and only partially address instructional and content needs of individual teachers. Mentoring enables mentors to provide teachers with the necessary knowledge and skills by engaging in a plethora of mentoring activities during school visits. Like any other SUP that uses mentoring, the SPP mentors in the project of this study engaged in numerous activities when they conducted weekly school visits (Jacobs, 2018).

Desimone (2009) advises that mentoring should consider key characteristics, such as active learning, content focus, coherence, duration, and collaborative participation if it is to successfully lead to changes in mathematics and science teaching. Active learning is about the activities mentors employ while they professionally support teachers in quintile 1–3 schools, and it includes classroom visits, demonstration lessons, provisioning of teaching and learning material, and occasional educational tours for teachers and learners (Cheng & So, 2012; Lee, 2012; Ndlovu, 2011a; Nel & Luneta, 2017). In terms of lesson observation, Hargreaves (2011) stresses that mentors should focus their intentions on where good practice should be developed by teachers. Good mentoring provides space for teachers to self-reflect on their teaching practice at schools, and this strategy can increase teachers' devotion to their own development. Using learning resources exposes teachers to new and different content and pedagogical knowledge.

Content focus is another key characteristic that can be influenced by mentoring of in-service teachers. Mentoring teachers in their own classrooms enables mentors and teachers to discuss and engage in activities in specific subject areas. Mentoring as a practical-oriented approach allow both the mentor and teacher to engage deeply on content knowledge and pedagogical approaches that can be used to deliver the

content (Bransford *et al.*, 2005; Desimone & Pak, 2017). Mentors help teachers with to understand the content of the subject better and mainly focus on the subject knowledge where improvement should be made.

Mentoring provides coherence, as mentors help teachers to navigate new instructional practices grounded on their previously held knowledge and skills about teaching mathematics and science. Mokhele (2013) agrees that mentoring or coaching teachers is a coherent practice, as it dwells on the knowledge that teachers have and the knowledge and skills that must be developed. Mentors assist teachers in a coherent way to teachers' internal viewpoints and what is expected of teachers in the profession, by serving as thought partner (Gutierez & Kim, 2017).

Social interaction between teachers and mentors refers to collective participation creates a productive environment for teacher learning (Desimone, 2009). Such arrangements stimulate potential interaction and conversation, which can be a highly productive form of teacher learning and the "collective dimension, supported through verbal interactions … allow teachers to verbalise their reflections and confront attitudes and beliefs" (Grau *et al.*, 2017:24). Teacher reflection in interactive sessions helps to establish a shared vision, their expectations can be known, and their commitment and responsibility for learners can be identified. The availability of mentors in schools is useful especially when teachers need academics/expert opinion to tackle a challenge of implementing newly acquired instructional knowledge, it is also useful for teachers to restructure their practice (Coburn & Woulfin, 2012).

The above-mentioned characteristics indicate that teachers can develop new knowledge and skills when they participate in professional development innovations such as SUPs. Wang and Wong (2019) report that individual teachers expand their knowledge base and skills when university academics interact with teachers at schools. Additionally, they argue that university academics enhance teachers' pedagogical knowledge through contextualising newly built knowledge. The role of an SUP is to allow teachers to translate new instructional notions and methods into notions that teachers can understand and handle in their teaching practice (Cheng & So, 2012; Wang & Wong, 2019). When the activities executed in an SUP align with teachers' experiences, according to Borko (2004), they have the potential to assist teachers to enhance their knowledge and skills. The enhanced knowledge has

implications for classroom teaching practice and, therefore, teachers can change their instructional practices. SUP activities can lead to changes in teachers' knowledge, their beliefs about content and pedagogy, and attitudes; to changes in their teaching practice and, subsequently, to improvements in learners' achievement. It can, then, be argued that improving teachers' knowledge and skills does not merely have implications for changing teaching practice, but also represents one of the critical steps in improving student academic achievement (King & Newman, 2001, as cited by Steyn, 2008). If it is true that universities and schools could benefit from sharing expertise and knowledge as claimed by Wang and Wong, (2019), then it would be helpful to know how teachers implement the learned knowledge in their classrooms independently of their mentors.

Mentoring in-service teachers does not always yield positive outcomes, as many challenges can compromise the value of partnerships in teachers' CPD. Insufficient time has been reported as a challenge that prevents mentors and teachers from having post-observation meetings to allow for meaningful constructive feedback sessions (Jacobs, 2018; Ndlovu, 2011a; Nel & Luneta, 2017). Insufficient time can have a negative impact on attaining teachers' professional development needs, especially when teachers and mentors need to reflect on lesson observation.

Jacobs (2018) reports that another challenge SUPs face is financial sustainability, as some of SUPs are fully dependent on external sponsorship. This argument is advocated by Ndlovu (2011a), who argues that SUPs can make a greater impact if they are adequately funded. This suggests that insufficient funding can lead to premature termination of partnerships, and cause teachers to develop conflicting views about the value of partnerships for their professional learning. The dynamics of funding have an impact on the type and form the partnership should take (Mockler, 2013). Against this background, SUPs may fall short of comprehensively addressing emerging professional development needs of teachers, as the partnership could be prematurely terminated. This leads to SUPs lacking long-term sustainable impact on improving the teaching of mathematics and science. Mentoring is also quite labour-intensive and not easy to roll out on a large scale.

It can be argued that universities and schools have a symbiotic knowledge relationship, this is because both institutions can simultaneously produce and

implement knowledge for education reform and university research purposes (Bartholomew & Sandholtz, 2009). This knowledge symbiosis is seen when schools assist university academics during partnerships to understand the realities of the classroom, thereby allowing university academics and teachers to design and implement professional development interventions that can address the professional development needs of teachers while advancing university research. Bartholomew and Sandholtz (2009) argue that SUPs generate opportunities for teachers and university academics to acquire knowledge by referring to each institution's knowledge and expertise. In line with this, Walsh and Backe (2013) explain that university academics are well positioned in partnerships by virtue of their mandate of training and producing teachers. University academics have the capability to choose relevant instructional methods and strategies for teaching specific topics, especially topics that teachers find difficult to teach. In this context, participation of teachers in SUPs is a continuation of teachers' professional development, beyond their pre-service training, to refine their instructional methods and content knowledge.

2.7 TEACHER KNOWLEDGE AND SKILLS DEVELOPMENT

The concept of knowledge is related to human actions, such as producing and using knowledge, which constantly involve a communication process (Papadouris, Hadjigeorgiou & Constantinou, 2013). Knowledge is often described by words such as everyday, scientific or curriculum, to indicate the type of knowledge and the classroom. This suggest that words describe the place where the knowledge exists. This implies that teachers share knowledge by organising it and assigning specific meaning to it, depending on the community they belong to. For Edwards and Mercer (1987), "Knowledge is presented, received, shared, controlled, negotiated, understood, and misunderstood by teachers and children in the classroom". This quote implies that each community shares knowledge in a certain way and constructs specific meanings in their own ways. Thus, the life of knowledge is definite to the community in which it lives. This means each teacher who participates or who has participated in an SUP has their own set of knowledge and skills as a unique feature. This suggest that each teacher has a way of constructing knowledge and skills that could respond to their CPD needs.

The value of an SUP is that university experts can accelerate the process of teacher knowledge and skills acquisition, to influence teachers' knowledge and practice. Tsui and Law (2007) argue that it is essential to involve university academics in schools, so that they can positively influence how teachers develop knowledge and pedagogical competencies. The inclusion of university academics in professional development innovations constitutes the driving impetus for the renewal of teachers' professional knowledge and skills (Coburn & Penuel, 2016). Day and Smethem (2010) and Akkerman and Bruining (2016) believe that collaboration between teachers and university academics provides a wide external source of academic support and expertise that teachers have access to to improve their teaching practice. This suggests that SUPs represent an intersection of two different communities with different knowledge assets. The partnership encourages teachers to move out of their terrain to build a network with universities, this could lead to acquisition of knowledge. Universities partners can contextualise the knowledge and teachers could develop new knowledge especially in mathematics and science. Therefore, teachers participate in SUPs to acquire and create new knowledge that can be useful to their own teaching (Hawkins & Rezazade, 2012; Mitchell, Eby & Ragins, 2010; Wang & Wong, 2019; Xu, 2009).

2.7.1 Knowledge and skills development through sharing of curriculum resources

Rural education is often critiqued for the absence of teaching and learning resources, such as textbooks, which is attributed to socio-political factors around rurality (Engelbrecht, Nel, Smit & Van Deventer, 2015; Okeke & Mtyuda, 2017). Scholars such as Khumalo and Mji (2014) and John (2019) contend that the one of the challenges adversely affecting educational outcomes in rural schools is inadequate teaching and learning resources. They maintain that school infrastructure remains a serious problem in rural schools, with some schools still lacking adequate school infrastructure to support teaching and learning. Historically disadvantaged schools, particularly those regarded as quintile 1–3 schools, find it challenging to adjust to current developments in education, owing to lack of school infrastructure, textbooks, and technology (Du Plessis & Mestry, 2019). This implies that teachers in lower-quintile schools are deprived of the opportunity to execute their constitutional obligation to

convey their knowledge and skills in mathematics and science, and to ensure that effective learning takes place and that learners comprehend the concepts of these disciplines.

Lower-quintile schools that form partnerships with university academics, especially around mathematics and science, require academics to use their intellectual capital to synthesise additional teaching resources for teachers. In a study on how university academics perform as boundary crossing to support teacher learning in an SUP, Wang and Wong (2019) report that teachers regarded university experts as irreplaceable sources of new instructional ideas and innovations particularly in their theoretical forms. Wang and Wong (2019) extended that the provisioning of curriculum resources, and textbooks amongst others, can transmit new knowledge to authentic teaching situations. This suggests that university academics use their intellectual capital to cultivate the development of curriculum material, which could serve as resources that support teacher learning, as well as the teaching and learning of science (Petersen & Treagust, 2014), including that of mathematics (Luneta, 2012). University academics act as knowledge dispensers by introducing curriculum resources for teachers to use for their own learning, and to imitate the concepts these resources portray. University academics, therefore, play a critical role in teacher learning by influencing teachers' learning through provisioning of a variety of learning resources (Clarke & Hollingsworth, 2002; Wang & Wong, 2019).

Although introducing new teaching material could illustrate new teaching concepts, Wang and Wong (2019) warns that this is a one-route flow of knowledge, from knowledgeable academics to teachers. This suggest that democratic principles of equality in the creation of teaching material is not considered by academics who possess the intellectual capital needed to generate these resources. The perspectives of teachers are, in the process, supressed, as teachers cannot echo the ideologies related to the way these resources should be developed so that they are meaningful for their own development (Tsotetsi & Mahlomaholo, 2015). Nevertheless, teachers need the essential resources to tacitly and explicitly transmit knowledge in mathematics and science teaching. Chen and Wang (2015) report that teachers sought out assistance from external agencies to develop new knowledge and teaching skills. These scholars conclude that the professional development of teachers depends on the external resources provisioned by university academics. This

conclusion suggests that university academics will continue to support teachers when teachers require them to build interdisciplinary engagement, which enables expertise and resources to be harnessed to support efforts to improve the excellence of teaching (Silbert *et al.*, 2015).

The literature reviewed in this section acknowledges that the provisioning of teaching resources influences teacher learning, as it helps teachers to develop new knowledge and skills for teaching mathematics and science. However, knowledge and skills development are broad routines that are impacted upon by a variety of processes that could lead to teacher learning. In SUPs, teachers interact not only with provisioned learning resources, but also interact socially with university academics to improve their knowledge and skills. Section 2.7.2 will review literature on mentoring of in-service teachers.

2.7.2 Mentoring in-service teachers

The SUP under investigation employed mentoring – university partners mentored school-based teachers. Given the extent to which SUPs employ mentoring, it has arguably become imperative to interrogate how in-service teachers construct knowledge and skills by participating in these partnerships.

Literature on mentoring suggests that it is a widely contested concept, and just like any other philosophical term, mentoring cannot be discussed from a single definition (Ambrosetti & Dekkers, 2010, Halai, 2006; Kemmis *et al.*, 2014). Definitions vary greatly, giving the reader differing expressions of what is regarded as mentoring. Most definitions regard mentoring as a hierarchical relationship between an experienced mentor and a teacher, in which there is a power struggle about who possesses more knowledge and skills (Korhonen, Heikkinen, Kiv'niemi & Tynjälä, 2017). Despite the mentor possessing more knowledge and expertise in teaching, Ambrosetti (2010) contends that mentoring should be a less authoritative relationship that harnesses mentors and mentees to work together to achieve specific professional and personal outcomes of the mentee. Mentoring enables individual mentees with less experience to develop specific skills and knowledge that could enhance mentees' professional and personal growth. This implies that mentoring represents a democratic practice that encourages mentors and mentees to share authority for the purpose of teacher

empowerment. Bradbury (2010) claims that the democratic principle of mentoring emerges when mentor and mentee share knowledge, work together, and nurture the whole person to improve their practice.

It can, then, be argued that mentoring represents an equitable social practice through which teachers and university academics socially relate with each other. Kemmis *et al.* (2014) view practice as a supportive social activity that binds partners to jointly work together in a distinct project. This practice involves three different, interdependent, distinctive systems of understanding, methods of action, and the ways in which partners relate to one another. Therefore, mentoring is what partners refer to while they are engaged in practice, that is, the activities of mentoring, such as communication between partners, modelling of good practice, and reflection discussions.

Scholars argue that mentoring activities assist teachers to cultivate their knowledge and skills, execute the learnt skills practically and reflect on their own practice (Gutierez & Kim, 2017; Korhonnen *et al.*, 2017; Shwartz & Dori, 2016). Mentoring as a social practice encompasses the general aims that stimulate the practice, activities undertaken to achieve these aims, and the anticipated outcomes that partners intend to achieve through mentoring – although these outcomes may not be achieved. By virtue of participating in mentoring, teachers could socially construct the knowledge and skills they need in their teaching practice.

The social construction of knowledge and skills by teachers in mentoring depends greatly on mentors' prior knowledge and how mentors enact mentoring. Clarke, Killeavy and Moloney (2013) and Ulvik and Sunde (2013) report that mentors' knowledge emanates, to a large extent, from their professional experiences and preferences. It is the context in which mentors' experiences emanate from that robustly influences how mentors conceptualise and practice mentoring. Daily activities of mentors are essential sources of knowledge, and these activities contribute to their knowledge about mentoring (Aspors & Frasson, 2015; Izadinia, 2015). However, it does not necessarily mean that effective teachers who possess knowledge and expertise in mathematics and science can become worthy mentors at schools. In support of this notion, scholars such as Ambrosetti (2014) contend that mentoring is not a natural ability that individuals inherently possess. Nevertheless, mentoring skills

can be acquired and developed over time by individuals who are entrusted with this responsibility (Hennissen, Crasborn, Brouwer, Korthagen & Bergen, 2011). Therefore, teachers participating in SUPs should be mentored by individuals who understand the dynamics of mentoring, who can challenge teachers' thinking and make implicit expertise visible and deliberate to teachers. Allen *et al.* (2013) make it clear that mentors should undergo training to learn the basics of cognitive mentoring, so that they develop the capacity to mentor adults.

Mentors also develop knowledge about mentoring if they view themselves as co-learners in partnerships. This suggest that mentors should employ "co-constructivist approaches to mentoring to build teachers' knowledge of practice" (Langdon & Ward, 2015:240). Mentors changes their ways of working with mentees and develop their mentoring skills through the changes, they view themselves as co-learners than experts (Langdon, 2014). In this instance, the context in which mentoring is undertaken serves as a terrain that promotes mentors' learning. The process of mentoring is learned by engaging in social practice, which is a continuous learning process for the mentor, and which changes over time and with the context within which it is taking place.

It can be argued that mentoring is a multidimensional social practice. In their study on perceptions regarding mentoring experiences, Shwartz and Dori (2016) report that mentoring of in-service teachers is a multifaceted job. Their findings reveal that mentoring is a complex social practice that is affected by key professional, affective, and technical dimensions (see Figure 2.1).

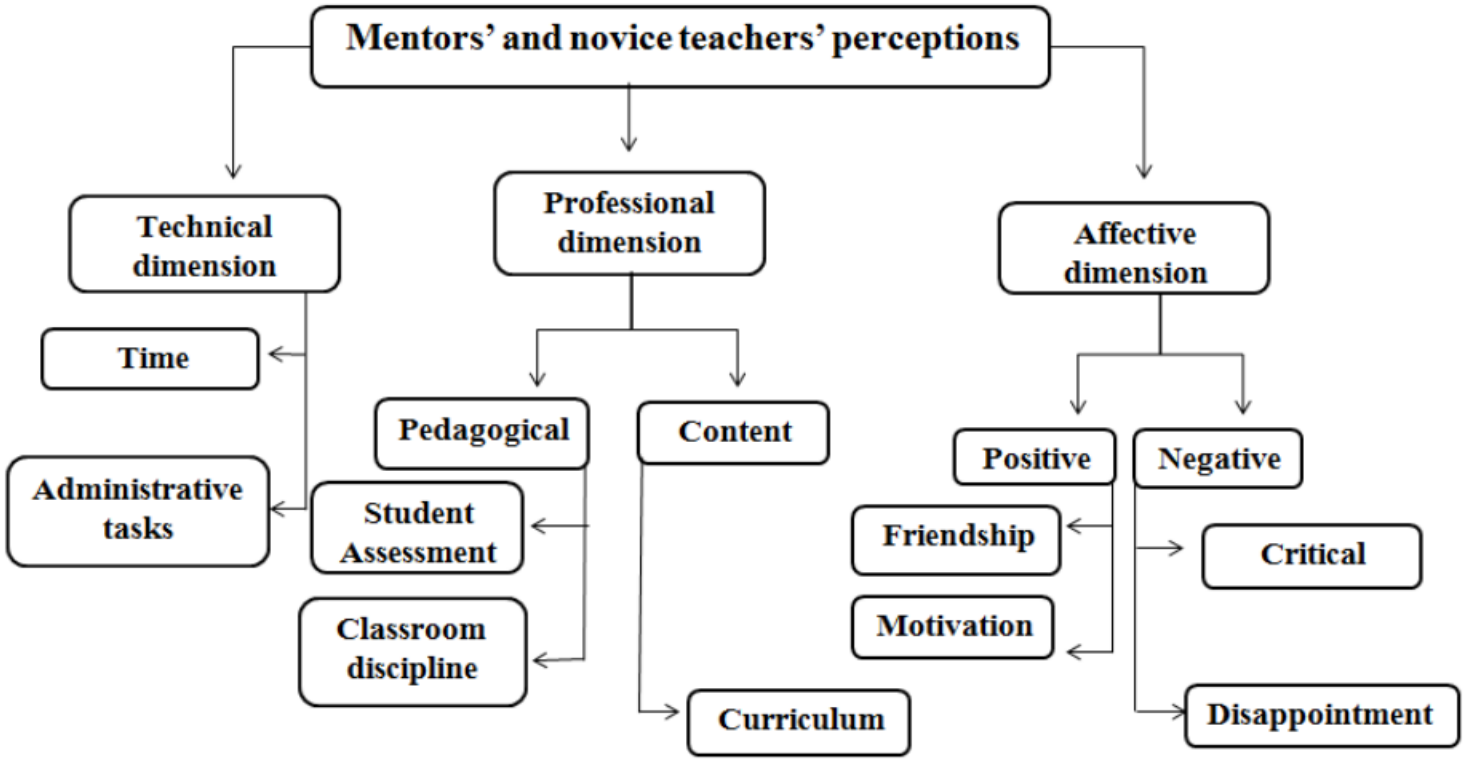

Figure 2.1: Schematic representation of how novice teachers perceive mentoring

Source: Shwartz and Dori (2016)

The diagram in Figure 2.1 illustrates that mentors and novice teachers perceive mentoring to be a social process that has technical, professional, and affective dimensions (Shwartz & Dori, 2016). These perceptions are in line with other empirical studies that examined the perceptions of teachers about mentoring. For example, in an investigation about the views of mentoring in-service teachers and university teacher educators, Lai (2010) found that mentors' views encompassed traditional and constricted concepts of mentoring, such as those of providing instructional guidance and sensitive and procedural support.

It is essential to unpack these dimensions in detail. First and foremost, the technical dimension refers to the amount of time teachers and mentors require to implement partnership activities. In this regard, Desimone and Pak (2017) argue that the longer teachers are exposed to learning activities in professional development innovations such as SUPs, the more likely they are to develop knowledge and skills for teaching. Longer duration implies that teachers are on a continuous reflective cycle and this action could foster teacher development. When teachers engage in longer activities, they dwell deeply on content, conceptions and misconceptions of learners, and instructional strategies. This suggest that time is important in mentoring relationships, teachers are more likely to discusses and negotiate various aspects related to mathematics and science teaching. Also, time is needed to reflect on teaching practice. In mentoring, teachers and mentors carry tasks that slightly out of their daily repertoires, academics connect with the practicality of teaching and teachers to reflect on their teaching practice beyond the classroom (Hennessy & Deaney, 2009; McLaughlin & Black-Hawkins, 2004).

Lastly, mentoring relationships affect the emotional wellbeing of participating teachers. This conception refers to the affective dimension, which can promote creation of friendships and motivation amongst participants in mentoring relationships (Shwartz & Dori, 2016). However, mentoring relationships can lead to disappointment when mentoring does not address the CPD needs of teachers involved in a collaborative programme (Aléman, Freire, McKinney & Bernal, 2017). Some scholars argue that the professional and affective dimensions of a mentoring relationship somehow overlap (Shwartz & Dori, 2016). Mentors may have feelings of disappointment or motivation, based on how teachers manage their classrooms while they are being observed. In the

case of disappointment, mentors can provide emotional support to encourage teachers to improve on classroom management. This is the reason why Israel *et al.* (2014) argue that the emotional support is embedded in professional support.

2.7.3 Content and pedagogical knowledge

Shulman's (1986) work on teachers' professional development identified four communalities: content and pedagogical knowledge, PCK, and knowledge of the subject-matter. Content knowledge is viewed as knowledge that teachers are required to teach and that learners are anticipated to learn in each subject or content area (Shulman, 1986). Pedagogy is about the action that teachers take together with their learners and this take place within a confined environment, it includes the learning tasks that needs to be carried out. For Shulman (1986), classroom learning depends on the instructional strategies that teachers employ in the classroom. PCK on the other hand denotes to knowledge of subject-matter that deals with the teaching process performed by teachers in their classroom settings (Santos & Castro, 2021). Teachers translate subject knowledge matter for teaching, known as PCK, this is a special kind of knowledge from other knowledge known to teachers, it is about the practice of teaching (Shulman, 1986).

For SUPs to have relevance in teachers' professional development, they must engage teachers deeply on the content and pedagogical knowledge that teachers should develop and enhance (Desimone, 2009; Desimone & Pak, 2017). Mokhele (2013) argues that effective professional development that involves deep engagement in the subject-knowledge matter increases the knowledge and skills of mathematics and science teachers and changes their beliefs about the teaching profession. Through mentoring, SUPs help teachers to acquire the necessary pedagogical skills, so that they can implement newly acquired pedagogical skills in classroom teaching. Xu (2009) suggests that university academics disseminate new pedagogical ideas and practice at schools. However, research has found that the sharing of practice between teachers and university academics does not guarantee the transmission of good practice (Hargreaves, 2011). This implies that, to ensure effective practice transfer, teachers and university academics should be in an environment (classroom) within which that practice should be enhanced

by means of classroom observations and instructional coaching (Nel & Luneta, 2017; Wang & Wong, 2019). According to Webster-Wright (2009), university academics help teachers to improve their pedagogical practice through contextualising newly introduced knowledge through lesson demonstration and guidance. Overton (2018) argues that university academics must gain belief by enacting teaching practice in the classroom and by providing professional development in the classroom *in situ*. The classroom enactment can be followed by reflection on that teaching practice.

CPD in South Africa is intended to furnish teachers with the knowledge and skills to meet the pressing challenges of the 21st century. Nel and Luneta (2017) argue that only certain CPD interventions are more focused on mathematics content and pedagogical challenges experienced by individual teachers. It is essential for professional development to focus deeply on specific content, such that teachers' professional needs in a specific topic could be attained. Teachers at different stages of their profession – ranging from primary to secondary schools – have different perceptions and professional development needs (Mansour *et al.,* 2014). Mathematics and science teachers may share professional development needs; however, they may be in need of different instructional strategies. Mokhele (2013) concurs with this argument and claims that the form in which a professional development is presented is not significant for each member who participates in CPD, as each individual teacher has different personal circumstances and invest differently in a programme. The difference in the investment in a professional development programme could be as a result of differing professional development needs of each teacher.

When a teacher experiences a challenge in a topic specific to mathematics or science, classroom-embedded professional development in a specific topic could assist them to comprehend aspects of the content knowledge. The teacher could transform the content knowledge and thereby develop unique knowledge for teaching a specific concept in the process (Rollnick & Mavhunga, 2014). Therefore, topic-specific PCK (TSPCK) can be defined as knowledge for teaching a topic by translating the main concepts into forms teachers can easily comprehend and be able to teach (Mavhunga & Rollnick, 2013). Regarding mathematics TSPCK, Ndlovu (2011b) reports that teachers gave positive

feedback of learning about square and square roots after participating in an SUP. Similarly, regarding science TSPCK, Mavhunga and Rollnick (2016) investigated the relationship between TSPCK and teacher beliefs following professional development for the topic chemical equilibrium. They report that teachers changed their beliefs and opted to adopt learner-centred teaching approach to teach chemical equilibrium in physical sciences. The findings of these scholars are significant, as they indicate the value of TSPCK for algebra and chemistry, to translate conceptions of a topic into a form appropriate for teaching. It is important to note that it is when teachers consider certain aspects of content knowledge that they can transform this knowledge and they could develop an exceptional knowledge of presenting the concept (Mavhunga & Rollnick, 2013).

One of the central features of effective professional development is content focus, as suggested by Desimone (2009). Mentors, as instructional coaches in embedded classroom professional development, employ activities that dwell deeply on subject knowledge expertise; mentors stimulate the activities that engage teachers deeply in the subject-content knowledge (Desimone & Pak, 2017). Mentors work one-on-one with teachers with the primary purpose of developing specific subject area through a professional dialogue. Research studies have found that professional development experiences with an unequivocal focus on the content that teachers present in their classes have impacted on student learning in mathematics and science (Van der Walt, 2016). This suggests that, when a CPD focuses on content, the attitudes, knowledge, and instructional practice of teachers could change, as could, ultimately, student outcomes.

From the above discussions, it emerged that the ability of mentors to focus on content knowledge and offer instructional strategies for teachers to present such knowledge in classrooms represents PCK. Thus, PCK is the “knowledge to make subject matter accessible to students” (Kleickmann *et al.*, 2013:91) and is understood as a mixture of “content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding” (Shulman, 1987:8).

2.7.4 Technological pedagogical content knowledge

By linking pedagogical knowledge, content knowledge, PCK, and knowledge of context, Mishra and Koehler (2006) expand the concept of PCK to include a technological, pedagogical content knowledge (TPACK) framework. The framework is a complex interaction of different sets of knowledge. The interaction of these forms of knowledge give rise to PCK (Liu, Tsai & Huang 2015; Seufert, Guggemos & Sailer, 2021) (see Figure 2.2). However, although TPACK refers to knowledge, scholars such as Willermark (2018) have conceptualised the component of the TPACK framework as skills or competence. The skills or competence refer to the application of knowledge by individuals possessing such knowledge. A teacher has to demonstrate the acquisition of such skills or competence in practice to demonstrate they have been successful in developing the competence. Knowledge can, therefore, not be viewed independently of its application, as its implementation shows if teachers have successfully developed such knowledge. This application of knowledge has the potential to identify which factors promote and inhibit the implementation of the knowledge possessed.

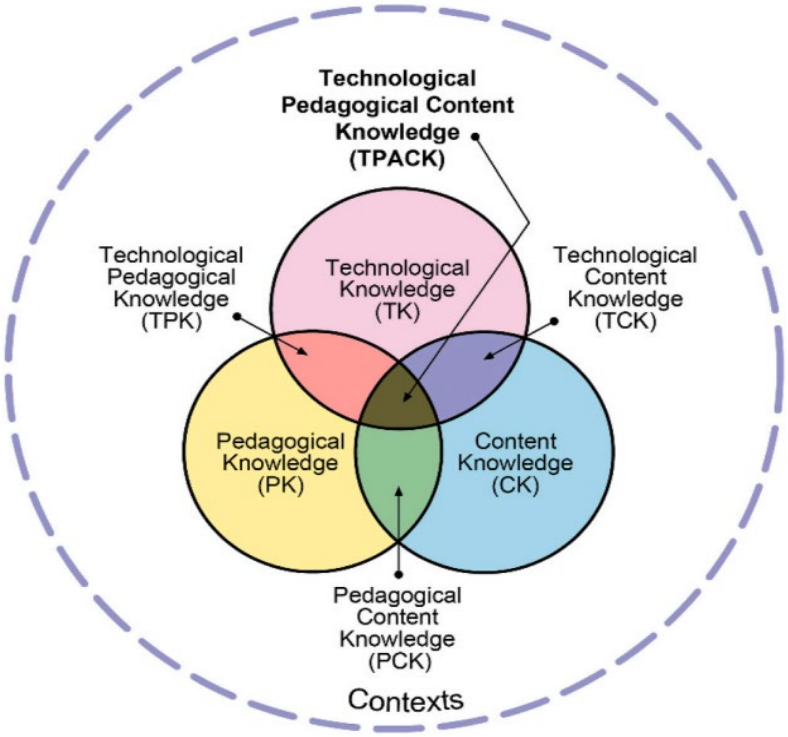

Figure 2.2: TPACK framework

Source: Seufert *et al.* (2021)

In South Africa, the DBE legislated a draft on information communication and technology (ICT). The aim of the policy was aimed at providing a common vision and specific framework for ICT implementation at schools. The SPP in this study included the internet broadcast project, known as IBP, to distribute live-streamed videos across schools in the Free State province, which included those that had formed partnerships with the university involved. This concurs with the report of Liu *et al.* (2015), that many professional development programmes have been designed to include technology integration for educational reform. This is because the introduction of ICT in schools enables teachers to use technology in their own teaching. In an article by the *Mail & Guardian* newspaper in 2018, the IBP was hailed by both the University of the Free State vice chancellor and the member for the executive council for education in the Free State due to its contribution to the improvement of matric results for two consecutive years. The benefits associated

with the IBP is ICT skills development and integration in classrooms. As illustrated in Figure 2.2, TPACK is not merely about the technological pedagogical and content knowledge, but it is also concerned with its application.

Success indicators have been associated with technology integration and teachers' professional development. For example, Mtebe and Raphael (2018) adapted the TPACK framework to investigate teachers' competence in relation to skills, and report that teachers had modest self-reported assurance in all TPACK elements. This study provides insights into how teachers are using ICT within schools to prepare learners for skills required in the 21st century. Teachers mainly focus on knowledge of technology independent of ICT, and later integrate technology in their classroom teaching (Koh & Divah'aran, 2011).

Technology integration in classrooms has been marred by challenges. For example, Kafyulilo *et al.* (2015) examined factors that affect whether teachers continue to use technology in teaching. Their study reveals that, despite teachers experiencing challenges in using technology for teaching, the school management team encourages teachers to maintain using technology in their teaching. Scholars investigated teachers' perception of computer use in classrooms (Nikolopoulou & Gialamas, 2016); they identified three barriers, namely lack of support by school leadership, lack of teacher confidence, and lack of equipment in classrooms. Scholars have tried to identify supporting or hindering school contextual factors for ICT integration in mathematics lessons. Characteristics at school level do have an effect on how ICT is integrated in teaching and learning and appear to be relevant across education systems (Eickelmann, Gerick & Koop, 2017). A common feature mentioned by these scholars is that knowledge and skills implementation is dependent on the teaching environment within which such implementation takes place. Teachers can develop the knowledge and skills in technology integration for mathematics and science, however, the teaching milieu is an essential factor that can either promote or inhibit technology use.

According to scholars such as Liu (2011), teachers occasionally fail to succeed in technology application in the classroom because they lack classroom strategies for implementing technology. This suggests that teachers lack TPCK, which refers to the

knowledge of technology use in teaching to develop innovative ways of teaching (Liu *et al.*, 2015).

2.8 FACTORS THAT INFLUENCE TEACHERS' KNOWLEDGE AND SKILLS DEVELOPMENT

Extensive review of the literature exposed that several factors play key roles and influence how knowledge and skills are developed, and which foster teacher professional learning and development (Myende & Chikoko, 2014; Whitworth & Chui, 2016). According to Cochran, DeRuiter and King (1993), social, cultural, political, and environment affect teaching and learning in schools. Since this study was aimed at examining different schools in rural settings in one province in South Africa; it is worth highlighting some of the key contextual factors that may impact on teachers' knowledge and skills development.

2.8.1 Teacher experience

Individual teachers who participate in an SUP have varying amounts of teaching experience, which influences how each one develops and implements knowledge in their classroom. Teacher experience – regarded as the number of years in the classroom – is a critical factor to consider in an SUP (Whitworth & Chui, 2015). Novice teachers in their early teaching years should attain knowledge and different skills; they should be able to learn to evaluate their improve so that they can improve in the profession. Novice teachers participate more in professional development activities than their counterparts (Marsh, 2020). Novice teachers appear to find it challenging to implement their knowledge of teaching in actual classroom practice (Cochran-Smith *et al.*, 2014) as a result of the decontextualised nature of theoretical knowledge acquired at higher educational institutions. In their study, Luft (2001) did a comparison study about the beliefs and practice of novice and experienced teachers after a CPD participation. They found that novice teachers changed their teaching beliefs than their actual teaching practices, whereas experienced teachers transformed their teaching practice more than they changed their beliefs.

Similarly, teacher experience can influence why teachers want to participate in a SUP for their professional learning. Novice teachers participate in an SUP to learn about classroom management, assessment and to learn about new pedagogy (Bach, 2019; Bastian & Marks, 2017), whereas experienced teachers participate in an SUP to inquire about advanced content and pedagogical knowledge (Mokhele, 2013; Ndlovu, 2011a; Wang & Wong, 2019).

A differentiated teaching experience, thus, shapes how teachers develop knowledge and skills, and could have an impact on how teachers implement the knowledge and skills acquired in the partnership in their classrooms. Most importantly, this also suggests that SUPs, in their content and format, need to customise partnership activities to consider teachers with different teaching experience, in order to accommodate all the stakeholders.

2.8.2 Teacher efficacy

SUPs strive to engage in-service teachers in highly effective learning experiences that promote professional growth and development (Trent, 2012; Trent & Lim, 2010). Specifically, teachers' beliefs in their ability to impact on student learning – referred to as self-efficacy – is a key concept in the professional knowledge and skills development of teachers. Self-efficacy is about learning of an individual in a social content, this contributes to the development of certain social behaviours of the individual involved in the learning process (Bandura, 1995). In accordance with Bandura (2001), the central characteristic of "what makes human agents in their own lives is their own self-belief in their ability to exercise some sense of control over their own behaviour and of their environment" (Petersen & Treagust, 2014:155). It can be argued that self-efficacy refers to what individuals think of their competence, and this does not necessarily concentrate on the level of efficacy itself. Bandura (2001) refers to this self-belief as a person's apparent self-efficacy, which influences on how people think and behave and self-motivate themselves to be effective in their daily repertoires. The assumption that could be made from this statement is that teachers who have lower levels of self-efficacy will

circumvent activities that they consider they are not proficient of doing, which can influence their continuing personal and professional development.

Teacher self-efficacy can be linked to teacher experience. Self-efficacy is connected to the distinct factors of individual teachers, which include whether a teacher is a novice or have extensive experience in teaching. It is teachers who have extensive experience who tend to have more unwavering self-efficacy, whereas novice teachers still need to navigate their ways in the teaching profession to develop more stable efficacy (Whitworth & Chui, 2015). Teachers that have a stronger self-efficacy are more likely to transform their practices as a result of participating in an SUP, and this likelihood varies between novice and experienced teachers.

In this study, I wished to find out if teachers participating in an SUP were more likely to enhance their self-belief to impact on learners. Self-efficacy is not merely about teachers' ability to transmit their knowledge in a certain area but is also prompted by the ability of teachers to construct an effective learning environment and make use of appropriate resources to maximise student learning (Petersen & Treagust, 2014). School-based teachers could develop or transform their own knowledge by means of opportunities for trying and testing new ideas emanating from collaboration and talk about learning and teaching in new ways. When teachers participate in CPD that provide mastery experience, their professional and personal competence level likely improve (Epstein & Willhite, 2015). Teachers can enhance their self-efficacy, this can be achieved by implementing new instructional strategies in their teaching practices, and self-efficacy could improve particularly when teachers see these new instructional strategies work (Sharma, Loreman & Forlin, 2012). SUPs with adequate duration and extensive contact sessions can also help teachers, regardless of their experience, with low self-efficacy to augment their self-efficacy. A study conducted by Lakshmanan, Heath, Perlmutter and Elder (2011), for example, found that the professional development that helps science teachers develop subject-matter knowledge lead to increased self-efficacy.

2.8.3 Teacher identity

The participation of teachers in an SUP shape their identity development. Gee (2001:99) defines teacher identity as “being recognized as a certain kind of person” on the part of teacher themselves, and by others in their situated learning community. This definition suggests that identity is about “our understanding of who we are and who we think other people are” (Danielewicz, 2001:10). Contrary to traditional approaches of teacher learning, which perceive teachers as knowledge absorbers, SUPs are seen as contributors to independent teacher professionalism (Mockler, 2013), and lead teachers to enhance their teaching practice, it enriches their identity and promote their teaching competency. An increasing body of knowledge recognises the role teacher identity have in teachers’ learning, which could assist teacher to develop their professional self-image that boosts effective teaching and elevate their interaction with their complex working contexts (Trent, 2012; Trent & Lim, 2010; Yuan & Burn, 2016).

SUPs have been shown to be an effective means of enriching teachers’ CPD through classroom-embedded interventions (Wang & Wong, 2019; Ndlovu, 2011a; Trent, 2012); and the partnership is a key contextual structure that shapes teacher identity (Trent & Lim, 2010). For example, in a school–university collaborative project reported by Ndlovu (2011a), teachers appreciated professional autonomy in problematising their teaching and making methodical alterations to their teaching practice. At the same time, the university-based facilitators introduced different types of knowledge. This suggests that SUPs can operate as a community of learning, teachers can construct meanings and their professional identities. They can also seek professional development through reflective discussion or professional dialogue.

Developing an understanding of a comprehensive identity in the context of SUPs requires paying attention to both identity through discourse and identity through practice, as suggested by Varghese, Morgan, Johnston and Johnson (2005). The former, identity-in-discourse, concedes that “identity is constructed, maintained and negotiated to a significant extent through language and discourse” (Varghese *et al.*, 2005:23). The latter, identity-in-practice, explains an action-oriented approach to understanding identity, which

underlines the need to understand identity formation as a social matter that is operationalised through concrete practices and tasks.

As described by Wenger (1998), identity construction is premised on three key characteristics: engagement; imagination, and alignment. Firstly, the participation of teachers in an SUP enables teachers to engage in different social interactions, for instance classroom observations, co-teaching and reflection sessions (Nel & Luneta, 2017; Wang & Wong; 2019). According to Yuan and Burn (2016), participation by teachers in many forms of engagement that were previously absent from their prior work, becomes a critical source of teacher identity development. This suggests that teachers become who they are by their involvement in social engagements that are embedded in their classrooms. However, identity does not merely shape teachers' engagement in the partnership, but also how these teachers might be able to partake in other activities beyond the SUP.

Secondly, imagination is about generating images of the world and our place within it by seeing beyond the instant context and making associations across space and time (Wenger, 1998). SUPs stimulate teachers' imagination, which enables them to create a picture of the environment in which their identities could be forecasted and adapted. Through imagination, teachers could actively engage in constructive reflection sessions about their observed practice, which can in turn stimulate the learning of new pathways and the development of different lenses for perceiving and executing their daily repertoires. For Yuan and Burn (2016), teachers exercise their imaginative thinking by implementing an innovative idea of co-teaching, through which identity could be enriched and enhanced. The view implies that imagination could have an essential impact on teachers' future identity investment, in which teachers can project that they can enhance student academic performance.

Lastly, alignment organises an individual's activities in wider structures, thereby granting the identity of a bigger community to be part of the identity of individual within that community (Wenger, 1998). Participants in an SUP align to the objectives of the partnership and promote social interaction and communication with their mentors, thus, contributing to the teachers' emerging identity as "partners" in the collaboration. Yuan and

Burn (2016) argue that distributing the practical knowledge created through social engagements embrace teachers' new identity. Teachers' identity construction can be reflected in teachers' alignment of their individual classroom practices and activities, including their use of the resources made available to them through their engagement in a partnership (Trent & Lim, 2010).

2.9 NEW KNOWLEDGE AND SKILLS IMPLEMENTATION

This section will review the literature on the continued implementation of newly acquired knowledge and skills by teachers who participated in a CPD project. The rationale is to understand the relationship between teachers' participation in professional development and their continued application of the new knowledge and skills in classrooms. It was discussed in Section 2.6. that teachers participate in SUPs to develop knowledge and skills to enhance classroom enactment. However, only a few studies have examined the implementation of newly acquired knowledge and skills beyond professional development such as an SUP, especially in a South African context.

Mansour (2010) argues that effective knowledge and skills implementation cannot be achieved if mathematics and science teachers are not well prepared with the knowledge and skills required for teaching. This claim suggests that professional development should endow teachers with the knowledge and skills that are lacking in teachers' classroom enactment, so that teachers have different views of classroom instructions.

Scholars such as Guskey (2009) describe five essential levels for assessing professional development, namely (a) participants' reactions, (b) learning of participants, (c) organisation support for personal change, (d) the use of knowledge and skills by participants, and e) student learning outcomes. However, this study was limited to examining teachers' use of the acquired new knowledge and skills.

Researchers have attempted to understand the implications or advantages of participating in professional development programmes and the impact thereof on teaching practice. For example, a study examined the benefits of participating in a professional dialogic CPD and concludes that teachers ascribed the improvements in their

professional practice to their participation in professional development (Rodriguez, Condom-Bosch, Ruiz & Oliver, 2020). Similarly, research has found that science teacher development becomes effective and successful when teachers echo their perspectives on the learning activities (Mansour *et al.*, 2014). Professional dialogue enables teachers to have a discussion of what they are doing in the classroom, it give them opportunity to express what they do in classroom to implement ideas acquired from the CPD.

It can be argued that teachers continuously apply new knowledge and skills acquired from professional development in order to improve their teaching (Stoll, Bolam, McMahon, Wallace & Thomas, 2006). At the same time, the teachers can recognise developments in their analytical and argumentation skills while they are interacting with others (Rodriguez *et al.*, 2020). Therefore, science-based CPD empowers teachers strongly in their professional practice. This suggest that the aim of CPD, therefore, is to support high standards of professionalism and to ensure that knowledge and skills are translated into best practices. To understand how teachers integrate content and pedagogical knowledge in their own teaching, Section 2.9.1 will discuss PCK.

2.9.1 Pedagogical content knowledge

The matter of the implementation of PCK has gained traction in recent years. PCK elaborates how mastery of subject matter knowledge should be presented to students. It associate content and instructions with the goal of cultivating better teaching practices in the content realms (Santos & Castro, 2021). This claim clearly indicates that teachers are required to understand how students learn the content, which requires teachers to learn how to attend to or notice learners' thinking. Teachers are also required to make deductions about what learners already know, in order to assess what actions they need to employ to assist student learning. For classroom enactment, teachers could bring in the new acquired knowledge and skills they have acquired from an SUP to ensure that learners understand concepts. Combining these knowledge and skills in the form of classroom enactment represents teachers' PCK (Gess-Newsome, Taylor, Carlson, Gardner, Wilson & Stuhlsatz, 2019). PCK can be viewed as the "teachers' understanding and enactment of how to help a group of students understand specific subject matter

using multiple instructional strategies, representations, and assessments while working within the contextual, cultural, and social limitations in the learning environment" (Park & Oliver, 2008: 264). Based on the literature, teachers seem to struggle to implement new learner-centred pedagogical strategies in STEM (Han, Yalvac, Capraro & Capraro, 2015). Scholars have noted that, although teachers who joined CPD obtained basic understanding and conceptualisation of knowledge and skills and made significant pedagogical and shifts, there is a variation in implementation process (Shernoff, Sinha, Bressler & Schultz, 2017). This finding is concerning, since poorly executed curriculum can adversely affect student learning in classrooms and, consequently, impact negatively on students' academic performance.

2.9.2 Utilisation of teaching and learning resources

University academics are more knowledgeable and have extensive experience of generating teaching and learning resources in higher education institutions. Such intellectual capital, that is, knowledge resources, can be transmitted into teaching and learning material or resources that teachers can find useful in their own teaching. According to Anderson, Blitz and Saastamoinen (2015), teachers who participated in CPD expressed gratitude for the use of resources from the university to classrooms. However, these teachers reported experiencing challenges, the challenges were notably around implementing their learning experience in the classroom. It could be that the teaching and learning materials are too conceptual or theoretical, and that teachers need to undergo professional induction to learn how to enact the resources in their own teaching.

Teachers in primary schools need knowledge and skills, and suitable curriculum material so that they can effectively integrate STEM (Lehman, Kim & Harris, 2014). Mokhele (2013) reports that teachers use their experiences from a professional development programme and integrate the support materials and resources in their classrooms.

2.9.3 Integrating technology in the classroom

Teachers are encouraged to integrate innovative teaching approaches in their instruction, to make teaching and learning more meaningful. Technology integration remains one of the innovative teaching approaches teachers are encouraged to enact while they are engaged in lesson presentation. It should be noted that the term technology is used in this study to denote both hardware and software used by teachers for teaching and learning purposes. Therefore, the integration of technology in this study refers to the use of hardware and software by teachers for presentation of information (Evoh, 2007:1). In its 2030 Agenda for Sustainable Development, the United Nations has promoted the technology integration (United Nations General Assembly, 2015). This implies that mathematics and science teachers should prepare their learners to understand the influence of technology in a modern 21st century as enshrined in the United Nations Agenda for Sustainable Development (McCarthy & Oliphant, 2013; Spaull & Kotze, 2015).

Teachers with adequate TPACK acknowledge that ICT has a positive impact, as they are able to access an abundance of curriculum resources for teaching and learning purposes. However, there is a degree of variation in the ways teachers integrate technology in their instruction. Technology integration fluctuates from classroom to classroom due to varying factors, such as the grade, type of school, equipment availability, teacher knowledge, and personal beliefs (Mokotjo & Mokhele, 2021; Saal, Graham & Van Ryneveld, 2020). Stols *et al.* (2015) found that teachers used personal computers for teaching and to prepare lessons either daily or at least once a week. This could be because technological resources are still lacking at schools, which obliges teachers to improvise by using personal equipment to facilitate teaching and learning. In this case, teachers rely on hardware, such as personal computers, to integrate technology in their instruction.

Literature reports that teachers integrate technological software in their classroom for teaching purposes. In this regard, Mokotjo and Mokhele-Makgalwa (2020) found that teachers believed GeoGebra mathematical software was fun to integrate, and it was essential for conceptualisation and visualisation of mathematics concepts. GeoGebra software “incorporates geometry, algebra and calculus” into a single source and enables teachers to generate problems on these concepts (Mokotjo & Mokhele, 2021:964). This

clearly shows that GeoGebra software integration in mathematics is topic-specific, as it enables teachers to tackle problem such as Euclidean geometry using the software (Mosia, 2016). The documents of the SPP reveal that GeoGebra and Graph are technological software programs that teachers could use in their lesson preparation and presentation. Therefore, it was essential to review literature on the use of software in mathematics pedagogy.

In physical sciences, particularly in chemistry, literature reports that a number of computer software programs exist, which include PowerPoint, Chemoffice, LabVIEW software, computational chemistry software and organic chemistry software, such as ChemSketch (Yu & Chen, 2012). The integration of software promotes comprehension of chemistry, and helps to keep learners active. For the purpose of this study, ChemSketch was identified as important software, since the documents of the SPP contain a folder on ChemSketch which can be integrated in classroom instruction. ChemSketch is chemical drawing software, designed to be used for drawing chemical structures, reactions, and schematic diagrams (Engida, 2014). Teachers infuse TPCK in chemistry by using free software that is available for educational purposes. Crocodile Clips has emerged as physics software that can be used to construct electrical circuits.

Kafyulilo *et al.* (2016) investigated continuation of technology integration in mathematics and science after teachers have attended a professional development programme. The study reports conflicting results. At certain schools, teachers ceased to use technology in their teaching while other teachers have continued to integrate technology in their teaching.

Technology integration in mathematics and science pedagogy encourages teaching approaches that are learner-centred and help learners to take ownership of their learning. Scholars have noted that technology integration helps learners to be creative in problem-solving, as it develops learners' problem-solving skills and changes their attitudes to mathematics (Saal *et al.*, 2020). When technology is used in teaching and learning, it can advance comprehension, problem-solving and creative thinking skills, also higher-order thinking skills. In support of learner-centred approaches, Ramnarain and Moosa (2017) report that teachers use physical education technology (PhET) project simulations in

science classrooms, and that this practice reduces, to a certain extent, misconceptions previously held by learners. Tefo (2020) reports that teachers use smartboards in their teaching, but argues that teachers need to undergo training, particularly in the pedagogical use of smartboards.

2.10 FACTORS THAT AFFECT KNOWLEDGE AND SKILLS IMPLEMENTATION

Continuing to use newly attained knowledge and skills in mathematics and science teaching cannot be attributed to a single factor, but to a combination of various factors. The next subsections will discuss some of the factors that affect successful implementation in classrooms of acquired knowledge and skills.

2.10.1 Individual factors

Mansour *et al.* (2014) report that motivation for change, workload of teachers, the abilities and skills of teachers affected how teachers implement what they acquired in a CPD. As indicated in a study by McLeskey (2011), teachers did not change their teaching practice, but their perceptions were affected even though professional developments were more learner-centred than expert-centred. This suggests that teachers sporadically enact different knowledge and skills than those that were intended by the professional development programme. This supports the argument made by Han *et al.* (2015), that teachers present different enactments in classrooms, which deviate from the one intended by professional development. These scholars argue that while some teachers could not change their pedagogical approaches, other teachers developed misconceptions of the intended practice. Even though teachers developed new conceptions about how they should implement, their understandings seem to have contrasted from their classroom enactments. Mokotjo and Mokhele (2021) indicate that lack of confidence and a particular set of beliefs about and attitudes towards the role of technology are barriers that prevent transfer of knowledge and skills to practice. In support, Spangenberg and Freitas (2019) report that teachers' pedagogical beliefs affected the implementation of the knowledge and skills after a professional development programme.

2.10.2 Professional development factors

Assan and Thomas (2012) attest that lack of training and skills in relation to the integration of resources in mathematics and science makes it challenging for teachers to implement their new knowledge and skills in teaching. Similarly, Wang and Wong (2019) found that teachers were provided with innovative conceptions relating to curriculum and classroom enactment, though the resources tended to be rather conceptual or theoretical. These scholars emphasise that university academics need to strengthen the interaction between teachers and external curriculum resources. This suggest that a detailed induction on how to use the resources in classroom teaching is essential for teachers, so that they can autonomously integrate the resources in their own teaching. Additionally, a lack of teacher training on the integration of curriculum resources could render these essential resources unusable in classrooms.

2.10.3 Institutional factors

The institution in which knowledge and skills implementation takes place can enable or hinder the success of the implementation process. Anderson *et al.* (2015) argue teaching environment creates impediments for classroom staff to implement new instructional strategies and use the knowledge and skills they had gained in a professional development programme. In a school where a teachers experience a lack of support from school management, teachers find it challenging to transfer knowledge and skills to the job, and this inability inhibits their application of new skills. Spangenberg and Freitas (2019) support this claim and argue that poor school leadership is one of the inhibiting factors for technology integration in schools. Kafyulilo *et al.* (2016) substantiate the above views and argue that, in schools where teachers lack support from school management, teachers are unable to implement new knowledge and skills. Teachers have attributed lack of technology integration to lack of support and motivation by the school management team Eickelmann (2011) reports the teachers can continue with their teaching using technology if they receive support from schools, their peers, and they participate in decision-making and have access to technology (Almekhlafi & Almeqdadi, 2010), these are one of important factors that influence teachers' continued use of

technology. In a complex school environment, technology integration in classroom instruction rests on institutional support, which should stimulate and motivate the use of technology in teaching.

Mosia (2016) conducted a study that designed a strategy to improve teachers' TPACK for teaching geometry with the aid GeoGebra, as an integrated ICT software program, particularly for Euclidean geometry. His study found that one of the encounters teachers faced regarding technology integration is access to ICT tools at schools. Scholars have examined factors affecting teachers continued use of technology or teaching (Kafyulilo *et al.*, 2016). The findings show that continuing technology use varied for teachers participating in a CPD programme. Although teachers have claimed they developed the knowledge and skills from CPD and were also more positive to integrate technology in their teaching; only few teachers continued to use technology in classroom teaching. Institutional factors, such as large classes and struggles with electricity supply, are institutional factors that affect technology use in mathematics and science (Kafyulilo, *et al.*, 2016). In contrast, Mokotjo and Mokhele (2021) report that teachers are unable to integrate technology resources in teaching because of theft and vandalism when the resources are on the school premises. This challenge is a societal factor that negatively affects the investments made by education stakeholders who have donated the resources to promote teaching and learning in mathematics and science. Mokotjo and Mokhele (2021) argue that, once they have been stolen, ICT tools are never replaced. Kafyulilo *et al.* (2016) argue that a professional development programme could enable teachers to enhance the knowledge and skills needed to integrate technology in teaching, but without accessibility to technological resources, teachers cannot integrate technology in their teaching.

2.10.4 Technological factors

Knowledge and skills related to technology for mathematics and science teaching is key if teachers are to successfully integrate technology in classroom instruction. Scholars have identified technology skills of teachers as a significant inhibitor of technology integration. For example, Spangenberg and Freitas (2019) argue that teachers often

grapple to utilise transformative teaching approach using ICT to support learners' mathematics understanding. Other scholars agree that teachers do not best use, or successfully integrate technology in classroom teaching and learning (Cassim, 2010; Howie & Blignaut, 2009; Peters, Kruger & Fitzpatrick, 2018; Stols *et al.*, 2015). Similarly, Agyei and Voogt (2011) found that, despite government efforts to establish computer labs at schools, teachers did not integrate technology in their instruction. They report that some of the barriers are related to current teaching strategies used in schools and teachers lacking knowledge of the ways to integrate technology in instruction. Teachers lack strategies to incorporate ICT in their classroom teaching as reported by Niess *et al.* (2009). Teachers hesitate to use technology in their teaching, as they possess rather limited skills, even if they have access to sufficient equipment (Stols *et al.*, 2015). This suggests that many mathematics and sciences teachers struggle to effectively integrate ICT in their teaching, and indicates a need for CPD programmes to improve their TPACK and ensure that effective implementation takes place.

2.11 SUMMARY

In this chapter, literature was reviewed, and it was found that SUPs are a policy-driven classroom-based intervention that is intended to enhance teachers' content and pedagogical knowledge. In the past few decades, the initiative of SUPs by broader higher education and in South Africa has proliferated in its content and format. In South Africa, to address mathematics and science teaching and learning challenges at schools, higher education is mandated to be socially responsive to these challenges. The social responsiveness of higher education to challenges faced by schools is seen as metaphorical bridges that aim to collaboratively design and implement professional development programmes to enhance teaching practice in mathematics and science. Due to the social nature of schools and higher education institutions, mentoring as a social practice is a commonly used approach to capacitate in-service teachers in mathematics and science. By explaining how the partnership develops knowledge, literature shows that context remains a key dimension that influences how knowledge and skills are acquired in an SUP. The argument made in this study is that SUPs influence teacher

knowledge development, which has implications for the way teachers implement the learnt knowledge and skills in their own classrooms. Chapter 3 will provide a theoretical framework to support this assumption.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 INTRODUCTION

In Chapter 2, I reviewed the literature on the role of SUPs on teachers' knowledge and skills development. The current chapter will outline the theoretical frameworks applied to this study, which assisted in the analysis of the empirical evidence of this research. In research, a theoretical framework is regarded as the logic of abstract configurations, which assists to view, comprehend, elucidate, and transform the social world (Ocholla & Le Roux, 2011; Ravitch & Riggan, 2012). This chapter will establish a theoretical understanding of mentoring teachers in their own school and classroom settings.

The theoretical framework provides a way to respond to the research question posited (*cf.* 1.3) for this study and explain how philosophical procedures are manipulated in relation to the issues raised. The theoretical framework consists of selected theories and reveals the theoretical standpoint with respect to understanding and mapping appropriate ideas related to the topic under consideration. This provides a theoretical lens that stipulates logical clarifications of the overall position of the study, which, in this case, is concerned with how teachers implement the knowledge and skills they acquired from an SPP, independently and beyond the existence of the partnership. The theoretical lens serves as a foundation for the identified research problem, the research questions, and the rationale for the study. Therefore, a theoretical framework, in this chapter, is viewed as a well-developed and logical explanation for an event (Vithal, Jansen & Jansen, 2013:17), that is, the implementation of knowledge and skills by teachers.

The identified theoretical lens is a transformative point of view, which was used to identity the nature of questions to be asked. The theoretical framework relates to the philosophical basis on which the investigation takes place, and constructs connections between philosophical facades and the real-world parts of the event under investigation. This study set out to explore the way teachers were implementing the knowledge and the skills they had acquired beyond their participation in an SPP and independently of their mentors. Since the construction of knowledge and the skills came about as a result of mentoring teachers in their own schools and within their own classroom settings, mentoring theory

was employed. This was done with a full recognition that, in most cases, mentoring theory is produced in the Western context and it might, thus, deviate significantly from the African context in general, and the South African context in particular. Despite contextual differences between Western countries and South Africa, this study adopted mentoring theory a theoretical framework. Although this study was set in a South African context, it was of paramount importance to adopt this theory in this context, as it was anticipated that it would provide a new theoretical perspective on context-based mentoring and could perhaps subject this theory to amendments.

Teachers are expected to be responsible for their self-development, they can identify the curriculum gaps in which they need to grow professionally, as stipulated in *The National Policy Framework for Teacher Education and Development in South Africa* (DOE, 2006). While the framework does not explicitly explain the important role of schools and universities as partners, the complex interaction of their relationship, or the role of mentoring in attaining these professional developmental needs, the framework does refer to the need for teacher development. Since teachers in this study were involved in a professional development project, that is, an SPP, in which mentoring was deployed to develop and enhance teachers' existing knowledge and skills in mathematics and science, this study adopted Kram's framework of mentoring to investigate how teachers implemented the knowledge and the skills beyond the SPP. This was done with the understanding that there are various mentoring theories that can be adopted to investigate the phenomenon under consideration. These theories serve as logical theoretical lenses to investigate the ways teachers implement their knowledge and skills. Despite this, the rationale behind the adoption of Kram's framework of mentoring is that this theory explicitly elucidates the type of mentoring functions that are crucial for the construction of teachers' knowledge and skills. However, it is crucial to bear in mind that this theory has been subjected to criticism for falling short of comprehensively explaining a phenomenon. It fails to explain the complexity associated with the knowledge and skills implementation, which this study sought to understand.

The implementation of knowledge and skills in schools occurs within a complex web of subsystems that interact with each other to influence the outcomes. Therefore, complex

systems theory was adopted as a secondary theory to supplement the gap that Kram's framework cannot address, thereby to comprehensively understand the questions this study sought to respond to. Hence, there was a need to fuse these two theories, to configure a lens through which to discuss and explain how teachers implement acquired knowledge and skills beyond the existence of the SSP.

3.2 THEORETICAL FRAMEWORK UNDERPINNING KNOWLEDGE AND SKILLS IMPLEMENTATION

As discussed in Section 3.1, this study adopted a theoretical framework as an analytical tool to analyse and interpret the empirical findings that emerged from the generated data. A theoretical framework was adopted by this study with a view to obtaining a well-developed and coherent explanation for an event (Vithal *et al.*, 2013), in the case of this study, teachers' participation in a professional development project. The theoretical framework is a theory that is regarded as the roadmap to use in an expedition to find solutions to a research problem (Bezuidenhout, 2014). Theoretical framework refers to a system of concepts that informed the research. This study is grounded in a theoretical framework because a set of concepts was described from the same theory (Imenda, 2014). This was done to explain a particular research problem that this study aimed to investigate, and which was explained in Chapter 1. A theoretical framework, therefore, appears to be appropriate for a study that attempts to investigate how teachers implemented the knowledge and the skills they acquired in an SUP.

3.3 KRAM'S MENTORING THEORY

In this section, mentoring theory will be discussed, with a focus on mentoring activities within the SPP that contributed to the construction of teacher knowledge and skills, with the view that these activities influence mathematics and science teaching practice at schools. The term mentoring dates to ancient Greek mythology, as a belief implemented by Odysseus, king of Ithaca. King Odysseus instructed his entrusted companion to mentor his son Telemachus during a time of war, when Odysseus was away. The implementation of mentoring by an entrusted companion marked the epistemological

beginning of mentoring relationships from an educational perspective (Irby, Abdelrahman, Lara-Alecio & Allen, 2020). Mentoring is not a myth, but rather a pedagogical social interaction that is undertaken to strengthen and mould an individual who has little experience. With developments due to extensive research on mentoring, it has been clarified that the concept is about the relationship between a mentor and mentee. This social interaction is attributed to the work of Kathy Kram in the 21st century. According to Kram (1983), mentoring represents a specialised social interaction, in which a more experienced mentor is responsible for transmitting tacit and explicit knowledge to a lesser experienced mentee (Kemmis *et al.*, 2014). One of the primary responsibilities of mentors in a professional development initiative, such as an SUP, is to impart their knowledge, skills, and expertise to teachers in mathematics and science (Ndlovu, 2011a; Mokhele, 2013). Hence, Kram's theory of mentoring has laid a solid epistemological foundation for understanding mentoring relationships when two organizations work collaboratively (Kram & Isabella, 1985).

The theory of mentoring points out that the primary task of early adulthood be attributed to the initiation of a mentee, and the primary task of experienced adults is one of reconsideration. According to Kram (1983), adult development is juxtaposed between two differentiated mentees in terms of individual experience within an organisational setting. It is noteworthy to understand that schools consist of teachers with different levels of teaching experience. Keeping this in mind, schools have novice teachers, who are regarded by this study as teachers who recently entered the teaching profession, and who have no to two years of teaching experience, and experienced teachers, who have at least three years of teaching experience. It can be reasoned that that novice and experienced teachers require different developmental approaches – although mentoring may be a central approach – since they have different developmental needs in their teaching profession.

Firstly, and with reference to novice teachers, Kram (1983) suggests that young adults – novice teachers in the case of this study – in the first stage of their careers, are eager to develop their identities (Levinson *et al.*, 1978). During this period, an individual asks questions about their competence, their effectiveness, and their ability to attain future

dreams are prominent. Therefore, this is the period when teachers of mathematics and science project their future self-image in the teaching profession as they develop critical features that can influence their future teaching careers (Ragins & Kram, 2007). Learning how the organisation works includes the development of obligatory personal skills, as well as a mentee sense of capability in their work (Kram, 1983). In this period, novice teachers are required to learn and adopt a school culture, relate with their colleagues daily and understand the school politics that they may find themselves engaged in and which influences their future perceptions about the teaching profession. According to Kram (1983), individuals entering work have anxieties about themselves and their career, they need developmental tasks to alleviate the anxieties. In other words, novice teachers who enter the schooling system from higher education could be confronted with the challenge of implementing theoretical knowledge acquired during higher education and translating such epistemological theory into practical knowledge. It is during this period that novice teachers need mentors who can act as guides in their first years in the teaching profession. Thus, it is during this period that an inexperienced teacher could seek a mentor that could provide prospects for solving predicaments (Kram, 1983).

Secondly, and in contrast to novice teachers, the more experienced individual need to reconsider their past achievements, they should readjust their future goals (Kram, 1983). In the context of this study, this is the period when experienced teachers reconsider their instructional teaching strategies, subject-content knowledge matter, and any other features that can contribute to teachers' professional and personal development, especially in subjects such as mathematics and science. The theoretical relevance of Kram's philosophy in the case of this study is that it necessitates that experienced teachers reconsider and modify their teaching repertoires by actively engaging in professional development activities, such as SUPs. According to Kram (1983), individuals who do not undergo development or growth could experience challenges that affect their performance at work, and this could provide to be troublesome. Teachers who neglect to participate in professional development activities compromise their developmental needs and, simultaneously, compromise the learning needs of their students.

From the above discussion, a mentor–teacher relationship has an eminent ability to accelerate career development of teachers, while simultaneously contributing to their psychosocial development to achieve their developmental tasks. Mentoring at its best is a life changing relationship that stimulates growth of a mentee.

Its effects can be extraordinary, intense, and continuing; it is through mentoring that individuals, groups, organisations, and communities could be transformed (Ragins & Kram, 2007). Therefore, mentoring, in this discourse, forms part of the lens that can be used to depict how teachers delineate their diverse experiences and memories of an SUP, with the view of understanding how their experiences influence their teaching practice in mathematics and science. Mentoring theory provides a learning situation wherein the mentor not only supports the mentee professionally, but also challenges them productively, so that progress can be made (Smith, 2007).

Mentoring is often seen as a relationship that has a progressive impact on the efficacy and constructive attitudes of teachers regarding their teaching practice. It can also have a significant positive impact on teachers' interpersonal skills, confidence, outcomes, motivation, and communication skills (Anwar, 2014; Munir & Amin, 2018). The implementation of the mentoring relationship might be beneficial for both the mentor and the mentee, for developing their professional skills and improving content knowledge (Javed & Iqbal, 2015). In this way, mentoring supports participant teachers to modify their teaching practice from conventional to advanced methods of teaching. This is not only useful for teachers' personal development, but is also beneficial for the improvement of the whole teaching and learning process of the school.

Kram's mentoring theory considers four key perceptions about mentoring, and they are clarified in detail below. It is important to outline the emerged insights of mentoring to understand their significance and relevance for this study.

- Mentoring research has pinpointed two functions that are provided by a mentor: career and psychosocial functions, which originate from different roots and therefore have outcomes;
- Career and psychosocial support vary greatly across mentoring relationships;

- Mentor-mentee relationship evolve continuously through phases of initiation, cultivation, separation, and redefinition; and
- Mentors could provide either career or psychosocial supports.

Career and psychosocial functions have been found to signify two different functions served by mentors. The research suggests that career and psychosocial functions serve as two distinct, overarching functions of a mentor–mentee relationship (Kram, 1983; Ragins & Kram, 2007). Although this is the case, career and psychosocial functions interrelate, such that the psychosocial function is embedded in career function. The mentors' emotional support is entrenched within the mentors' professional support. This notion deviates significantly from mentoring theory as suggested by Kram (1983) and Ragins & Kram (2007). It was, therefore, imperative to analyse data gathered by this study to determine whether career and psychosocial functions are interwoven, or whether each function exists independently of the other. It can, then, be argued that both career and psychosocial functions are the greatest predictors of a mentee's job and career satisfaction within their organisation.

Second, mentoring relationships vary between individuals and, just like any other relationship, no two mentoring relationships are alike. In expanding this notion, some mentoring relationships offer either career or psychosocial functions, whereas other relationships offer an expansive variety of activities that integrate both types of mentoring functions (Ragins & Kram, 2007). In this instance, mentors offer either career or psychosocial support or both, depending on the professional development needs of their mentees. These functions are used to overcome mentees' needs in a more logical and strategic manner. Mentoring functions provided by a mentor are determined by the needs of a mentee, such as those related to interpersonal skills, resources, or power (Kram, 1985; Ragins, 1997). Mentoring focuses on the holistic development of an individual, resulting in a situation where both professional and emotional supports are provided (Israel *et al.*, 2014). It is important to identify which career or psychosocial functions are instrumental in this study and which contribute to the expansion of knowledge and skills in mathematics and science.

Third, mentoring relationships evolve through various stages and therefore are not static. In different phases, different functions, experiences, and patterns of interactions takes place. According to Kram (1983) and professional development scholars (Israel *et al.*, 2014; Sugimoto, 2012), mentoring relationships change across four different phases in a relationship: initiation, cultivation, separation, and redefinition. These phases provide a concrete theoretical lens through which to investigate how teachers implement the knowledge and the skills they acquire from an SPP following the termination of a professional development project. Lastly, individuals may provide these functions without necessarily being mentors. In the case of this study, this conception is not applicable, given that the primary objective of this study was conceptualised from a mentor–teacher relationship. To attain the objectives of this study, it was appropriate to consider key tenets of a mentoring relationship that provides scholarly direction, in the quest to respond to the research questions.

It is against this background that these key insights of mentoring relationships shed light, by presenting a theoretical underpinning to investigate the phenomenon under consideration. Section 3.4 will discuss the phases of mentoring, to examine how mentoring relationships change over time.

3.4 PHASES OF MENTORING

In this section, this study will consider the development of teachers' knowledge and skills as the mentoring relationship unfolds and transforms over time. The theory of mentoring states that developmental relationships differ in terms of their duration and the context in which it exists. The relationship generally progresses through four foreseeable, but not entirely divergent phases, of initiation, cultivation, separation, and redefinition, as illustrated in Figure 3.2.

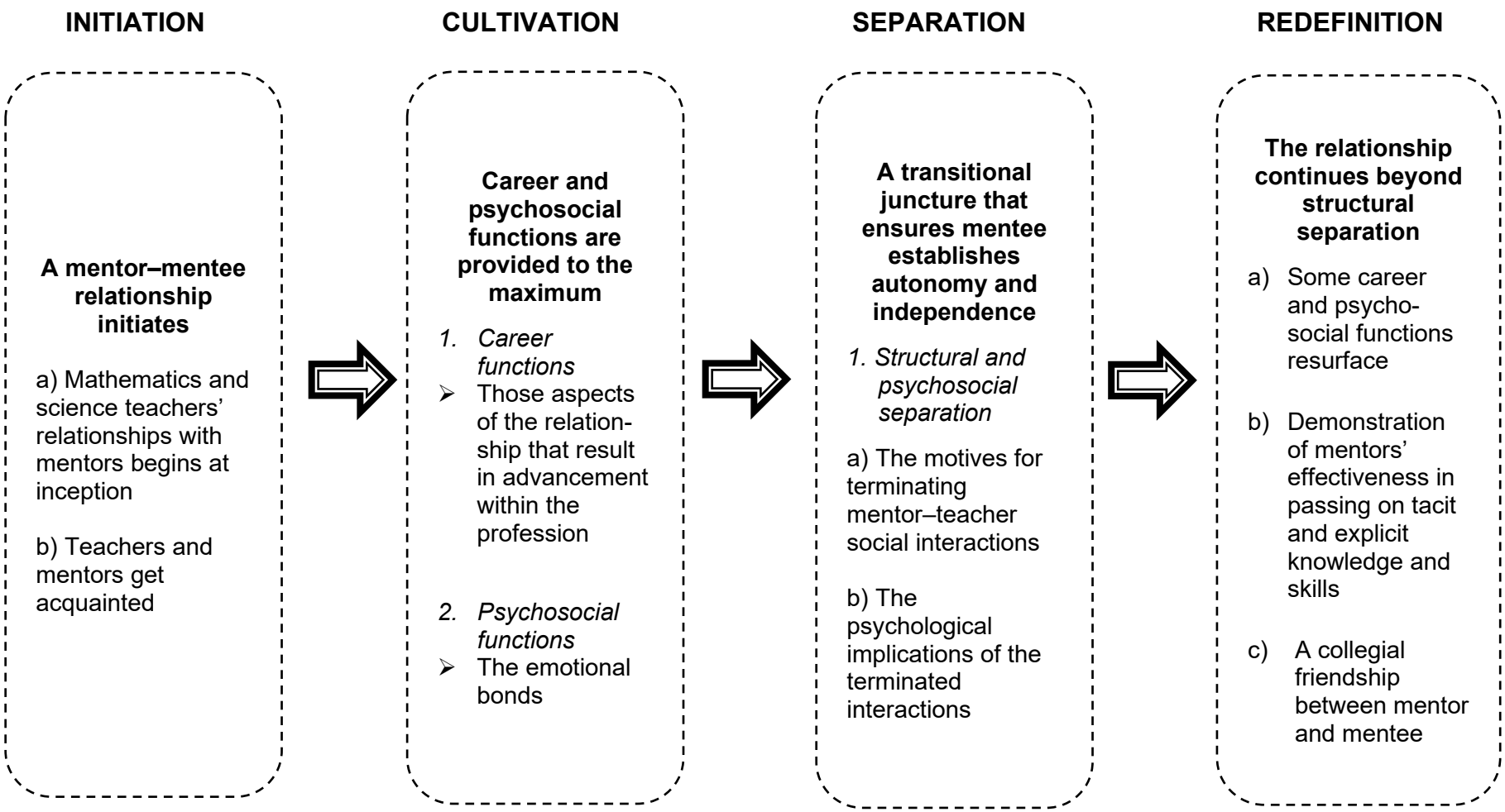

Figure 3.1: A depiction of Kram's four mentoring stages/phases

A brief explanation of each phase will be provided in relation to individual development. The initiation phase exhibits the inception of a mentor–mentee relationship, which lasts for about six months and can go to a year, during which the relationship commences to become important for both the mentor and mentee. Cultivation phase deviates from the initiation in the sense that both career and psychosocial support peaks during this phase. The separation phase is a period that comes after the cultivation and occur as a result of structural changes in mentoring relationship. Lastly, the redefinition phase comes after the separation phase and is an indefinite period during which the relationship is terminated. However, the relationship can take a different shape instead of being terminated and mentoring become a peer-like friendship.

Mentoring theory shows that each phase is exemplified by particular affective experiences, functions that develop a mentee, and interaction patterns that are shaped by mentees' needs within their own settings and their surrounding organisational circumstances. This dynamic perspective explains how a mentor relationship can enhance mentees' development as the relationship unfolds. In next subsections, an in-depth description of each phase will be provided.

3.4.1 Initiation phase

It is noteworthy to understand how teachers and mentors initiate mentoring relationship, so that we have a clear theoretical understanding of developmental relationships as they unfold over time. According to Kram (1983), the initiation phase begins the inception of the mentor–mentee relationship, as members of the relationship negotiate their responsibilities, boundaries, and rules of the relationship. Humberd and Rouse (2016) describe the initiation phase to be salient for a mentee to project their future selves, while, at the same time, this phase is essential for a mentor to relate to their past experiences and self in order to act as a guide to a mentee. In this phase, the mentor is a respected guide, and the mentee is eager and willing to acquire knowledge and skills from the mentor to enhance their effectiveness in the organisation. Kram (1983) view a mentee as someone who is easily coachable and who a mentor can enjoy working with them. During the initiation phase, a mentor and mentee do not know each well to recognise their

similarities and differences; Kram (1983) refers to this as recognition. Mentors and mentees recognise each other, and no mentoring activity is provided as the relationship is still in its earliest phase (Kram, 1983). Given the initial focus of the relationship – that is, the development of the mentee – mentees communicate their professional development needs to their mentors as they get acquainted.

Kram's conceptualisation of initiation involves mutual imaginations in which the mentee trusts a mentor can provide the support and guidance the mentee needs, and the mentor believes the mentee has some degree of potential. It is during this period of initiation that both the mentor and mentee develop imaginary ideas of each other of each other, even though both members of the relationship have developed imaginary ideas, a gap still exist that distinguish impression and reality. To bridge this gap and make sense of each other, each member projects their qualities onto the other member, in order to be recognised in the relationship. A mentee can profit from the relationship by receiving advice and counsel. Thus, the possibility of a mentor to contribute to the mentee's growth and success is an impetus for setting the relationship in motion and for moving to the next phase.

3.4.2 Cultivation phase

As the relationship develops, trust and emotional bonds based on collegial interaction ensue in the cultivation phase (Kram, 1983). Interaction occurs more frequently during the cultivation phase and the career and psychosocial functions of the relationship begin to emerge (Kram, 1983). Mentee's knowledge and skills development changes from being based on projections, to being based on recognition and integration. The source of knowledge and skills development expand. Therefore, expectation emerging from the initiation phase are continuously tested against reality during the cultivation phase (Kram, 1983). Sugimoto (2012) believes that a fruitful cultivation phase requires constant and frequent contact between the mentor and mentee. The mentor gets to know the mentee better and, thus, the relationship is not reliant on projection, but on reality.

It is only when the primary tasks are corresponding that a mentor-mentee relationship is likely to reach the cultivation phase and a mentors will provide a variety of career and/or

psychosocial functions that enable the protégé to meet their organisational objectives of initiation, and the mentor to meet the challenges of reconsideration at midlife (Kram, 1983).

Richmond, Dershimer, Ferreira, Maylone and Kubitskey (2017) believe that mentors and teachers engage in the relationship to explore challenges and experience, they in turn develop trust on each other. As they develop an affirmative co-dependence, the mentee teachers develop a set of knowledge and skills that assist them to enact reform-based teaching practices. Gordon (2017) describes the relationship between mentors and teachers according to two aspects. The first aspect revolves around the working relationship, which is about improving job-related knowledge and skills. The second aspect is about personal relationships that teachers can build with partners outside the school walls. Gordon (2017) believes that effective relationship building between outsiders and teachers is an important relationship for the retaining and preparation of novice teachers.

The assumption that can be drawn from this phase is that career and psychosocial functions are provided during the cultivation period, which is the period characterised by knowledge and skills development for mathematics and science teachers. This is the reason why Kram (1983:616) suggests that “the range of career and psychosocial functions characterizing a mentor relationship peaks during this phase”, as illustrated in Figure 3.2.

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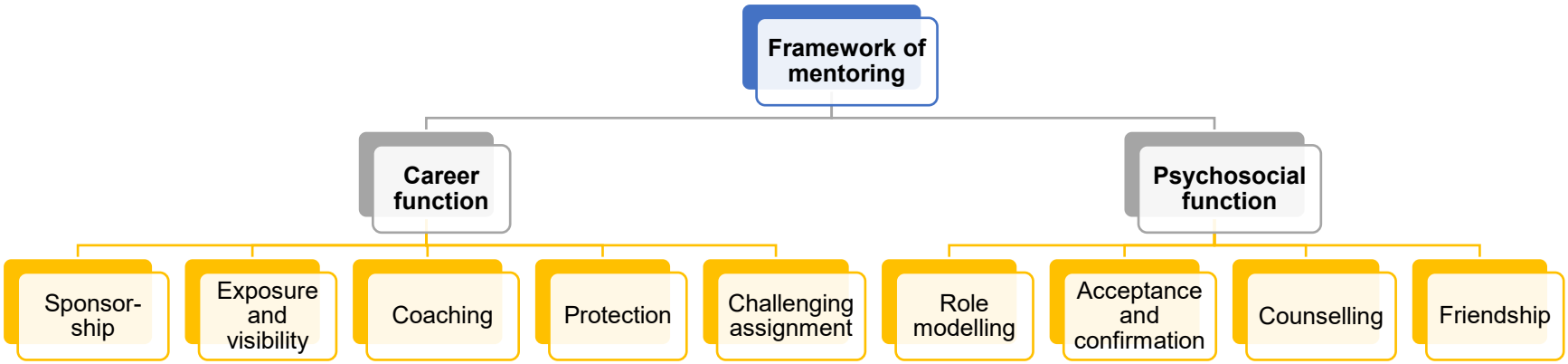

Figure 3.2: Kram's framework of mentoring, illustrating a range of career and psychosocial functions

From Figure 3.2, two distinct features of mentoring become apparent, which can lead to career advancement and psychosocial development of the mentee. Thus, mentoring relationships are unique in that the primary focus of the relationship is on career and psychosocial activities (Kram, 1983; Ragins & Kram, 2007). To have a clear understanding of what these functions are, it is worth providing an outline of these functions in relation to a developmental agenda. In this regard, Ragins and Kram (2007:5) explain as follows:

- ***Career functions*** involve a variety of behaviours that help protégés "learn the ropes" and prepare them for categorised improvement within their institutions. Coaching, sponsoring, exposure and visibility, protection and challenging assignments are career functions a mentor could provide to develop a mentee.
- ***Psychosocial functions*** are grounded on trust and interpersonal bonds. The functions include acceptance and confirmation, counselling, friendship, and role modelling. These functions enhance mentors' personal and professional growth, individual identity, and self-efficacy.

Career function relates to the support that a mentor offers to enhance mentees' improvement in the organisation (Kram, 1983). The second type of support is psychosocial support that can address the interpersonal facets of the relationship and refers to "those aspects of a relationship that enhance an individual's sense of competence, identity, and effectiveness in a professional role" (Kram, 1983:32). In her analysis, Kram (1983) found that the mentees noted that activities, as such as challenging work assignments, coaching, role modelling, and acceptance-and-confirmation, contributed to their growing sense of competence. The activities bestowed by mentors offer direction in developing a theoretical lens for understanding teachers' knowledge and skills development through social interaction. This also enable this study to understand how teacher improve their competence in teaching mathematics and science. Kram (1983) outlines multiple activities that can be undertaken by a mentor and mentee in a quest to develop the mentee and guide them to navigate their way through an organisation.

In SUPs that deploy mentoring, a varied range of career and psychosocial functions are provided by mentors and the activities endow an alternative pathway for teachers to acquire new and different perspectives on teaching. Therefore, it is important to consider the key tenets of Kram's framework of mentoring, in order to situate mentoring deployed by an SPP theoretically. Broadly, the focus of this study was not on mentoring, but on elements of mentoring, particularly those related to teacher knowledge and skills implementation. In this study, this focus formed part of the theoretical lens, which assisted me to interrogate the relationships of the participants in their context.

3.4.2.1 Coaching

Coaching is one of career functions provided by mentors, as shown in Figure 3.2. According to Ragins and Kram (2007), coaching is viewed as support in which mentors "suggest specific strategies for meeting work objectives, achieving recognition, and achieving career aspirations" (p. 525). According to Desimone and Pak (2017), coaching is a multifaceted practice which has been used by mentors in schools for inducting new teachers, it has also been used to continuously develop experienced teachers. Coaching has been used to assist teachers to implement new instructional strategies and to implement new curriculum developments. It is a role undertaken by mentors to develop the subject content and presentation skills of the mentee within their confined environment (Kram, 1983; Ragins & Kram, 2007). Coaching is seen as a process of engaging in observation, upon which feedback can be received; the mentor subsequently reviews the protégés' work. Coaching enables a mentor to provide opportunities to tackle the task, to observe and engage the protégé in a discussion of how to improve their performance (Ragins & Kram, 2007). This personal developmental agenda may be either directive or nondirective. Directive approach implies that the conversation and process are driven by the mentee, while a nondirective suggest that conversations are driven by the mentor. The personal and professional development that occurs tends to be narrowly focused and is often on specific tasks or competences, for instance, presentation skills or personal effectiveness (Ragins & Kram, 2007). Teachers who are exposed to coaching are more likely to discuss their teaching experiences in their professional development with mentors. The conversation guides the mentor, and instructional interventions are

required to meet the developmental needs of the concerned teacher. Mentors support teachers to address the challenges of teaching practice, mentors engage teachers in activities that place an emphasis on key content ideas, as well as pedagogical principles that support how learners should acquire these ideas. Chalong, Tawisook and Ratanaolarn (2017) studied the development of teachers' competencies through coaching. They discovered that coaching could enhance teachers' competencies and increase teacher efficacy to teach mathematics and science. This finding is consistent with what Nel and Luneta (2017) found in their study. Nel and Luneta (2017) argue that instructional coaching is directed to teachers in their own classrooms, and that it has a positive impact on increasing feelings of teacher efficacy.

3.4.2.2 Challenging work assignments

During the cultivation phase, Ragins and Kram (2007) recommend that mentors assign challenging work to their protégés, and provide training and feedback. Mentors are tasked with exploring assignments that meet the mentee's development needs without overly interfering into mentees' personal time. Furthermore, mentors should attempt to provide the necessary resources, to prevent the protégé from becoming overwhelmed (Ragins & Kram, 2007). Mentors follow a complex two-step process of supporting and challenging teachers simultaneously (Daloz Parks, 2000).

Although the relationships between teachers and mentors in an SPP could be friendly and collegial, mentors should, nonetheless, challenge teachers to continue to grow. In support, Kroll (2017) argues that support for teachers in their classrooms should be provided in tandem with challenges, rather than being something that mentors do for teachers independently. Mentors should support teachers by giving feedback about teachers' work, should create a comfortable learning environment and should provide an explicit representation of the skill or knowledge that the teacher is learning (Ambrosetti & Dekkers, 2010). Challenge as a feature of knowledge and skills development that is concerned with a constructive criticism of the teacher's work, which is an important element of teacher learning. Challenge is a mentor strategy that provides a means to achieve shared goals by provoking reflective learning and discouraging taken-for-granted inactiveness (Ragins & Kram, 2007).

3.4.2.3 Role modelling

Figure 3.2 indicates that role modelling is one of the psychosocial functions provided by mentors. Role modelling refers to the ability of a mentor to express their attitudes and values through behaviour (Ragins & Kram, 2007). For Weinberg (2019), role modelling is a process that involves a protégé learning from someone who demonstrates archetypal knowledge and skills. For Weinberg, role modelling is premised on three activities, namely observation, emulation, and co-teaching. Firstly, classroom observation involves a series of activities where teachers observe mentors while they deliver a lesson in a particular curricular area (Weinberg, 2019). In their study on mentoring as a professional development intervention for mathematics teachers, Nel and Luneta (2017) detected that teachers expressed satisfaction regarding classroom observations conducted by their mentors. Classroom observation is critical for accelerating teachers' knowledge and skills development.

Secondly, role modelling remains most deeply embedded in emulation. Conceptualisation of role modelling as a function of mentoring relies on Kram's (1985) belief that role modelling occurs "when the protégé recognizes aspects of his or her current idealized self in the mentor and strives to emulate these aspects" (Mitchell *et al.*, 2015:4). In this study, the conception of emulation suggests that teachers could mimic the knowledge and skills learned from their mentors, who are trusted and respected and possess expertise in teaching mathematics and science. This emulation-driven perspective argues that the mentor models and the protégé emulates what they observe, and apply exemplary behaviours in teaching (Weinberg, 2019).

Lastly, the literature suggests that if individuals are to develop complex professional practice, they should do so by interacting with knowledgeable individual to be developed (Lave & Wenger, 1991). Tharp and Gallimore (1988:89) argue that co-teaching supports "the development of common understanding of purposes and meanings of the activity, [and] the joint engagement in cognitive strategies and problem solving are all aspects of interaction that influence each participant". Through co-teaching, the mentor works together with a less skilful teacher in realistic situations; they influence what happens in the classroom and then exchange interpretations of these events (Roth & McRobbie,

1999). Mentors who work alongside teachers in their classrooms encourage the school-based teachers to reflect more intensely about their practice, to identify problems associated with practice, and internalise specific high-leverage practices, such as organising classroom discussions. The activity of co-teaching enables teachers to both learn in the context of practice and engage in critical reflection.

3.4.2.4 Emotional support

Psychosocial domain is premised on emotional support as suggested by Kram (1983). This goes outside the academic knowledge that a mentor could share and the guidance the mentor might give about how to adopt certain teaching strategies or plan a lesson, to include the emotional welfare of the teacher. Israel *et al.* (2014) argues that self-esteem and confidence of teachers to teach and develop professional competences are part of the scope of the mentors' support. Mentors' support become essential in situations a teacher experiences lack of confidence to teach certain concepts. In an attempt to curb lack of confidence, mentors simultaneously support teachers emotionally and offer academic guidance. Teachers can then reconsider their situations and take a decision about what they should do next (Israel *et al.*, 2014). Emotional support could be essential in this case as it can develop or boost the self-confidence of teachers and their self-esteem, happiness, satisfaction in their professional role. Israel *et al.* (2014) examined mentors' emotional support and noted that mentors provide praise as an emotional attribute. The presence of strong emotional support results in better outcomes, such as building up confidence and feelings of self-worth, and perception of scholastic competence.

The initiation and cultivation phases are important for understanding how teachers develop knowledge and skills in mathematics and science through career and psychosocial activities. However, the separation and redefinition phases are also relevant in this study, as they provide a clear understanding of the aim of this study. Also, these phases are salient for attaining the objectives of the study, as articulated in Chapter 1.

3.4.3 Separation phase

According to Erdem and Omuris (2014), this phase starts when the mentoring process is formally terminated, which obliges a mentee to become more autonomous and independent. This is a transitional juncture, after which a mentee inevitably establishes independence. Separation “occurs when both [members] recognize that the relationship is no longer needed in its previous form” (Kram, 1983:620). This period is characterised as one with “some turmoil, anxiety, and feelings of loss” (Kram, 1983:618). Thus, the end of an SUP involves some affective experiences for both mentors and mentees, and it could involve conflicting emotions. The concept of separation is a critical component of this study, in which I wished to understand how teachers of mathematics and science implemented the knowledge and the skills they acquired from an SPP. Separation is one critical juncture for continuing development of teachers, as it provides teachers with an opportunity to demonstrate essential knowledge and skills, while they operate independently without the support of the mentor. This phase simultaneously enables the mentor to demonstrate to himself, peers, and superiors that, indeed, they have been successful in developing teachers’ knowledge and skills in relation to teaching of mathematics and science.

Bouquillon, Sosik and Lee (2005) examined the mentoring stages of working professionals in education, and found that mentees in the separation phase report that they received the lowest levels of career and psychosocial support in this stage. Similarly, Rikard and Banville (2010) report that, regarding teacher perceptions of the levels of support provided by their mentors, some teachers showed a level of development that indicated that they were gradually moving into the separation phase. Therefore, the mentee’s need to receive support from and be dependent on the mentor dramatically decreased during the separation phase. When teachers have been successful in mastering the activities in the cultivation phase, they may no longer need to continue receiving mentoring. In the separation phase, teachers could receive little to no mentoring functions, and they fully establish their autonomy and independence from their mentors.

Separation occurs in mentoring relationships and a sudden modification of social interaction is often required to accommodate the end of a mentor–mentee relationship.

According to Kram (1983), several changes occur in a mentor–mentee relationship. For example, (i) a mentee may receive a promotion, (ii) a mentor or mentee may change their organisations, (iii) a mentee could begin to seek their own independence from the relationship, and (iv) a mentor may believe they no longer possess the required knowledge and expertise to effectively support the mentee. All the modifications mentioned in this discussion can have two consequences. Firstly, structural separation could culminate in negative affective experiences, especially if the mentee feels unprepared to function more independently and without the immediate support of the mentor. Secondly, the mentor could feel like the mentee no longer needs their support, especially if the mentor feels the mentee has outgrown the relationship (Kram, 1983). Therefore, the separation phase has consequences for mentees' attitudes and emotions, especially for those mentees who are not prepared to leave mentoring relationships and those who feel the relationship should undergo readjustment to accommodate their new professional development needs.

Structural separation explains the reason why the relationship between a mentor and mentee ceases to exist, especially when both members of the relationship go their separate ways. Kram (1983) refers to this period as the phase when one member ceases to participate in the relationship, which culminates in a form of independence and autonomy, particularly for a mentee – a teacher, in the case of this study. In the SUP under consideration, the mentor–teacher relationship shifted into the separation phase because of physical reasons. For example, the relationship may terminate because one or both members physically leave the organisation they work for. Ragins and Scandura (1997) note that most mentoring relationships terminate due to physical separation, however, they have also noted that the relationship may terminate due to functional or dysfunctional psychological reasons.

Once a mentoring relationship has been terminated, mentees suddenly establish their autonomy and function independently. Autonomy implies that an individual is responsible for their own behaviour and expression of the self (Fagenson, 1992; Ragins & Kram, 2007). When individuals are autonomous, their behaviour become the express of self, and they develop a feeling that they are in control. The mentoring theory posits that

optimal well-being results when the basic need for independence and autonomy are fulfilled (Kram, 1983). In the case of this study, separation phase is an essential phase which give teachers an opportunity to function independently and autonomously of their mentors (Connell, 2007).

3.4.4 Redefinition phase

According to Kram (1983), some mentoring relationships are able to transit to the last redefinition phase, which is commonly referred to in mentoring literature as the collegiality period of the parties (Humberd & Rouse, 2016). It is during this period that some mentees quickly become more independent, while others remain dependent on the mentor for a while because of certain factors related to the mentors or mentees (Erdem & Omuris, 2014). Thus, if the relationship does not break up at the separation phase, it moves into the redefinition phase, which is characterised by both career and psychosocial functions. The redefinition phase is idealised as the period in which “the relationship becomes, primarily, a friendship” (Kram, 1983:620). Career and psychosocial functions are not as visible as they were during the cultivation phase and are therefore less evident, but some of the activities, such as counselling and coaching, may resurface in the redefinition phase (Ragins & Kram, 2007). This juncture can be seen as the phase in which the teacher becomes as equally established as the mentor and, thus, the relationship changes to a collegial friendship. It appears that, during redefinition phase, the mentor continues support the teacher and takes pride in the teacher’s succeeding accomplishments.

The teacher who is operating autonomously of the mentor go into the relationship as a peer rather than as mentee, they appreciate and have gratitude for guidance that was previously provided by their mentors; the teacher would be satisfied to continue with mentoring for the friendship it provides. Kram (1983) argues that, although the mentor may be removed from a pedestal in the protégés’ eyes, the mentor could still be recalled because of mentors’ indebtedness. At this juncture, the enthusiasm of the first two phases of the relationship is superseded by gratefulness and pragmatism about the influence of the relationship to the teacher’s professional development and advancement (Kram,

1983). For mentors, the teacher is proof of the effectiveness of passing on tacit and explicit knowledge and skills, and the mentor takes pride in seeing the teacher move on to greater responsibility. The redefinition phase ultimately culminates in independence and autonomy, as teachers are discharged from their participation in the SPP, and their strategic expectations of their mentors decrease dramatically.

From the above discussion, it is clear that mentoring theory provided a theoretical lens to understand how mentoring relationships are incepted in an SPP. This theoretical lens assisted the study to identify the typologies of career and psychosocial support provided by mentors during school visits, and provided possible reasons for the termination of mentoring relationships. The adopted theory states that mentees establish their autonomy during the separation phase, and that they start functioning independently of their mentors. However, Kram's theory falls short of comprehensively explaining factors that affect knowledge and skills implementation at schools, which makes this theory inadequate to respond to the stated research questions (*cf.* 1.4). Knowledge and skills implementation takes place within a complex web of systems that interact with each other to influence outcomes. In response to this pitfall of Kram's theory, this study adopted complex systems theory as a secondary theory to provide a theoretical understanding that cannot be addressed by Kram's mentoring theory. Therefore, the next section will situate the key concepts of complex systems theory, to understand how teachers implement the knowledge and skills they acquired beyond the existence of the SPP.

3.5 COMPLEX SYSTEMS THEORY

The term systems theory was coined by Emile Durkheim during early studies of social systems (Robbins, Chatterjee, Canda & Galan, 2006) and by the work of Talcott Parsons on "double contingency" and "social interactions" (Parsons, 1968). However, in social sciences disciplines, systems thinking is profoundly influenced by the work of a theoretical biologist, Luwig von Bertalanffy.

Scholars on complexity theory rightly emphasise that there is no single definition of complexity, and it is not surprising that complexity does not have a single definition like other philosophical concepts. Davis, Phelps and Wells (2004) state that the lack of single

definition is attributed to what has previously been referred to as “complexity theory,” “complexity research,” “complexity science,” and “complexity thinking”, which hauls from several generations of development, starting in the 1950s and 1960s. In the context of this study, complexity is seen as a system of interconnected components that collectively give rise to a distinctive behaviour (Ettekal & Mahoney, 2017). For instance, the interaction of schools and universities in SUPs is a collective interaction that leads to a certain pattern of teaching in classrooms, which is influenced by the knowledge, skills, and resources that are shared between partners.

Therefore, by studying the patterns that emerge and the interactional processes that lead to certain behavioural patterns, researchers can better understand how systems adapt, self-organise, fluctuate, and reach and maintain equilibrium (Yoon *et al.*, 2018). Exploring the ways in which teachers implement knowledge and skills in mathematics and science teaching provides a new perspective on the influence of mentoring in SUPs. Due to the complexity of social interactions, mentoring teachers within their restricted circumstances is not a linear relationship that can progress effortlessly from one point to the other (Kemmis *et al.*, 2014). Similarly, implementing new knowledge and skills cannot be described by a linear process that follows a pattern of doing. This indicates that mentoring teachers at schools and in classrooms is rather a complex practice, especially when teachers participate in professional development interventions with outsiders (Nel & Luneta, 2017; Wang & Wong; 2019). Enacting new pedagogical ideas in classrooms is, similarly, a complex practice that involves knowledge, skills, and dispositions. The actions of teachers as a result of social interactions in SUPs and with their students in classrooms constitute the complex phenomenon this study seeks to investigate. Hence, the adoption of complex systems theory enabled this study to explore how teachers implement the acquired knowledge and skills independently of their mentors. Complex systems theory sheds light on issues and tensions in the implementation of knowledge and skills, and explains how teachers mediate and negotiate their views of enacting teaching practice in institutional and wider ideological contexts.

Bronfenbrenner’s classic ecological systems theory provides a solid theoretical foundation for understanding how teachers implement what they learnt in an SUP in their

own classrooms. Bronfenbrenner (2005) proposes a nested model consisting of a complex web of components. Teachers work in extremely convoluted conditions, because the teaching–working context comprises multiple actors that shape teaching and learning; this makes teaching a rich but multifaceted and complex practice (DOE, 2006). According to complex systems theory, scholars assert that the environment comprises contextual influencers that are termed micro-, meso-, exo-, and macrosystems (Ettekal & Mahoney, 2017), which interact dynamically with one another to influence the outcomes of teaching practice, that is, the implementation of knowledge and skills in the context of this study. Identifying the interconnection between these systems facilitated a better understanding of the implementation of knowledge and skills in diverse teaching contexts. It is worthwhile to consider the key subsystems emanating from complex systems theory, to gain a complete understanding of how teachers implement the knowledge and the skills they acquired through their participation in SPP.

3.6 BEYOND THE SEPARATION PHASE TOWARDS UNDERSTANDING TEACHERS' KNOWLEDGE AND SKILLS IMPLEMENTATION

To provide a theoretical lens to enable this study to explore how teachers implement their knowledge and skills in schools, this section will provide an analytical tool that brings together Kram's theory of mentoring and complex systems theory constructs to provide a theoretical lens with which to understand teachers' knowledge and skills implementation (see Figure 3.3). This analytical tool integrates significant components of the literature that detail the relationship between the knowledge acquired in the SPP (Fricke, 2008; Mokhele, 2013; Ndlovu, 2011a) and implications of applying the acquired knowledge in teaching practice. It departs from the literature, however, by focusing on how teachers independently implement the learnt curriculum and non-curriculum-related aspects at schools, in classrooms, or in any context teachers find themselves entangled in. This provides a new and different perspective on teachers' CPD. This new perspective is derived from the finding that studies on mentoring relationships in SUPs in South Africa focus more on the initiation and cultivation phases (Fricke, 2008; Mokhele, 2013; Ndlovu, 2011b), that is, the implications of the activities executed within the parameters the SUP

and their influence on teaching practice. Thus, the literature contains abundant evidence of the experiences and consequences of these phases. However, there is little information on what happens beyond the separation phase, or on the complexities associated with knowledge and skills implementation. Therefore, the details regarding teachers' experiences about the separation phase is essential for understanding the long-term implications of mentoring on teaching practice. Beyond the separation phase provides a basis to investigate what happens in classrooms after teachers have participated in SUPs.

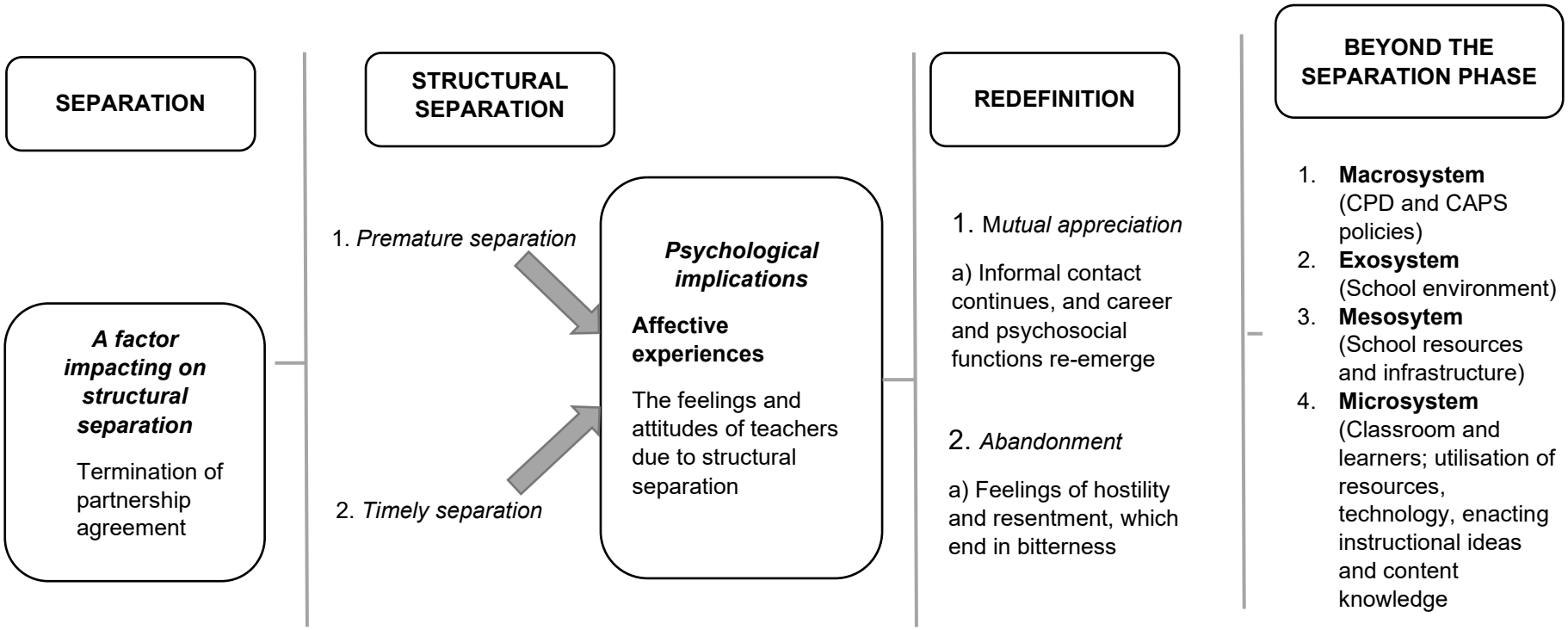

Figure 3.3: A unit of analysis to link the separation and redefinition phases of mentoring and teacher knowledge and skills implementation

In order to show how the separation and redefinition phases of mentoring can be linked to the principles of teacher knowledge and skills implementation at schools, Figure 3.3 will be discussed in detail. Figure 3.3 consists of four columns, depicting separation, structural separation, redefinition and knowledge and skills indicators, and their interconnectedness is shown.

Eventually, mentoring relationships are required to adjust their form to accommodate structural or psychological changes. Column 2 of Figure 3.3 depicts two structural separations that may be presented to the teacher undergoing mentoring, depending on the duration of their participation in the SPP. Firstly, structural separation could occur prematurely, for instance, when a mentee is promoted to other positions, a mentor or mentee changes organisations, a mentee begins to seek autonomy and independence, or a mentor believes they no longer have the required expertise to effectively support their protégé (Humberd & Rouse, 2016). A teacher undergoing mentoring may receive a promotion at work, for example, to head of department or deputy principal of another school that is not part of the SPP or is in a different district. All these structural changes in the mentoring relationship can result in an affective experience, because structural separation is conceptualised as a juncture that may “stimulate a period of anxiety” (Kram, 1983:618), particularly when the protégé feels unprepared to function more independently. For example, a teacher may inevitably be coerced to operate independently of their mentor before being ready to be independent and autonomous. An imposed structural separation could make the teacher experience feelings of being abandoned, and the teacher may be unprepared to meet new challenges on their own.

Conversely, if the structural separation is timely, it could stimulate an emotional separation that enables the teacher to test their ability to function effectively without the close guidance and support of the mentor (Kram, 1983). It is during this period that the teacher experiences the satisfaction of being tasked with implementing the knowledge and skills acquired in the SPP independently of their mentor. Timely separation could yield different affective experiences, as both members could be aware of the structural separation in good time prior to separation, and the teacher could be prepared well in advance to be independent and autonomous. Therefore, the formalised separation could

be a less tumultuous experience, in that both parties may be conscious of an explicit separation point after which the formal relationship will no longer exist in its previous form (Sugimoto, 2012).

Column 3 of Figure 3.3 represents a redefinition phase. The first sphere, mutual appreciation, involves “gratitude and appreciation for the guidance of the earlier years” (Kram, 1983:620), as the teacher operates independently of the mentor and the teacher realises they are on an equal footing with their mentor. Rikard and Banville (2010) argue that, if the relationship leads to mutual appreciation, the mentor and teacher would continue to have some informal contact sessions to continue with the mutual support built by the previous interactions. For teachers, the ability to relate with a mentor in a more peer-like manner, and the ability to function independently in their own setting without immediate support of the mentor, indicates greater teacher competence, teacher self-confidence, and autonomy. For mentors, the peer-like relationship and the ability to impart tacit and explicit knowledge to the teacher suggest competence and productivity. Therefore, both members could experience a change in developmental tasks, so that a mentor–teacher relationship is no longer required.

The second sphere, abandonment, is characterised by significant hostility and resentment once the relationship transitions into the redefinition phase (Kram, 1983). Kram (1983) argues that, conceivably, the emotional intensity and the expression of hostility provide the means for completing the psychological separation and, at this point, the relationship could end in bitterness. If it happens that a structural separation occurs after an emotional separation, the teacher is likely to feel distressed about the mentor as the relationship becomes impassive to the mentee’s changing needs. This phase is a period of readjustment, because career and psychosocial functions can no longer continue in their previous form (Kram, 1983). At this point, the final phase of a “mentoring process cannot be divided clearly contrary to what is claimed” (Erdem & Omuris, 2014:541) in the literature, which is consistent with an approach that associations the separation and redefinition phases. For example, termination of the mentor-teacher relationship does not mean transitioning into the redefinition phase, as the mentor and teachers are from different educational institutions. But, as the teacher finally discovers that they can

operate independently without the mentor's support, the teacher's hostility may diminish. The redefinition phase is, finally, evidence of change having occurred, especially in the teacher.

3.6.1 Skills and knowledge implementation

Lastly, column 4 of Figure 3.3 incorporates complex systems theory constructs that impact on knowledge and skills implementation. Knowledge and skills implementation takes place within a web of subsystems, which are interwoven. Despite teachers having different affective experiences as a result of structural separation, they need to establish their own professional independence and autonomy from mentors beyond partnership. This conception is in accordance with Kram (1983), who suggests that the key aspects of the redefinition phase are protégés' independence and autonomously. Closely linked to this notion is that partnerships between schools and universities for teacher CPD "should be focused on the fostering of teacher autonomy and responsibility" (Mockler, 2013:287). Consistent with this recommendation, Wang and Zhang (2014) argue that promoting teacher autonomy through university-school collaboration enables teachers to develop an understanding of what they do in classrooms, and this represents a major step towards their professional independence. It is for this reason that separation of mentoring necessitates a degree of relative autonomy, particularly if teachers' abilities for teaching mathematics and science are to be continuously tested.

Column 4 is divided into four systems, as illustrated in Figure 3.3. Firstly, within this complex web, the macrosystem represents the set of values and norms such as those in policy documents, as reflected in the organisation of society (Ettekal & Mahoney, 2017). Policies are important component of macrosystems, and influence teaching practice at schools, so that teachers can ensure that learners attain the needs of democratic South Africa in the 21st century (DOE, 2006).

Educational policies, such as CAPS documents for mathematics and science and CPD, are components outside schools and classrooms (microsystem) that articulate the way teaching practice can be enacted to achieve desirable educational outcomes; as well as how teachers should participate in professional development interventions to enhance

their practice (DBE, 2014; Steyn 2008). In this regard, both conceptual knowledge, that is, content and pedagogical knowledge, are basic for effective teaching, but cannot happen if teachers lack willingness and ability to reflect on practice. The CAPS and CPD polices are situated in the outermost macrosystem, and they exert an essential influence on what should happen in classrooms for teachers to equip learners better.

The exosystem is the second level and includes the subsystems in which individuals are directly involved, but not directly rooted (Ettekal & Mahoney, 2017). The exosystem trickles down to influence implementation through other people involved in individuals' lives. This suggests that the exosystem refers to settings in which a teacher is not immediately involved, even though occurrence within these environments still affect how teachers enact the learnt knowledge and skills, and use resources. The primary institutional factor that influence the constant use of knowledge, skills, and resources after the SUP is the value and belief system of the school, which is driven mainly by the school management team. The school management team steer drive this through motivation, rewards, incentives and financial support (Marsh & Farrell, 2015; Naidoo, 2019). Eickelmann (2011, cited in Kafyulilo *et al.*, 2015) identifies institutional factors in terms of the support for individual teachers at schools, support from colleagues, and teachers' participation in processes of decision-making.

Another exosystem element that is assumed to impact on knowledge and skills implementation is teachers' motivation (Stols, Ferreira, Pelser, Olivier, Van der Merwe, De Villiers & Venter, 2015; Keller, Neumann & Fischer, 2017). It is indisputable that a shortage of motivated teachers contributes to students performing poorly in classrooms, which contributes to a dysfunctional education system. Teacher with low motivation and low self-efficacy are deterred to efficiently implement the acquired knowledge and skills in classrooms and to use resources, such as technology, to impact positively on students' academic outcomes (Keller *et al.*, 2017; Schiefele & Schaffner, 2015). It can be assumed that teachers' lack of motivation to implement the knowledge, skills and resources they have acquired could have a direct impact on student learning. Therefore, teachers' motivation determines their instructional behaviours at schools and within classrooms.

Thirdly, shifting outwardly in Bronfenbrenner's levels, is the mesosystem. This subsystem consists of processes that take place between multiple microsystems where individuals are rooted (Ettekal & Mahoney, 2017). The key point is that what happens in one subsystem affects what happens in another subsystem. It can be assumed that the implementation of knowledge and skills is guided by macrosystem elements (e.g., CAPS and CPD policies) that act as a framework for what constitutes teaching practice and what needs to be done to address the cognitive development of students (DBE, 2017). Even though the policy may exert an influence on what should happen at schools and in classrooms; the school infrastructure and resources, including ICT, determine the use of provisioned resources. It is only when school infrastructure and ICT resources are available that teachers can be able to implement (John, 2019; Khumalo & Mji, 2014).

Lastly, the most innermost ecological level is the microsystem. It includes the surroundings in which individuals interact directly (Ettekal & Mahoney, 2017). The microsystem is the innermost subsystem and is the immediate locations that contains the individual who is implementing the knowledge. This subsystem is related to face-to-face interaction with persons and objects that are available within that location (Bronfenbrenner, 1979). As an example of this ecosystem that comprises macro-, exo-, meso-, and microsystems, the classroom is a classic example of a microsystem, in which teachers are embedded to implement the acquired knowledge and the skills within this nested web (Khajavy, Ghonsooly, Hosseini Fatemi & Choi, 2016). Therefore, it can be assumed that the classroom represents the context in which teachers need to implement their acquired knowledge and skills in practice. Elements of a microsystem that might impact on how teachers enact teaching practice include teaching and learning resources provisioned by university partners, learners in classrooms, the school infrastructure, such as mathematics and science laboratories, as well as the ways in which teachers manage their classrooms during teaching and learning.

Both Kram's framework of mentoring, and complex systems theory provide theoretical platforms to investigate how teachers implement knowledge and skills in their classrooms. This necessitates fusing the two theories to form a lens that would guide this study to gain insight into how teachers implement the acquired knowledge and skills and how they

utilise resources after their participation in professional development interventions. The inclusion of these theories in the framework enabled this study to explore how teachers acquired the knowledge by being members of an SUP. Most importantly, the fusion of these theories enabled this study to understand the ways in which the acquired knowledge is applied in practice, together with the successes and challenges that come into play when teaching practice is executed independently by teachers in classrooms. This indicates that knowledge and skills implementation is not being studied from a narrow perspective, but from a broader perspective that takes into consideration critical elements that have the potential to lead to changes in mathematics and science teaching practice. In turn, this lens was used to describe, analyse, interpret, and critique the role of mentoring relationships in SUPs and critique how the involvement of external agents in schools affects the daily teaching practice of in-service teachers.

3.7 SUMMARY

This chapter presented the theoretical framework that was used as a lens through which the study was considered. Kram's framework of mentoring theory and complex systems theory, which constituted the theoretical lens, were discussed. This chapter focused on the different theories and their key tenets to understand the problem posed in Chapter 1. This was followed by a discussion on how the integration of chosen theories (theoretical framework) is related to the study. The next chapter will explain the research methodology that was employed to study the phenomenon in question.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The purpose of this chapter is to present the philosophical postulations underpinning the research strategy and design techniques that were applied in this study. The methodology used to investigate teacher knowledge and skills development in an SPP proposes an empirically driven journey to understanding the concept of knowledge and skills implementation in schools. The understanding of teacher knowledge and skills development is grounded in teachers' everyday lived experiences and sought to illustrate the interconnectedness between participating in an SPP, and classroom enactment.

The first section will present the research design, which is the logical sequence connecting the empirical data to the research questions (Cohen *et al.*, 2018). This study adopted a case study with the view that it is an in-depth investigation to provide insight into the implications of the SPP and to understand the concept of knowledge and skills implementation. The case under consideration is an SPP that was implemented in specific schools in Botshabelo and Thaba Nchu. The second section will present the research approach – qualitative research – and a research paradigm – interpretivist – thereby emphasising understanding individuals and their interpretation of their everyday lived experiences of implementing knowledge and skills in classrooms. The third section will present aspects related to data collection: access to schools, semi-structured interviews, focus group discussions and selection of participants. The fourth section will discuss research trustworthiness and ethics, to indicate that the research did not intend to quantify knowledge development. The last section will explain how data analysis was undertaken with the intention to gain insight into the implications of the termination of the SPP, which could be important for understanding the concept of knowledge and skills implementation.

4.2 RESEARCH DESIGN

A research design is a strategy that explains the practicality of the study, and enables the researcher to answer the research questions. It integrates different elements of the study in a coherent way, and it ensures that the research problem is effectively addressed and constitutes the blueprint for the collection of data and analysis of data (Labaree, 2013). According to Creswell and Poth (2016), a research design refers to the entire process of the research, from the conceptualisation of a problem until the research questions are written and on to collection of data, its analysis, interpretation, and lastly report writing. Yin (2003:20) comments that "the design is the logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions". The research questions that this study sought to address where articulated in Chapter 1 and they are reiterated here for clarity:

1. What knowledge and skills did teachers involved in an SPP gain as part of CPD?
2. How do teachers implement the knowledge and skills they attained in the project?
3. What threats (if any) are related to successful implementation of the knowledge and skills attained?
4. What are the conditions for success regarding implementation of the knowledge and skills gained during the project?

To provide a linkage to the proposed research questions, the literature review and the theoretical framework underpinning this study, an empirically driven investigation was required to understand the concept of knowledge and skills implementation in mathematics and science teaching. This empirically driven investigation integrates these significant components of the study to effectively address the main research question, that is: What are the teachers' experiences regarding the implementation of the skills and knowledge attained in the SPP?

4.2.1 Case study

One of several ways of doing research in the social sciences is through a case study. A case study specifically attempts to understand human beings within a social context as a

single event – a case (Yazan, 2015). This study adopted a case study design to empirically investigate the concept of knowledge and skills implementation. According to Yazan (2015), a case study design involves an inquiry that enables gaining comprehensive and in-depth insights of various components under investigation, so as to understand the complexity of the phenomenon under study. Yin (2009) views a case study as an empirical investigation about a current phenomenon (a case), set within its real-world context, especially when the boundaries between the phenomenon and context cannot clearly distinguished. Case studies investigate and report the real-life, dynamic, complex, and evolving interactions of events of human interactions and other factors in a unique occasion (Denscombe, 2014). This study explored teachers who had participated in an SPP, a case, in South Africa, by analysing their perceptions and experiences as mathematics and science teachers in relation to knowledge and skills implementation.

A case study is perceived as a design that examines a bounded system, a project, policy, institution, programme, or system. Furthermore, Yazan (2015) argues that a case may represent a class, a school, or a community. This study is a case of teachers who participated in SPP at selected schools that were involved in a professional development initiative. This warrants an investigation of the case, to analyse teachers' experiences and perceptions regarding the implications of the SPP for their knowledge and skills implementation. I opted for a case study as it allowed for an in-depth investigation of knowledge and skills implementation by analysing multiple teachers' perspectives gathered at a particular time (Simons, 2009); the researcher's view and interpretation is only one of many. Cohen *et al.* (2018) argue that the key feature of a case study is its rejection of a single reality; these scholars reiterate that there are multiple realities that operate in a situation. Individual teachers who participated in the SPP have their own meanings and interpretations of the project, especially on their personal and professional knowledge. Therefore, a case study attempts to show what it is like to be in a particular situation, and to elicit the close-up reality, rich detail, and thick description. In this study, a case study, thus, allowed for a better understanding of teachers' experiences and their views of SPPs and, more specifically, on their knowledge and skills implementation in mathematics and science.

4.2.2 Case study selection

In this section, I reiterates that this study selected an SPP programme as a case under consideration. The university involved is a multi-campus higher education institution with three geographically separate institutions: Bloemfontein campus; South campus and Qwaqwa campus. South campus is located at the periphery of the city of Bloemfontein and is responsible for university access programmes; it was also responsible for programmes such as the SPP, as part of a community engagement directive. Cohen *et al.* (2018) argue that case studies are set at a point in time and have temporal characteristics that define their nature. As explained in Chapter 1 and reiterated here for clarity, the SPP was initiated in mid-2012 and came to its conclusion in late 2019. The SPP explored in this study primarily sought to contribute to the performance of lower quintile schools in the Free State province of South Africa, and had set itself the goal of achieving meaningful change in the surrounding communities. The mentors appointed for the project worked with teachers, principals, and other members of the school management teams at specific schools.

When selecting a case study, geographical parameters allow for a definition of the case study in question (Cohen *et al.*, 2018). The SPP project under study was implemented in the Free State and certain parts of the Eastern Cape province. In choosing a case study, Simon (2009) argues that consideration should be given to the location of the case study, this includes the travel costs and time needed to conduct research. The case in this study involved gaining an in-depth understanding of certain teachers who participated in the SPP in the Free State province, predominantly in selected Botshabelo and Thaba Nchu schools. I selected schools in Botshabelo and Thaba Nchu in Motheo District, Free State province, in which SPP-designated mentors professionally supported teachers, principals and school management team members in lower-quintile schools to excel at their core functions. The professional support for teachers was aimed primarily at subjects such as accounting, English (language of teaching and learning), mathematics, and physical sciences.

In the introduction of Chapter 1, I explicitly highlighted that learner's performance in mathematics and sciences remains a serious problem in South African schools (Stott &

Graven, 2013), particularly in lower quintile schools. The concept of rurality, which is a key element in both Botshabelo and Thaba Nchu, exacerbates learners' performance in these subjects further: "rural education is most notably underperforming" (Hlalele, 2012:113). To understand rural education, Hlalele (2012) emphasises that socioeconomic implications are key determinants of learners' performance in rural schools, where poverty and financial instability run in the same mutually supporting circles. Therefore, I considered the element of rurality and socioeconomic issues in the selected case. Borrowing from Simon (2009), it was decided that the selected case study was necessary since it would involve an in-depth investigation of a specific real-life project in order to describe its complexity and uniqueness.

Yin (1993) identifies three typologies of case study approaches: explanatory, descriptive and exploratory. In addition to these, Cohen *et al.* (2018) discuss three other types, namely descriptive, interpretative, and evaluative. A descriptive case study is one that requires a descriptive theory to be developed prior to starting the project. This suggests that a specific theory or certain concepts that guide the study are set prior to the data collection and analysis. Cohen *et al.* (2018) describe an interpretative case study as involving developing conceptual sets inductively to examine initial assumptions. An evaluative case study involves the researcher explaining and judging the case in question.

This study used a combination of interpretative and evaluative case studies to comprehensively analyse the empirical data. A case study can be single or multiple, embedded, or holistic (Yin, 2012). An embedded case study is one in which the study investigates multiple units of analysis within a single case, while the holistic case study attempt to investigate an organisation or global programme (Tellis, 1997; Yin, 2012).

This study is grounded in and refers to a single case study with embedded units, in which more than one unit of analysis are incorporated into the design (Cohen *et al.*, 2018). The selected schools were categorised as quintile 1–3 schools, which implies that these were different in terms of context, school infrastructure and resources. These differences had an impact on how the teachers implemented their acquired knowledge, skills and resources.

A case study is often critiqued because its results, generally, cannot be generalised. This failure leads to the claim that a case study lacks scientific importance (Yazan, 2015). In response to this criticism, Yin (2009) argues that analytic generalisation is normally adopted in a case study to address this general criticism, such that previously developed theoretical propositions are used as template for comparing the empirical results of the case study. In this study, this shortcoming was addressed by using the theoretical propositions discussed in Chapter 3 under theoretical framework (*cf.* 3.2), which acted as a frame of analysis (template). The case study opted for analytic generalisation, whereby I sought to generalise a particular set of results to some broader, existing theory. However, it should be noted that the aim of this study was not to generalise the findings to the general group of teachers that participated in the SPP. Instead, the aim was to gain a better understanding of the impact of the project on teachers' skills and knowledge implementation in classrooms. Generalisation requires extrapolation, and the case study researcher, whilst not certainly being able to extrapolate on the basis of typicality or representativeness, can nevertheless, generalise to relevant theory (Cohen *et al.*, 2018).

4.3 RESEARCH METHODOLOGY

This study opted for qualitative research to address the research questions this study sought to answer, as this kind of research approach has various advantages for a study of this nature. With an attempt to better understand the phenomenon in question, qualitative research endeavour to gather rich and descriptive data of that phenomenon (Creswell *et al*., 2010). It provides an in-depth and thorough understanding of meanings, and it gives voices to participants as it probes issues that lie behind their actions. I was particularly interested in the perceptions of teachers as they experienced the SPP, and how the project had an impact on their classroom teaching practice. The SPP provided the context, referred to as the "world" by Cohen *et al.* (2018) in which teachers constructed and reconstructed meanings and understandings and interacted socially with SPP mentors in a way that could be analysed and interpreted. This study attempted to get an in-depth and detailed understanding of teachers' perspectives of how they implemented the knowledge and skills acquired from the SPP.

Qualitative research focuses on attitudes, to gain an understanding of the experiences and interpretations by individuals of the social world and how they enquire about these aspects (Cohen *et al.*, 2018). Through the adoption of this research approach, I attempted to understand what it means for teachers, what they think of the SPP, and how the SPP project affected their teaching practice in classrooms. Additionally, a qualitative research approach enabled me to clearly understand the processes of the SPP, together with the social context within which the practices, meanings, attitudes and beliefs were created by mathematics and science teachers who participated in the project. I, as an educator at one of the schools that partnered with SPP, also participated in SUP activities in this study, which meant he could reflect on the entire SPP experience and was assisted by the other teachers.

4.3.1 Research paradigm: Interpretivist

In education research, Kivunja and Kuyini (2017) describe a paradigm as philosophical ways of thinking about a particular phenomenon that is under consideration. Cohen *et al.* (2018) group research paradigms into three taxonomies, namely positivist, interpretivist, or critical. In the same way, Creswell (2013) lists four philosophical worldviews: postpositivism, constructivism, advocacy or participatory and pragmatism. A positivist paradigm focuses on a scientific method that "involves a process of experimentation that is used to explore observations and answer questions" (Kivunja & Kuyini, 2017:30). An interpretivist paradigm places emphasis on understanding the individual and their interpretation of the world around them, while the critical paradigm focuses primarily on social justice matters and pursues to address the political, social and economic issues that leads to social oppression, conflict, struggle, and power structures, which could occur at any level in the society (Willis, 2007).

This study is an attempt to interpret the experiences and perceptions of teachers in relation to implementing the knowledge and skills they acquired from an SPP. To comprehensively interpret teachers' experiences of their actions in classrooms, an interpretivist paradigm was adopted as a research paradigm. The interpretivist paradigm was adopted in this study because it would assist in understanding the perceptions and

experiences of teachers on knowledge and skills development through mentoring relationships and the implications of the acquired knowledge in practice during classroom teaching and learning.

A key aspect of the interpretivist paradigm is comprehending the subjective world of human experiences (Cohen *et al.*, 2018). This approach tries to probe what the individual who has experienced a phenomenon is thinking, or what meaning they are making of that phenomenon (Kivunja & Kuyini, 2017). Expressed in other words, teachers who have experienced SPPs have developed their own subjective reality of the project, which they could narrate and make known to enable understanding of knowledge and skills implementation in mathematics and science teaching. With this paradigm, an effort is made to understand the viewpoints of the individuals being studied, rather than the viewpoint of the researcher (Cohen *et al.*, 2018). Although researcher reflexivity was embedded in this research, this study was extended to understand the views of other teachers on implementing knowledge and skills learned from the SPP, to develop a better understanding of the concept. In this study, teachers were tasked with providing their own experiences of the knowledge and skills implementation through social interaction with me. The knowledge about their experiences was socially constructed. This is the reason why Scotland (2012) claims that the key tenet of an interpretivist paradigm is that reality is socially constructed by individuals experiencing the phenomenon – that is why this paradigm is sometimes referred to a social constructivism (Cohen *et al.*, 2018; Kivunja & Kuyini, 2017). Knowledge and meaningful realities are socially constructed in and out of the interaction between humans and their world and are developed and transmitted in a social context (Crotty, 1998:42). This paradigm pinpoints the analysis of the SPP in the subjective knowledge by which teachers socially construct meaningful knowledge and skills essential for their CPD in mathematics and science. Constructing knowledge and skills in the SPP can be either an individual process through which mentors visit teachers in their classrooms, or can be a collective effort, by which mentors hold cluster meetings with teachers of mathematics and science, regardless of the grade a teacher is teaching.

4.3.1.1 Ontological perspective

The assumption of a relativist ontology indicates that the researcher has a belief that the situation that is being studied has multiple realities (Kivunja & Kuyini, 2017). Indeed, multiple teachers of mathematics and science have their own realities about the implementation of knowledge and skills learned from the project in their own classrooms. These realities can be investigated, and meanings could be constructed by teachers, or recreated through social interactions between the researcher and the participants in the research (Cohen *et al.*, 2018). To understand these multiple realities of differentiated teachers in different school settings, I interacted with teachers to understand how they were enacting the acquired knowledge in practice. Knowledge and skills constructed by the teachers within the SPP, because of social practice, are bound by culture and context, and there exist multiple realities and no single truth for interpreting them. Multiple realities result from differentiated teachers within different school settings, which could subject teachers to experiencing the SPP differently. Yin (2003) explains that multiple realities are constructed, which lead to individuals having multiple interpretations of the same phenomenon. In the same context, people and events are distinctive and have meaning given upon them, rather than owning their own intrinsic meaning. This suggests that teachers in the same school setting could have experienced knowledge and skills development differently within the SPP, because these teachers would have a different teaching experiences and expertise in relation to content and pedagogy for teaching mathematics and science.

4.3.1.2 Epistemological perspective

In relation to epistemology, Stake (2005) argues that setting shapes activity, experience, and one's interpretation of the case study. I engaged in the activity as it occurred in a context, and by doing so, I attempted to capture the interpreted reality of the context (Stake, 2005). In an attempt to understand the long-term implications of the SPP in classrooms, I engaged with the teachers who had experienced the SPP, in order to get in-depth insight into their everyday lived experiences of knowledge and skills implementation beyond the project. This approach suggests that I interactively collected data in a non-interfering manner as situations unfolded and without controlling the study

and its outcomes. Kivunja and Kuyini (2017) claim that the assumption of a subjectivist epistemology implies that the researcher derives meaning of their data through their own thinking and cognitive processing of data, which is informed by interactions with participants. There is an understanding that the researcher will socially construct knowledge, because of their personal experiences of the real life within the natural locales under investigation. The participation of myself, as the primary source of data collection, signifies that multiple sources of data collection are used to capture the genuine nature of the phenomenon, and doing so provides a more synergistic and comprehensive view of the SPP in relation to the concept of knowledge and skills implementation. The SPP enabled teachers, within their contexts, to socially construct knowledge and skills deemed necessary for their continuing development and which could possibly enhance their content and pedagogical knowledge. Table 4.1 describes distinctive aspects of the interpretivist paradigm that were applicable to this study. They are categorised for the purpose of the research: ontological aspect (reality as socially constructed by individuals); epistemological aspect (nature of knowledge and the relationship between the researcher and the researched); and methodology used for data collection.

Table 4.1: Distinctive aspects of interpretivist paradigm as applicable to this study

Aspect	Description
Purpose of the research	Reality as experienced by people who lived it: Understand and interpretations of teachers' experiences, perceptions and understandings of implementing the knowledge and skills acquired in the SPP that could impact their CPD for mathematics and science.
Ontological aspects	▪ There are multiple realities, as each teacher had their own perception of knowledge implementation ▪ Reality of an individual teacher can be explored through their implementation of knowledge acquired from the SPP ▪ Understand how teachers make sense of SPP resources and knowledge in their natural settings by means of classroom experience ▪ Many social realities exist due to teachers having different experiences, and their knowledge, views, and interpretations being different
Epistemological aspects	▪ Events are understood by the teachers through their interpretations of knowledge and skills implementation ▪ Those who actively participated in the project socially constructed knowledge and skills through engaging with their mentors. ▪ I and teachers were interlocked in an interactive process characterised by talking, listening, and writing ▪ Acknowledgement that context is vital for knowledge and knowing
Methodology	▪ A qualitative methodology ▪ Processes of data collection using semi-structured interviews and focus groups ▪ Research is the product of the values of the teachers

4.4 METHODS OF DATA COLLECTION

Qualitative research is typically associated with the collection of data through techniques such as in-depth interviews, focus group discussions, member checking and participant observation (Cohen *et al.*, 2018). The case study design that was adopted for the intention of conducting an extensive and holistic investigation of the experiences of teachers of implementing knowledge and skills allowed for a combination of data collection and analysis techniques: semi-structured interviews and focus group discussions.

Using multiple data sources in this study enabled heightened rigor and trustworthiness of the collected information for the understanding of the implications, beyond the SPP's existence, of teachers' everyday reality in implementing their acquired knowledge and skills. The data collected from the semi-structured interviews and focus group discussions grounded the interpretation of key verbal interactions in an empirically rich and narrative account of the SPP mentoring programme. The case of the SPP in the selected schools was intended to provide guidance in the development of a framework that investigates the importance and significance of the SPP for teachers' professional knowledge and skills in South Africa.

4.4.1 Access to schools

Prior to data collection, I needed to gain access to the schools, to explain the purpose of the study to mathematics and science teachers who would participate in the study. Conducting empirical research, especially in schools, requires the researcher to obtain permission from relevant educational authorities. The permission to conduct the investigation of knowledge and skills implementation was granted by the university's ethics committee (see Appendix C). After receiving permission to conduct research, the significance of the principle of participants' informed consent became evident at an early stage of the research project – that of access to the institutions or organisations where the research was to be conducted, and acceptance by those whose permission was required prior to the commencement of the research (Cohen *et al.*, 2018). Early access offers the best opportunity for researchers to present their credentials as serious

investigators and to institute their own ethical position with respect to their proposed research.

Entry into schools was not a difficult undertaking, because of my role as an educator at one of the schools that partnered with the SPP. To prepare for school visits, the principals of the selected partnered schools were sent letters that explained the purpose of the research and requested permission to conduct the research at their schools. After a thorough discussion with school principals, they granted permission for the study. One school in Botshabelo was an exception, and entry was not granted on the proposed date, as the school principal was not available for consultation to receive an explanation of the purpose of the study. At the schools that provided access to conduct the research, teachers showed willingness to participate in the study after they had received a thorough explanation of what the study entailed, as well as the significance of providing data on their experiences of the implementation of the knowledge and skills acquired in the SPP. After every discussion, I thanked all the teachers who participated in the research with honesty and requested the opportunity to contact them should there be a prerequisite for clarification and/or further questions regarding our discussions. After access had been gained to schools and prior to data collection, participants were required to sign a consent form (see Appendix B) to indicate their voluntary participation in the study. The data was collected through semi-structured interviews and focus group discussions, which analysed the implications of the SPP on participants' teaching practice.

4.4.2 Participants' selection

For Patton (2002:123), qualitative research considers a limited sample for the selection and identification of information-rich cases to explore a phenomenon. Flick (2009) recommends that the basis for choosing sample strategies for qualitative research is to provide rich and relevant information. Therefore, sample strategies deployed in this study were purposive sampling (Cohen *et al.*, 2018) and, more specifically, criterion sampling. This was done to ensure that teachers "that meet certain predetermined criteria" (Suri, 2011:71) were selected according to common characteristics. Through purposive sampling, I used my ruling to select cases that would best enable me to answer the

proposed research question(s) and achieve the research objectives. The advantage of using purposive sampling was that participants can add rich and informative data to the study based on their personal experiences of the phenomenon in question (Johnson & Waterfield, 2004). This implies that individuals who have not experienced SUPs were automatically excluded from the study, as they would not have added any value to the research objectives.

In this study, 16 teachers from eight different schools were followed, based on their involvement in the SPP and the type of information required to answer stated research questions. Their selection was based primarily on the specified criteria that (1) participants had to be teachers in the partnered schools as envisaged by the university; and (2) the participants had to be teaching either mathematics or science at the partnered schools. Since this research was intended at gaining insight into the experiences of teachers in implementing the knowledge and skills acquired in the project, using one participant or participants from only one school would not have provided the perspectives of other teachers. Thus, teachers were selected from different schools, to comprehensively understand from a much broader perspective the impact of SPPs on teachers' knowledge and skills implementation at schools. Details of the teachers who participated in the study are depicted in Table 4.2.

Table 4.2: Details of participants

Pseudonym	School	Subject speciality	School quintile
Teacher 1	School A	Mathematics	Quintile 1
Teacher 2	School A	Physical sciences	
Teacher 3	School A	Natural sciences	
Teacher 4	School B	Physical sciences	
Teacher 5	School C	Physical Sciences	Quintile 3
Teacher 6	School C	Mathematics	
Teacher 7	School D	Mathematics	
Teacher 8	School D	Physical sciences	
Teacher 9	School E	Physical sciences	
Teacher 10	School E	Mathematics	
Teacher 11	School F	Mathematics	Quintile 2
Teacher 12	School F	Physical sciences	
Teacher 13	School G	Physical sciences	Quintile 1
Teacher 14	School G	Mathematics	
Teacher 15	School H	Mathematics	
Teacher 16	School H	Physical sciences	

4.4.3 Semi-structured interviews

An interview refers to an exchange of views between two or more people, the discussion is on a particular topic that participants share or understand. Interviews enable participants – interviewer and interviewees – to discuss their interpretation of the world in which they live and to articulate how they regard situations from their own point of view (Cohen *et al.*, 2018). In this study, individual semi-structured interviews were conducted to capture the teachers' lived experiences of the implementation of knowledge and skills obtained from participation in an SPP. The semi-structured interviews were open-ended, in order to "yield direct quotations from people about experiences, opinions, feelings, and knowledge" (Patton, 2002:4). Semi-structured interviews represent a technique of understanding the complex behaviours of people without imposition of any developed

categories that may limit the field of inquiry. Semi-structured interviews are often undertaken in the form of conversations that aim to explore participants' views, attitudes, beliefs, and concepts about certain events or phenomena (Cohen *et al.*, 2018). I conducted semi-structured interviews with teachers, who provided their interpretation of their experiences they had generated through social interactions with mentors. Teachers who partaken in the study were requested to provide complete information regarding their experiences of knowledge and skills development, well as how it affected their daily teaching practice.

The semi-structured interviews were guided by predetermined categories of questions (see Appendix D), which were posed to all mathematics and science teachers who participated in the SPP at the selected schools. The interviews solicited the general views of participating teachers on how they implemented acquired knowledge and skills in classrooms. The semi-structured interviews provided information about teachers' perceptions regarding the implementation of knowledge and skills acquired in the SPP, their experiences of implementation, and the challenges and successes they experienced in their classrooms. Lastly, using semi-structured interviews ensured that I could probe more deeply into teachers' experiences by exploring responses that were relevant to the conceptualised research topic.

4.4.4 Focus group discussions

Focus group discussions are a type of interview that involve a group of people that has experienced a certain phenomenon and the reliance is placed on the interaction within the group. The researcher provides the group with a topic of interest which yield collective meaning rather than an individual view (Cohen *et al.*, 2018). The significance of focus group discussions in the context of this study was that they were expected to produce insights that could not have been gained from individual interviews. Focus group discussions were also used to substantiate data that emanated from semi-structured interviews.

Two focus groups discussions, lasting not more than two hours each, were conducted with each group consisting of four teachers. The use of focus groups is more

advantageous than individual interviews, as the participants in focus groups interact with each other in a way that means their views can emerge and be clearly articulated (Cohen *et al.*, 2018). The focus groups were conducted to "get high-quality data in a social context where people can consider their own views in the context of the views of others" (Patton, 2002:386). The group discussions were recorded by making use of an "unobtrusive digital recorder" (Merriam, 2009:109) and the recordings were transcribed verbatim to provide "the best database for analysis" (Merriam, 2009:110). The benefit of using focus group interviews is that it "is an intensive social encounter that weaves a complex web of communication styles that may convey ambiguous messages" (Leshem, 2012:6), as the researcher and teachers bring their own values, cultures, and backgrounds to the situation, which "inevitably affect the way they perform in a constrained reality" (Leshem, 2012:6). The information provided in the focus groups were treated as confidential between the participating teachers and myself. Mathematics and science laboratories at each school were used for these group interviews. The purpose of the research was explained to the participants during interaction, as were other issues related to ethics.

4.5 DATA COLLECTION PROCEDURE

4.5.1 Individual interviews

The starting point for data collection in this study involved conducting individual interviews with mathematics and science teachers. The research questions guided creation of the interview protocol. This interview protocol was first used with only one participant: Teacher 1, who is a mathematics teacher from School A. This interview was conducted on 08/02/21 with the aim of familiarize me with the process of interviewing participants, and to ensure that the interview questions would yield rich data to enable the study to respond to the research questions (Ritchie *et al.*, 2013). This participant's audio-recorded interview was transcribed and engaged with and based on these findings, minor adjustments were made to the interview protocol. An expert in the field of Higher Education Studies also scrutinized the adjusted protocol and the data generated from the first interview, and on the basis of these pronounced that the protocol could be considered

valid. I then proceeded with the interviews from 8 February 2021 to 25 March 2022, excluding school holidays when the teachers were unavailable.

4.5.2 Focus group discussions

As it was discussed in section 4.4.4, focus group discussion was the second data collection procedure with each group consisting of four teachers. In this regard, I conducted the first focus group discussion on the 2nd of March 2022 in Thaba Nchu, Motheo District. This group discussion was conducted on a Saturday to ensure each participant was able to attend the discussion which was held at School A. The second group discussion was conducted on the 23 March 2022 in Botshabelo, and was also held on a Saturday, this time at School H. This allowed participating teachers to join the discussion without disturbing their teaching duties. Both schools were chosen because of their centrality in these regions and teachers could easily access the venues. I purposefully selected participants based on the data that emanated from semi-structured interviews to participate in focus group discussions, with the aim of obtaining rich information from participants (Yin, 2012). Thus, four teachers who were able to provide me with rich information were purposefully selected to provide their experience with implementing the knowledge and skills acquired from the SPP.

4.5.3 Artefacts/images

In this study, participants were required to provide images/pictures of themselves taken while they presented lessons using the resources from SPP. Photographs were used in this study to support the part of the interview in which the participants said that they use the resources provided by SPP mentors. Cohen *et al*., (2018) argues that photographs can support and supplement other sources of data the researcher used in qualitative research. Photographs were instrumental in this study as they elicited information which I could not directly observe. They evoked meanings and reflections together with information and factual data of what teachers were doing with the resources in their classrooms. Scholars such as Richard and Lahman (2015) and Elliot *et al*., (2016) regard photographs as source of data that present a real situation, they are often concrete and

contextualized. The photographs were taken after individual interviews and focus group discussion were conducted so that they can supplement the data that emanated from these two data collection sources.

4.6 RESEARCH TRUSTWORTHINESS AND ETHICS

4.6.1 My positionality in this study

I was encouraged by the personal experience of the SUP to conduct the study to understand the concept of knowledge and skills implementation that relied on teachers' social construction of knowledge and skills. Researchers often have preconceived ideas about research, and this often emanates from their experience of the world. Denscombe (2014) have noted that a researcher does not embark on research with a clean sheet, they use a varied of tools that include culture and values or even personal experience. My reflexivity and motivations related to this study posed the risk of unduly influencing and biasing the study findings. As I was involved in the SPP for a time (2016 to 2019) and therefore had inside knowledge of its content, I remained cognisant of the likelihood that my own perceptions might hamper the generation of real data. Therefore, I remained reflexive of my perspective and constantly kept my views from the participants. However, it could be argued that my personal interest as a researcher, in combination with my placement as a teacher and a PhD student at the Bloemfontein campus of the university, at the time that I collected data for the study, from January 2019 to October 2021, improved my credibility as a participant observer (Cohen *et al.*, 2018). Moreover, this positioning helped me to make appropriate choices to develop a more complex palette and it gave the study a simple, yet sophisticated and insightful character (Patton, 2009). The embedded nature of myself as the research on the SPP site, and the use of a case study design enabled me to investigate teachers' complex experiences. As a teacher I had continuous access to research resources, such as writing instruments, a quiet office which was a safe place to conduct research, as well as a computer to use while collecting data. I was flexible in scheduling interviews and focus group discussions.

The qualitative research approach adopted in this study is often critiqued for lacking or missing scientific rigor. Therefore, case study researchers need to guarantee construct validity (through the triangulation of multiple sources of evidence, chains of evidence, and member checking), internal validity (using established analytical techniques such as pattern matching), external validity (through analytical generalisation), and reliability (through case study protocols and databases). For Guba and Lincoln (1994), rigor refers to matters of credibility, transferability, dependability and confirmability. Each of these aspects is concerned with key dimensions that a qualitative researcher needs to consider in order to ensure that the research is of accepted quality and, thereby, to meet scientific standards.

4.6.2 Credibility

The term credibility is described as parallel to internal validity of qualitative research (Yin, 2009). Internal validity pursues to establish that the explanation of an event, issue or set of data that a piece of research provides can actually be supported by the data and the research (Cohen *et al.*, 2018). This implies that the findings must describe accurately the phenomena being studied, that is, knowledge and skills implementation, in the case of this study. This is the reason why Patton (2009) argues that triangulation strengthens a study by combining various methods of data collection.

The study used multiple sources of evidence for strengthening the credibility of data to ensure construct validity. The use of semi-structured interviews and focus group discussions assisted in achieving convergence of data. Significantly, the primary focus was not to measure participants' perceptions and their experiences, but rather to gather valuable information and understanding about the long-term effects of the SPP in teacher classroom practice. Thus, using multiple sources of evidence ensured credibility.

4.6.3 Transferability and dependability

In accordance with Cohen *et al.* (2018), transferability is analogous to external validity, which refers to the degree to which results can be transferred to a wider setting. Given

the number of teachers who participated in this study, they were not representative of other teachers in other schools that partnered with the SPP. This suggests that this study opted for analytic generalisation, in which the concern was not about a representative sample. Yin (2009) claims that analytic generalisation impacts on the expansion and generalisation of theory. He argues that case studies can help to generalise to a broader theory, which can be tested in one or more empirical cases. While it is certain that the data from a qualitative study is not replicable, it is not difficult to operate a qualitative study in a different setting. The research findings can be transferred to a different study of other partnered schools, for example, by interviewing teachers from other partnered schools.

In qualitative research, dependability corresponds with the notion of reliability. Dependability refers to the degree to which research findings can be reproducible when using the same subjects in the same context (Merriam, 1998). Dependability involves taking into consideration the changes in a natural setting and how these changes affect the way research is executed.

4.6.4 Confirmability

Confirmability refers to the degree to which others can authenticate the findings to ensure that the results exhibit the experiences and understandings of the observed participants, rather than the researcher's own preferences (Lincoln & Guba, 1985). This focuses on objectivity, that is, the extent to which influences on the researcher's judgement are diminished (Mertens, 2007).

To ensure that confirmability was maintained in the study, I used various methods to assure confirmability and rigor. Data was transcribed verbatim, and I used the original text to support the interpretation of the results. I also employed an audit trail, which involved using documentation and recording raw data. I kept the records of analysis and data reduction, reconstructions and syntheses of data and taking process notes. The audit trial enabled the research to address the question of confirmability of results, in terms of process and product. Other ways I maintained an audit trail involved the use of data analysis and themes that emerged in the study.

4.6.5 Ethical concerns

Ethical research concerns relate to what researchers should and ought not to do in their research and research behaviour (Cohen *et al.*, 2018). Ethical concerns indicate what is right and wrong, good and bad, when engaging with participants in a quest to collect data. The direct interaction of myself with the researched sample obliged me to address certain ethical issues.

I ensured that all participants (teachers in different school settings) were informed about the purpose of the research prior to the collection of data. I ensured that the participant received information of the research and I also explained that participation in this research was voluntary and that they could leave the study at any time, without negative consequences. This is why researchers honour informed consent, by giving participants the opportunity to provide consent after being informed of the research processes, risks and benefits (Cohen *et al.*, 2018). Teachers at selected schools agreed to participate verbally and signed the informed consent form (see Appendix B) after a brief discussion that explained the significance of the research in their school settings.

One other important aspect of ethics in this study was the privacy of participants. One way of addressing privacy and protection from harm is by applying anonymity and using pseudonyms (Cohen *et al.*, 2018:129). Participants were guaranteed that they would remain anonymous in this study and, thus pseudonyms were used to refer to them in the reporting of the data.

4.6.5.1 Consent forms

There are inherent ethical issues involved when humans participate in the research (Cohen *et al*., 2018). Since this study involved sixteen mathematics and science teachers, informed consent was needed to ensure that participants understood the implications of the research. I was able to draft a consent letter that explained the details of the research to the participants. As Hammersley and Traianou (2012) put it, research should respect the autonomy of the participants by gaining informed consent from the participants (Appendix C). An ethical principle that guided this study was to respect participants' autonomy prior to the commencement of the research and their own personal choices,

their integrity as human beings and not subjects of research. The consent letter detailed that any participant voluntarily participated in the study and could withdraw their participation any time if they wish to, without prejudice, if they felt uncomfortable to participate in the study.

Prior to informed consent distribution, I was able to interact with participants to explain what the research entails as well as the significance of participation in the study. Amongst things that were discussed are the processes of data collection methods and data analysis, as well as reporting the results back to the participant once the study has been concluded.

4.6.5.2 Confidentiality

During the initial discussion, teachers were informed that collection of data was treated as confidential, and that only the researcher had access to such information before publication. Teachers were reassured that copies of verbatim transcripts together with the research report was accessible to them. The notes from my reflective journal, and audio used during interviews were stored safely in a secured place and only myself had access to such information.

The data collected from participants' interviews was kept private and each participant was given a pseudonym to conceal their identity. The school names were also given pseudonyms to prevent tracking of teachers within mathematics and science and not to compromise schools and teachers' confidentiality and privacy. The participants were advised that anything that would compromise this confidentiality would be discarded from the research report.

4.6.5.3 Ethical clearance

I applied for permission to conduct research within the parameters of the SPP. Through engagement with the coordinator of the SPP, I was advised that they had already applied and received permission to conduct the research from both the Free State Education Department and the University of the Free State. Following engagements and discussions about what I intended to research, the title of this study was added to an already existing ethical clearance. However, this was a length process since various stakeholders were

involved in the process, and ultimately, I was granted permission to conduct research (see Appendix B).

4.7 DATA ANALYSIS PROCEDURE

Data collected for research purposes are ultimately analysed, to give a study its direction, meaning and worth. According to Creswell (2012:461), data analysis involves "organizing, accounting for and explaining the data; in short, making sense of the data in terms of participants' definition of the situation, noting patterns, themes, categories and regularities". In this study, I continuously analysed and became an iterative process (Creswell, 2013; 2014; Nieuwenhuis, 2012). This implies that collection of data and analysis, in this study, were undertaken concurrently, which helped to identify issues that required further clarification and details. This process helped me to fill in the gaps in the process.

The analysis of data was done thematically in this study. Thematic analysis involves identifying themes and categories from the empirical data to make sense of the empirical data (Cohen *et al*., 2018). I undertook several phases in the process of data analysis. The first critical phase was to listen carefully to all the audio recordings several times prior to the process of transliterating them verbatim and reading the field notes. For Creswell (2012), it is the researchers' responsibility to carry out the process of transcription, and, thus, I transcribed all the audio recordings personally to ensure that all the utterances were captured. The next phase was to search for response that were similar and to bring them together through the process of categorical aggregation. Critical segments on teachers' perceptions about their knowledge and skills were identified from the study's objectives (Cohen *et al.*, 2018; Ritchie *et al.*, 2013). This was followed by a coding process, which involved "reading carefully through your transcribed data, line by line and dividing it into meaningful analytical units" (Nieuwenhuis, 2012:105). I assigned codes to pieces of text extracted from participants' responses, which had the same meanings or were about the same thing. This phase ensured that data that had similar thematic concepts were examined collectively and evaluated (Creswell & Plano Clark, 2011; Flick, 2014; Silverman, 2013). The next phase was extending categorical aggregation, in which

data was organised to generate meanings through categorisation. This stage involved grouping similar responses together and ordering units of meaning that had been extracted from the interviews and the focus group discussion. Finally, after these phases, an interpretive phase was conducted to generalise the data as a whole and report on teachers' knowledge and skills implementation.

I also conducted the document analysis of the IBP videos, content notes, and content discs provisioned by SPP mentors. The contents of these documents were analysed to determine the types of knowledge and skills teachers could acquire. These documents yielded a plethora of information about the types of knowledge and skills relevant to the study, and the ways in which teachers could implement the documents in their own teaching. The data from these documents were compared with the narratives representing teachers' perspectives on the type of knowledge and skills development they participated in. The data from the two data sources were performed using thick descriptions and as a combined whole. From these data sources, a complete picture was drawn about teachers' perspectives on their knowledge and skills implementation in mathematics and science teaching.

Data from semi-structured interviews and focus group discussions were recorded. I started transcribing data on the same day individual interviews and focus group discussion were conducted while the details of the interview were still fresh. In this study, I coded, segmented, and categorised data from both data sources. The codes were divided into meaningful units that were relevant to the stated research questions and were organised according to the research questions. Coding assisted in identifying the themes that emerged from the data analysis. Data analysis was taken concurrently with data generation, this simultaneous process was essential for probing constantly to address the recurring issues. For deductive analysis, the theoretical frameworks were used as unit of analysis to come up with themes, while the literature was mainly used for inductive analysis. After identifying the themes, I then engaged in the data interpretation and discussions of the main findings of this study. The interpretation and discussion of the findings were organised according to the stated research questions. While interpreting

and discussing the findings, I incorporated the theoretical frameworks adopted and the literature reviewed in this study.

4.8 SUMMARY

In this chapter, I presented a description of the research design and methodology. The rationale for positioning this study as a case study and within the interpretivist paradigm was presented, coupled with the reasons for using a qualitative research approach. As discussed, qualitative research grounded in interpretivism requires a researcher to obtain participants' perceptions on a phenomenon within their contextual locale. I also provided a comprehensive discussion of research methodology and data analysis strategies. The methodology deployed provided a space for investigating and understanding the implications of the SPP in relation to acquired knowledge and skills, from teachers' perspectives. The next chapter will present the research findings of the experiences and perceptions of teachers.

CHAPTER 5: PRESENTATION AND DISCUSSION OF THE STUDY FINDINGS

5.1 INTRODUCTION

As indicated in Chapter 4, after I received permission to conduct a study in schools that had partnered with the concerned university, and after receiving ethical clearance (*cf.* Appendix C), appointments were made with selected school principals to ask for permission to enter schools. After that, teachers were informed about the research and were provided with informed consent forms, to ensure they participated in the study voluntarily. Once teachers had provided informed consent, the data generation process started; consequently, individual interviews were carried out. The data generation was targeted at provoking information about the experience of teachers. through a method driven by an epistemological belief that knowledge about the topic under study was entrenched in the participants' action at their schools. Therefore, this chapter will present the findings derived from data collected through semi-structured interviews and focus group discussions, which sought to understand the experience of mathematics and science teachers of the SUP for teacher development. The rationale for using these data collection strategies was explained in the previous chapter (*cf.* 4.4). Teachers involved in the study were a group of staff from Botshabelo and Thaba Nchu schools in the Free State province of South Africa.

The analysis in this chapter will be organised according to the themes generated by the data that had been collected and analysed using Kram's framework of mentoring, and complex systems theory. The research questions that were used to generate data and on which the analysis is based are the following (*cf.* 1.2.1):

1. What knowledge and skills did teachers involved in an SPP gain as part of CPD?
2. How do teachers implement the knowledge and skills they attained in the project?
3. What threats (if any) are related to successful implementation of the knowledge and skills attained?
4. What are the conditions for success regarding implementation of the knowledge and skills gained during the project?

As explained in Chapter 4, the voices of teachers who had experienced SPPs were heard in this study. The voices of 16 teachers from eight different schools were heard; they provided empirical data through the use of semi-structured interviews and focus group discussions. The empirical data that emerged from document analysis were integrated during the discussion to support or contrast with the empirical findings from teachers' voices. The direct quotations are from transcriptions of the data provided by teachers, and will be given in italics to distinguish it from the discussion. In this chapter, the presentation of the empirical findings will be infused with the discussion, and will be based on the findings. In most parts of this chapter, the empirical findings are mapped to the literature, previous studies and the theoretical framework adopted in this study.

The discussion in this chapter will be structured according to Kram's phases of mentoring, namely the initiation, cultivation, and separation phases. In the discussion on separation phase, complex systems theory is incorporated to explain how teachers implement the knowledge and skills acquired in SUP. The rationale behind this structure was to bring to the fore the journeys of teachers during their participation in the SPP, and their subsequent independence after the separation phase. These phases of mentoring and complex systems theory were essential, as they guided this study to respond to the stated research questions.

5.2 INITIATION PHASE

It should be noted that the SPP under investigation adopted a mentoring approach, as discussed in Chapter 1. The project allocated one mentor for each subject of the project – accounting, English, mathematics, and sciences. However, this study limited its scope to mathematics and science, and comprehensive reasons for this limitation were provided in Chapter 1 (*cf.* 1.2). Empirical data that emanated from the interviews reveal that teachers had expectations when they were informed about their participation in the SPP. The expectations that teachers developed regarding the mentoring relationship during the initiation phase of the SPP will be discussed in Section 5.2.1.

5.2.1 Teachers' expectations of their mentors

Teachers' participation of the SUP was found to have triggered them to have expectations about what the project should produce in terms of content and pedagogical knowledge. However, the expectations were not limited to content and pedagogical knowledge. It was found that teachers also expected the project to contribute to the development of assessment skills for mathematics and science disciplines. The following response attests to teachers' expectations during the initiation of the project:

> *I was expecting, firstly, for mentors to share the information, particularly in mathematics. Secondly, I was expecting the mentor to exchange the ideas on how we can easily deliver the content to the learners. Third one is different methods or approaches to the classroom. (Teacher 1)*

Another participant expressed similar views; they expected the mentor to

> *make some of the topics easier to learners because if you can check physical science is one of the core challenging subjects. (Teacher 3)*

Teachers' expectations seem to have been the starting point of teachers' CPD. Participants seem to have expected mentors to exchange instructional strategies that simplify concepts and make concepts easier to teach in lessons. This indicates that teachers had a belief that mentors would provide the required support and guidance teachers needed. Teachers developed imaginary images of their mentors, which corresponds with Kram (1983), who found that mentees develop fantasies about their mentors at the initiation of mentoring. The expectations of Teacher 1 and Teacher 3 in this study seem to have been centred on the expectation that they would acquire new instructional strategies for teaching of mathematics and science.

In addition to the expectations of Teacher 1 and 3, other participants expressed their expectations as follows:

> *I was excepting to be assisted in terms of subject, the skills that are required, and then how to set the question paper, assessment as well as all the resources. (Teacher 13)*

I was expecting that I will be having more skills, more ways of explaining things and then it [the SUP] will develop me as a person. (Teacher 5)

The participants who shared these expectations expected the mentor to provide them with new knowledge about mathematics; they expected the mentor to share their knowledge and expertise for teaching mathematics. Humberd and Rouse (2016) believe that in the early stages of mentoring, mentees project their future selves and mentors use their past experience to act as a guide to a mentee. The participant expected the mentor to share their knowledge and expertise on classroom instructional strategies that would make concepts more understandable to learners. This indicates that Teacher 1's expectations were centred on the acquisition of new instructional strategies for teaching of mathematics. Teacher 3 expressed similar views regarding science, as they expected the mentor to "make some of the topics easier to learners because if you can check physical science is one of the core challenging subjects".

The participants made an implicit connection between the SUP and skills development for mathematics and science, and this connection was based on teaching and learning. Teacher 13 expected a mentor to develop their assessment skills. Assessment skills are among of the curriculum administration duties that teachers are required to fulfil in the teaching profession. Teacher 5 was more specific about the skills they needed to develop in this project. In this instance, the participant emphasised the need to develop new insights on instructional strategies. This suggests that the participant expected to develop new pedagogical knowledge for teaching science, which supports the expectation of Teacher 1 had during the initiation phase of the SUP.

Some of the participants mentioned that they were novice teachers who had graduated recently. Upon their arrival at their schools, they were integrated in the project. Regarding their expectations of the SPP, a novice teacher, explained that

I was expecting to get maybe some mentors who could help me more especially when it comes to teaching and learning, how do we deliver the content … so my expectation was that can I get somebody or some guidance from those people from the university. (Teacher 2)

Another novice teacher expressed their expectations as follows.

> *I was expecting the mentor to teach the topic so that I observe on how to tackle that topic. I expected the mentor to come and observe when I teach and when I have weakness, they strengthen me by giving me the input. (Teacher 12)*

Data analysis indicates that novice teachers expressed differing views about their expectations about participating in the project upon their arrival at their schools. For Teacher 2, the expectation revolved around the development of instructional strategies to deliver the content meaningfully to the learners. Teacher 12 was more specific about how they expected the mentor to contribute to the development of instructional strategies. Additionally, Teacher 12's response seems to suggest that they expected classroom observation to be a bidirectional process. This participant believed that classroom observation would enable a mentor to identify content knowledge or pedagogical knowledge gaps and address these gaps through reflective discussion.

From the above discussions, data seems to suggest that teachers' expectations were based on their professional development needs, and they expected the project to be accustomed to their needs. In this study, teachers expected mentors to share instructional strategies, so that teachers could develop better and different ways of teaching. Additionally, teachers expected mentors to develop in teachers assessment skills for the purposes of assessing learners. The development of expectations during the initiation phase of the mentoring relationship is consistent with what Kram (1983) and Sugimoto (2012) report; they agree that a protégé – teachers in this case – develop expectations about their mentors during the initiation phase.

Having reported on some of the participants' expectations during the initiation phase, Section 5.3 will discuss the cultivation phase, which follows the initiation phase in mentoring relationships.

5.3 CULTIVATION PHASE

The cultivation phase is associated with frequent social interaction between the mentor and mentee, and, thus, a wide variety of mentoring activities start to emerge (*cf.* Kram, 1983). It should be noted that this study was not about mentors, but rather about the actions mentors took to develop teachers' knowledge and skills. The concept of teachers' knowledge and skills implementation cannot be studied independently without understanding how the participants acquired knowledge and skills, or what types of knowledge and the skills were developed in the project. Data analysis from the participants' responses indicate that mathematics and science teachers developed knowledge and skills when mentors endowed two types of mentoring functions, namely, instructional coaching and role modelling. Therefore, this section will respond to the first research question, which refers to the types of knowledge and skills teachers acquired through their participation in the SPP.

5.3.1 Instructional coaching

Instructional coaching was a constant activity by teachers in this research. This study found that instructional coaching influenced the development of teachers' content knowledge and instructional strategies. The focus was on certain concepts. Through instructional coaching, the data shows, mentors used sketches to deepen teachers' content and pedagogical knowledge, as suggested by participants.

> *MM [the mentor] did summarise the topic [Euclidean geometry], instead of doing it for two weeks she has shown me the method of summarising the topic within two or three days only and learners understood it very well. Mrs MM emphasised that I should highlight the key words that learners should know so that they have a better understanding of Euclidean geometry. (Teacher 1)*

In a follow-up interview, Teacher 1 expressed that

> *The mentor helped me to deliver the content to the learners so that the learners can understand it much easier. She advised me to do sketches of Euclidean geometry theorems on the board and use different colours to highlight each angle. She also mentioned that each theorem has its own definition and a formula to solve. In terms of content [of Euclidean geometry], I can say the project played a vital role. I'm confident now to teach the Euclidean geometry and the content that I was a bit sceptical about teaching in the past. (Teacher 1)*

Teacher 13 confirmed the role of instructional coaching on knowledge and skills development.

> *The mentor did sketches to show me different ways of approaching the concepts and he showed various ways of approaching difficult concepts in the syllabus. The sketches helped me to better understand work, energy and power as a concept and the sketches summarise the concept as they are brief and clear. He mentioned that some of the concepts in science have both a definition and a formula. For example, there is a definition for work, and it has a formula. The sketches had a definition and a formula which made it easy for me to understand the concept and its application. (Teacher 13)*

Using sketches seemed to have improved teachers' PCK. Examples of this technique are given by Teacher 1 and Teacher 13 in the quotes above. This finding support Ragins and Kram's (2007) view that mentor use coaching activity to suggest strategies mentees can implement to meet their work objectives. Instructional coaching was found to be rather topic specific ("the sketches helped me to better understand work, energy and power" and "she has shown me the method of summarising the topic [Euclidean geometry]"). Coaching has been used to assist teachers to implement new instructional strategies and to implement new curriculum developments (Desimone & Pak, 2017). Topic-specific instructional coaching could be done in the curriculum areas teachers need the professional development for. The participants seemed to have enhanced their content knowledge and developed unique knowledge for teaching these concepts. Teacher 1's

response seems to suggest that the participant lacked confidence for teaching Euclidean geometry prior participating in the SPP, and mentors' instructional coaching improved teachers' self-assurance ("I'm confident now to teach the Euclidean geometry"). This finding is consistent with the literature. For example, Anwar (2014) and Munir and Amin (2018) argues that mentoring has a positive impact on teacher confidence as mentors can act as a guide to instil confidence while mentoring teachers.

The data suggest that mentoring teachers in their own classrooms enabled mentors and teachers to discuss and engage in activities on specific subject-knowledge matter ("he mentioned that some of the concepts in science have both definition and a formula"). This suggests that a professional dialogue between mentors and teachers allowed for a deep engagement in subject knowledge matter. This concurs with Desimone and Pak (2017), who report that coaching allows the mentor and the teacher to engage intensely in subject-matter content, which may be directed to classroom pedagogical approaches and student understanding. The statement by Teacher 1 shows that mentors were expected to have better subject-matter knowledge, and could help to refine teachers' pedagogical content expertise ("she also mentioned that each theorem has a definition and a formula").

The findings on instructional coaching suggest that teachers transformed the core concepts of Euclidean geometry and work, energy and power into versions that are teachable (Mavhunga & Rollnick, 2013; Ndlovu, 2011a). Professional development that enhances knowledge and skills of mathematics and sciences teachers does not have to be uniform, as teachers indicated having different professional development needs, as shown by the participants' responses ("Euclidean geometry" and "work, energy, and power"). Coaching teachers in their own settings is, therefore, a unique practice that considers the individual needs of teachers and how those needs should be addressed (Mokhele, 2014).

Additionally, teachers report that instructional coaching did not only focus on content, but also on curriculum management tasks. Data analysis shows that classroom-embedded coaching assisted teachers to align their teaching with stated completion dates of teaching, and to complete certain sections of the curriculum within the required time. It

was essential for helping teachers to manage curriculum changes that could be proposed during the academic year. Responses about the curriculum management are as follows:

> *The project did contribute because I remember the first two months, I was a little bit slow in terms of curriculum coverage. I was a little bit slow in terms of connecting the content, but the mentor taught me how to cover the curriculum within the stated time frames. (Teacher 2)*

> *Whenever there is anything new or any curriculum changes, they [mentor] would come and inform me about the changes, how I should approach and manage the changes. (Teacher 5)*

When teachers have a developmental need related to managerial tasks, instructional coaching does not have to be grounded in content delivery only. Rather, instructional coaching may also be used to develop management skills, such as curriculum management strategies ("I was a little bit slow in terms of connecting the content") and by connecting the content with the required completion timeframes. This suggests that, when the mentor realises a teacher is struggling to complete the curriculum within a specified timeframe, a mentor's instructional coaching on curriculum management helped the teacher cope with curriculum delivery. Thus, teacher dependency on the mentor can be seen in which specific curriculum management strategies that mentors suggested for teachers to apply to meet their work objectives and align their work with curriculum completion dates ("the mentor taught me how to cover the curriculum within the stated timeframe"). This finding suggests that the professional development that occurs tends to be relatively narrowly focused, often on specific tasks or competences, which, in the case of this study, was curriculum management skills.

In addition to curriculum management skills, assessment skills were found to be essential skills that teachers developed in the mentoring relationship. Assessment skills were narrowly focused on cognitive skills that learners should have developed after completing sections of the curriculum. The development of assessment skills in this study are consistent with the literature. Bach (2019) and Bastian and Marks (2017) argues that teachers also participate in SUP to learn about assessment skills to enable them to

assess learners different thinking abilities. Participants believed that learners performed optimally when teachers assessed them on different cognitive abilities, as suggested by Teacher 7. Consistent with Chalong *et* al., (2017), instructional coaching in this study seems to improve on teachers' efficacy, it improves teachers' competency in assessment skills and teachers have a believe that this competency contribute to learner academic achievement. The development of assessment skills is essential, given that teachers are assigned authority by the provincial education department to set and administer papers, particularly in the lower FET (further education and training) grades.

> *They [mentors] were also showing us how to assess certain topics. We are now allowed by the department to set our own papers more especially in Grade 10 and 11 physical sciences. I believe the partnership has assisted me in learning how to assess learners at different cognitive abilities. (Teacher 2)*

> *She [mentor] advised that the paper [informal or formal] should address all four different cognitive level questions in science. For example, a definition question [level 1], a comprehension and application question [levels 2 and 3], and high-order question [level 4]. I have developed a better understanding of setting the assessment tasks, this skill was lacking before but now I can do this with confidence. (Teacher 8)*

> *The weekly assessments exposed learners to questions with different cognitive levels, and learners do well in provincial papers whenever I set questions that expose them to weekly assessments. (Teacher 7)*

In order to develop a deep understanding of mathematics and physics teaching, teachers should not merely acquire knowledge on central concepts and principles, but they should also develop assessment skills to evaluate student understanding of these concepts at different cognitive levels ("she advised that the paper should address all four different cognitive levels"). If teachers lack assessment skills, it poses a challenge for learners, who are not assessed correctly on critical thinking and reasoning skills ("this skill was lacking before"). This shortcoming contravenes the physical sciences CAPS document

(DBE, 2012), of which the assessment taxonomy stipulates that teachers should assess learners at all cognitive levels in all knowledge areas. Conversely, teachers' participation in the SPP shows they were assisted to develop assessment skills, as suggested by Teacher 7 ("in terms of assessment, she inducted me on how to make use of the disc to prepare weekly assessments for learners and for a specific topic"). It is interesting that the development of assessment skills through SUP mentoring brought about self-belief in Teacher 8 about assessing learners at different cognitive levels ("I can do this with confidence").

In this section, data analysis showed that teachers developed content and pedagogical knowledge, PCK, curriculum management skills, and assessment skills through instructional coaching. The findings corroborate the literature, which reports that SUPs enhance content knowledge and provide teachers with a variety of instructional strategies worthy of practice in lessons (Fricke, 2008; Mokhele, 2014; Ndlovu, 2011b).

The next section will discuss the psychosocial functions of mentoring relationships.

5.3.2 Classroom observations

Role modelling refers to the ability of a mentor to express their attitudes and values through exemplary behaviour (Ragins & Kram, 2007). Kram (1983) revealed that role modelling is a psychosocial function, while Weinberg (2019) extended that observation, emulation, and co-teaching are role modelling activities. It was essential to find out how role modelling was used by mentors to develop the knowledge and skills in mathematics and science.

Classroom observation was found to be one of the activities that mentors used to develop content and pedagogical knowledge of teachers (Nel & Luneta, 2017). When teachers observe mentors while mentors engage in classroom presentation, it could contribute to the development of instructional strategies teachers can implement in their own teaching.

> *I was observing in the presence of learners, and it was so interesting because we tend to realise different methods or approaches particularly on Euclidean geometry. (Teacher 1)*

> *The mentor will sometimes present for me, and I observe them, and in that way, I develop my professional teaching skills. (Teacher 5)*

Observing a mentor presenting a lesson stimulates teachers' ideas about classroom teaching ("it was so interesting"), which gives teacher an opportunity to learn, develop, or enhance their existing instructional strategies from someone else's perspective. Teacher 1 had a positive experience of observing a mentor as this practice exposure them to different instructional strategies that could be used for Euclidean geometry. Through classroom observation, teachers gain insights into other ways of teaching that could be enacted, particularly for challenging concepts ("we tend to realise different methods"). This suggests that teachers assimilate alternative instructional strategies and gain different perspectives on teaching, which enhance their sense of competence. Weinberg (2019) have noted that observation as one of role modelling activities assist mentees to learn from an individual who demonstrates archetypal knowledge and skills. Mentees can acquire the knowledge and skills for their own benefit and to enact them independently in their own practice.

Data analysis shows that mentors also had the opportunity to observe how teachers enacted lessons. Mentors possibly did this to identify teachers' content knowledge gaps or to identify misconceptions teachers had about mathematics and science. It was found that classroom observation was by mentors to evaluate how teachers present concepts that are challenging. Classroom observation brought to the fore content knowledge gaps or misconceptions teachers had, and lead to a professional dialogue to address the knowledge gaps or a misconceptions.

> *He observed how I was coping especially in areas I highlighted as problematic. He would observe me and when he did that, he identified some of the sub concepts I needed to improve. (Teacher 13)*

In a related vein, Teacher 11 explicitly mentioned that

> *The mentor was visiting me in the classroom to observe, while she was in the classroom, we used to engage in a dialogue on what I am teaching,*

and she intervened to share some of the teaching skills that I can use in my teaching. (Teacher 11)

From these reports, it can be concluded that observing teachers while they presented lessons gave mentors the opportunity to identify teachers' individual needs. This finding concurs with Nel and Luneta (2017), who report that lesson observations enable mentors to identify individual needs of teachers, and to offer immediate support to address the needs. Ndlovu (2011b) explains that, through school visits, teachers' individual needs for support with content and innovative pedagogy can be identified. It seems reasonable to speculate that the mentor's intervention in the case of Teacher 11 could have been triggered by an urgent need to address a pedagogical or content gap, or to correct a misconception demonstrated by the teacher. This could explain why engagement in professional dialogue was deemed necessary to address the gap or misconception.

5.3.3 Feedback discussions

Having a feedback discussion after classroom observation was found to improve teachers' content knowledge (Nel & Luneta, 2017). Mentors provided reflective feedback in a discussion about what had transpired during classroom observations. After lesson observations, mentors shared instructional strategies that could be enacted during lesson presentation. Teacher 3 said that feedback in teaching brought about positive feelings – feedback is rare when teachers work in isolation.

He [mentor] provided his criticism … but this was done privately not in front of learner s… he gave me advice as to how I could have tackled the lesson. (Teacher 13)

It developed my content knowledge, because after the lesson we had a one-on-one session with the mentor and then we discuss, she showed me where I'm lacking. (Teacher 5)

Teacher 3 had a more encompassing view on having feedback discussions:

> *I always felt better every time she was here because it is very rare to get feedback in education, when you get the feedback from a mentor it's a good thing. Sometimes you continue teaching whereas you miss something that is very important, and you are not definitely aware (Teacher 3)*

The data from the participant demonstrates that the mentoring that in-service teachers received in the SUP enabled mentors to provide them with constructive feedback on how they could improve their teaching. This suggests that mentoring is not necessarily a linear process, but gives mentors the opportunity to critique teachers' work through a professional dialogue. In section 3.4.2.2, it was noted that mentors challenge teachers' work as they critique teachers' work following classroom observations (Kroll, 2017). Challenging teachers' work through constructive criticism provoke reflective learning and discourage taken-for-granted inactiveness (Ragins & Kram, 2007).

Constructive feedback after lesson observation is informative and educational, as mentors give teachers a different perspective on their practice, as noticed by an observer ("he gave me advice as to how I could have tackled the lesson"); this feedback is rare when teachers work in isolation. It also shows that a misconception or content or pedagogical knowledge gap can be addressed after observation, while the content of the lesson is still fresh ("Sometimes you continue teaching whereas you miss something that is very important, and you are not definitely aware"). Introducing mentoring at schools enables teachers and mentors to discuss and reflect on the experiences of classroom enactment, so that teachers can improve their teaching practice (Luneta, 2012; Sibanda & Jawahar, 2012). Data shows that constructive feedback discussions took place in a conducive environment that could promote teacher learning ("this was done privately not in front of learners").

In summary, this section reports that instructional coaching, classroom observation, and reflective discussion contributed to the development of teachers' content knowledge (Kroll, 2017; Nel & Luneta, 2017). Through instructional coaching by mentors, teachers developed content knowledge and various instructional strategies. Classroom observation, during which teachers observed their mentors present lessons, contributed

to the development of instructional strategies. It was essential for mentors to observe teachers, in order to identify content or pedagogical gaps and misconceptions. Reflection discussions seem to have promoted teachers' communication skills.

The research findings emerging from the discussion about the initiation and cultivation phases indicate that mathematics and physical/natural sciences teachers who participated in the SPP expanded their communication skills through professional dialogue. Having established the type of the knowledge and skills that teachers acquired in the SPP, it was essential to evaluate the extent to which such knowledge and skills were implementable in classroom discourse. Therefore, Section 5.4 will discuss the separation phase, and report on teacher autonomy in the implementation process.

5.4 SEPARATION AND REDEFINITION PHASE

The separation phase is a period in which the mentoring process is formally terminated, and the mentor–teacher relationship ceases to exist (Erdem and Omuris, 2014; Kram, 1983). The stage inevitably obliges teachers to become autonomous of their mentors and continue with their daily teaching repertoires independently. In this study, the investigation into the separation phase focused mainly on the actions, patterns and behaviours of, and decisions teachers took to implement acquired knowledge and skills in their daily teaching practice. The evidence provided by the participants on the implementation of knowledge and skills seems to revolve around two essential components, namely, the use of provisioned curriculum resources, and implementation of the acquired knowledge and skills. These key components seem to concur with use of resources, knowledge and skills, as reported on by the literature (Nel & Luneta, 2012; Ndlovu, 2011b; Wang & Wong, 2019).

In this section, the empirical data that report on teachers' perspectives relate to achieving the second, third, and fourth research objectives of this study. Having listened to teachers in various schools, and by adding my own knowledge and experience of the partnership, I can now sketch the outlines of how teachers, at the time of this study, used curriculum resources and implemented the acquired knowledge and the skills independently. In the context of this study, the crux of the problem I sought to understand involved gaining a

clear understanding of how teachers implemented the knowledge and skills they acquired from the partnership. The separation phase reinforces teachers' professional autonomy, which allows teachers to own and administer their own teaching, without the immediate support of their mentors.

5.4.1 Experiences of teachers in the integration of curriculum resources

Termination of mentoring relationship between teachers and mentor implies that teachers suddenly establish autonomy and function independently of their mentors (Fagenson, 1992; Ragins & Kram, 2007). In this study, autonomy implies that teachers use the resources and implement the acquired knowledge and skills independently.

Teachers indicated that mentors provisioned curriculum resources, such as CDs, IBP videos, and content notes. It was essential to ascertain to what degree teachers continued to use the provisioned resources in classrooms once the formal mentorship relationship had ended. Data analysis shows that participation in mentoring by university academics exposed teachers to curriculum resources that teachers could integrate in their own teaching (Wang & Wong, 2019). The integration of curriculum in lesson preparation and presentation indicates that teachers established their autonomy.

Teacher 3 and Teacher 4 reported on establishment of autonomy as evidenced by integrating curriculum resources independently during classroom teaching and learning.

> *The disc contains content notes that I can integrate in my classroom. Each topic has its own folder in the disc, and I often use the notes for lesson planning and actual teaching in physical science. Mostly I use the content notes for teaching purposes. The notes have changed my style of planning and teaching, because initially I solely relied on the textbook. The notes go deeper on the content, and it became easy for learners to understand concepts when I am using the resources. (Teacher 4)*

At School A, Teacher 3 recalled when the mentor conducted a school visit to support the teacher and found them engaged in the classroom using provisioned SPP curriculum resources. The participant explained:

> *She came to class and found me using her learning material, and she was satisfied. Her learning material simplified teaching of natural sciences in the school and learners also find them useful as they can study using the notes without a textbook. (Teacher 3)*

Data provided by Teachers 3 and 4 suggest that SPP mentors were successful in promoting teacher autonomy in relation to the integration of curriculum resources. Mockler (2013) and Wang and Zhang (2014) agree that the role of SUP is not the of dependence, but one which should promote teacher autonomy and responsibility. The findings of this study seem to corroborate this notion. The findings of this study suggests that teachers found the teaching and learning material useful, hence, they integrated them in their teaching ("she came to class and found me using her learning material"). This study found that curriculum resources are the instruments of change in classroom teaching, particularly when teachers use only a single resource to prepare and present a lesson ("initially I solely relied on the textbook"). The finding suggests that university academics could have generated curriculum resources that will help teachers with lesson preparation and presentation. The data suggest that the provisioned learning material promoted learner-centred approaches, as the learners used the material independently to construct their own learning ("learners also find them useful as they can study on their own").

At School D, Teacher 7 explained that integrating resources was done by projecting SPP curriculum resources, especially those on Euclidean geometry. The quote of the participant is accompanied by a picture (Figure 5.1) that depicts the teacher in action. They expressed their views as follows:

> *In terms of teaching, the CD is valuable because it has what the teacher needs to teach mathematics in the classroom. I'd use the CD to project problems on Euclidean geometry while I'm also discussing and solving a given problem on the board. This action gets the attention of learners and I'd use a questioning method to find out if learners can solve a given problem before explaining it on the board. (Teacher 7)*

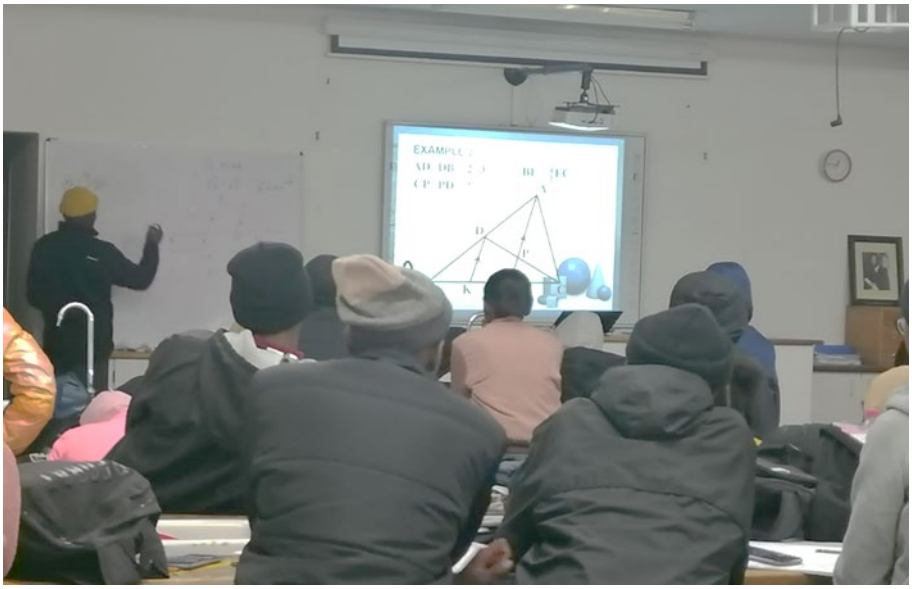

Figure 5.1: Demonstration of mathematics teacher integrating teaching resources provided by the SPP in the classroom

Anderson *et al.* (2015) report that teachers who participated in professional development expressed appreciation for the infusion of resources provided by the university in their classrooms – as was the case in this study. Teacher 7 seems to suggest that projecting a problem on a screen gets learners' attention. Additionally, data shows that the infusion of curriculum resources stimulated teaching approaches in the classroom that are learner-centred ("I'd use a questioning method to find out if learners can solve a given problem"). This approach enabled the teacher to explore learners' prior knowledge on Euclidean geometry, which could trigger the action that the teacher needs to take to teach the lesson. The data suggest that integration of curriculum resources depended on the availability of the resources at School D. It is only when school infrastructure and ICT resources are available that teacher can implement what they gain in SUP (John, 2019; Khumalo & Mji, 2014). This implies that integration of curriculum resources occur within a complex web of subsystems that fluidly interact with each other (Ettekal & Mahoney, 2017).

There was consensus among teachers regarding the CDs and their influence on lesson preparation. For example, Teacher 7 and Teacher 6 reported that their lesson preparation

in mathematics and science was impacted by the resources they received from the mentors. In reference to slides as a resource that helped in lesson preparation and presentation, Teacher 7 said

> *Sometimes I use PowerPoint slides that are in the disc to prepare and present my lessons (Teacher 7).*

At School C, Teacher 6 said

> *I went through the notes in the disc and realised that mentors summarised most of the topics in PowerPoint slides for physical sciences Grade 11 and 12. For each topic, the learning objectives are stated, the content in the slide is well structured and include class activities for learners and memorandum for remedial. In topics such as stoichiometry, which is sometimes difficult for learners to understand, there is a PowerPoint slide that easily explain the concept in detail with good examples and I often use the same slide to teach stoichiometry in both Grade 11 and 12. (Teacher 6)*

Teacher 15 said

> *Whenever I plan the lessons, I refer to the disc and use the content notes to plan how the concept will be introduced and what learners should know by the end of the lesson. If I teach momentum, learners should know how to define momentum and know which formula we use to calculate momentum and should do basic calculation on momentum. I don't only use one method of teaching because of the availability of resources I have. (Teacher 15, focus group discussion)*

The excerpts suggest that teachers relied on curriculum resources to plan and present their lessons. Although the curriculum resources were prepared by mentors independently of the teachers, difficult concepts have ready-to-use slides that expose learners to the depth of stoichiometry ("a PowerPoint slide that easily explain the concept in detail with good examples"). The introduction of new curriculum resources provided an alternative source of teaching ideas that were integrated in lesson preparation and

presentation. This study found that lesson planning in which teachers set goals (learning objectives) and selected tasks aligned with those goals was impacted by the provisioned teaching resources, as suggested by Teacher 15.

The findings of this study are similar to those reported by Acquah, Adzifome and Afful-Broni (2013), who found in their study that, after mathematics and science teachers had undertaken a professional development programme, they integrated curriculum material to prepare for lessons. The incorporation of a ready-to-use set of curriculum resources that are product-oriented assisted teachers with lesson preparation, which concurs with the findings of Xu (2016). Teacher 15 indicated that they incorporated multiple teaching approaches in their classroom, as a result of having abundant teaching resources available ("I don't only use one method of teaching because of the availability of resources I have").

Data analysis suggests that the curriculum resources teachers were provided with contained previous examination papers. This study found that teachers integrated previous examination papers in their teaching for two main reasons. In the first instance, teachers believed that exposing learners to previous papers enables learners to develop a variety of cognitive skills, such as interpretation skills. Teacher 4 seemed to suggest that previous papers reinforce the development of various cognitive skills in learners. Secondly, the data suggests that previous question papers served as a tool to promote learners' academic performance.

> *During lessons, I always start with teaching the content and afterwards I expose learners to different scenarios by using different question papers from Free State, national papers and from other provinces, such as Gauteng and Western Cape. When I use the papers, I allow learners to read a given scenario, interpret it, identify given information, and ask them to identify an unknown variable. Exposing learners to this type of teaching makes it easy for learners to understand scenarios, interpret them, and easily solve problems. (Teacher 4)*

In a focus group discussion, Teacher 13 expressed similar views and expresselIf as follows:

> *I would advise teachers, especially teachers that were not part of the project, to adopt a strategy of using previous question papers to prepare learners for school-based assessment. This is because learners are judged based on how they perform. Now that the resources we shared with university mentors are part of the Free State curriculum, I would advise teachers to use these important resources. There are different problems in a single topic in these resources that expose learners to the content they need to learn, and learners often do well when exposed to frequent writing. (Teacher 13, focus group discussion)*

When teachers integrate previous examination papers in their teaching, they tend to promote comprehension, identification, and interpretation skills that learners should develop ("I allow learners to read a given scenario, interpret it, identify given information, and ask them to identify an unknown variable"). This suggests that integration of previous question papers stimulates problem-solving skills in learners. Learners are more likely to perform well on school-based assessment tasks when they are exposed to frequent writing. Teachers 13 emphasised integrating previous question papers to promote learners' academic performance ("learners often do well when exposed to frequent writing"). The findings suggest the presence of an interplay between the integration of curriculum resources and teachers' self-efficacy. In this instance, the participant had a belief that they could impact on student learning by integrating previous examination papers, to prepare learners for school-based assessment tasks. In this study, teachers' belief in their ability to impact on student learning coincides with literature on teacher self-efficacy (Ndlovu, 2011b; Trent, 2014; Trent & Lim, 2010).

Regarding cognitive skills, participants highlighted the usefulness of using previous examination papers to develop various cognitive skills in learners. This study found that teachers appreciated the resources, as they assisted learners to develop the cognitive skills required by the assessment taxonomy enshrined in CAPS documents:

Each term we are required to administer a formal test or examination. Before learners can write the formal test or examination, I do hand out copies of previous question papers and organise them according to the topics. Learners would write two to three different papers as in like they are in an examination centre. This practice exposes learners to different styles of solving problems in the same topic, one topic has multiple terms that learners should know how to define, and the previous question papers assist learners in that regard. Generally, the previous questions papers expose learners to various cognitive skills. (Teacher 8)

A participant in a focus group discussion added the following:

In physical science we have four cognitive levels, and for me personally I think the most important levels are cognitive level 1 and 2. In level 1, learners must remember what I taught them in class when they solve problems, and in level 2, they must understand the given statement by interpreting and translating what I taught in the classroom. (Teacher 4, focus group discussion)

Other participants expressed similar views:

I second Teacher 13, because when a teacher uses previous question papers, they cover all four cognitive level questions that learners should develop in physical sciences. Each question in the paper has a definition which is a cognitive level 1 question, a level 2 question which is about understanding of the topic, calculations is level 3, and level 4 is more complex questions. (Teacher 16, focus group discussion)

Even in mathematics our teaching is based on helping learners to achieve four cognitive levels. After teaching learners what they need to know in a topic, I make copies of certain question papers to cover the curriculum areas presented in the class (Teacher 17, focus group discussion)

Data analysis implies that one of the reasons for using previous papers is to prepare learners for formal assessment tasks, as suggested by Teacher 8 (“Before learners can write the formal test or examination, I do hand out copies of previous question papers”). Although the formal task will differ from that in previous questions papers, data suggests that using old examination papers gives learners a variety of ways to approach problem-solving questions (“This practice exposes learners to different styles of solving problems in the same topic”). Without disregarding cognitive levels 3 and 4, Teacher 4 believed that it is essential to emphasise cognitive levels 1 and 2 questions, as they are about comprehension and interpretation. Teacher 4’s response indicates that working through previous examination papers enables learners to recall, remember and restate facts and other learned information. However, it is the responsibility of teachers to expose learners to questions that address all the different cognitive skills without being selective about which cognitive levels matter more (“when a teacher uses previous question papers, they cover all four cognitive level questions”). This could ensure that learners are able to develop the necessary skills for learning mathematics and science. Learners should be able to grasp the meaning of information by interpreting and translating what has been learned, apply the knowledge and the skills, and solve complex problems.

This study found that teachers integrated prerecorded videos (IBP) in their teaching. Data suggest that the prerecorded videos at the concerned university were a source of content knowledge that teachers could learn from to develop a better understanding of the concepts. It was indicated by teachers that not only do videos contain abundant content knowledge, but they also provided different instructional knowledge as far as mathematics and science were concerned.

> *I have some of the IBP videos to watch [and] to demonstrate how I can deliver the content. (Teacher 11)*

> *IBP videos contains content knowledge because you watch and listen to a subject advisor or experienced teacher deliver the content and, in the process, you learn different teaching strategies. (Teacher 8)*

By using prerecorded IBP videos, data analysis suggests, teachers enhanced their content knowledge ("IBP videos contains content knowledge because you watch and listen to a subject advisor or experienced teacher deliver the content"); and they acquired a variety of different instructional strategies. Regarding pedagogical strategies, integrating prerecorded IBP videos exposed teachers to alternative pedagogical strategies for teaching, which they can demonstrate independently ("I have some of the IBP videos to watch [and] to demonstrate how I can deliver the content").

The findings show that university academics promoted technology integration in the teaching of mathematics and science by providing prerecorded IBP videos. In the case of this study, integrating technological resources was supported and encouraged by the school management team.

> *I use the overhead projector and the laptop provided to allow learners to watch how other experts are teaching mathematics. I used to stop the video and explain what the expert is saying. (Teacher 14)*

> *My HOD [head of department] has recommended that we let learners watch IBP videos we got from university mentors. The videos assist learners with understanding the content, so they learn the content by watching the videos with me and on their own. (Teacher 8)*

These quotes reflect the ability of teachers to integrate technological resources independently of their mentors ("I use the overhead projector and the laptop provided"). This suggests that teachers have background knowledge of integrating technology in their teaching. The school management team seems to have played a managerial role by encouraging teachers to use the university's resources in their classrooms ("My HOD has recommended that we let learners watch IBP videos"). This indicates that key stakeholders at schools promote the integration of technological resources for teaching mathematics and science. While using IBP videos, Teacher 14 seemed to suggest that they emphasise what the presenter is teaching by using play and stop modes ("I used to stop the video and explain what the expert is saying"). Using available resources for

teaching contributes to learners' understanding of the concepts ("The videos assist learners with understanding the content").

Teacher 8 felt the need to share the resources with learners because they believed that learners would watch videos. Teacher 8 expounded further:

> *I have shared the IBP videos with learners at my school so that they can watch the videos on their own, either here at school or at their homes. The video makes my work easy because learners listen to someone different and when I teach the topic again, at least they have a background knowledge of the topic. (Teacher 8)*

Sharing IBP videos does not guarantee that learners can use the resources on their own. Learners in different rural settings do not necessarily have access to technological material, such as smartphones or laptops, to watch videos on their own. However, sharing prerecorded IBP videos could be essential for learners who have access to smartphones or laptops at home, and could provide the advantage of learning on their own. Data implies that Teacher 8 shared some of the IBP videos with learners prior to introducing the topic, to enable learners to learn on their own ("learners listen to someone different and when I teach the topic again, at least they have a background knowledge of the topic"). When teachers share resources with learners, they promote a learner-centred teaching approach that gives learners the opportunity to learn the content on their own. This finding suggests that, if learners experience content challenges, they have adequate time to undertake enquiry with their teachers during classroom teaching.

Data suggest that IBP videos are not only used for teaching purposes, as they address a variety of activities that include teaching, assessment and feedback, as explained by a participant.

> *In some of the topics, the presenter [in IBP videos] often teach the content first and allow learners to write a small assessment based on the topic. After maybe five minutes, the presenter does a remedial work and give learners approaches to how the answers were solved. (Teacher 2)*

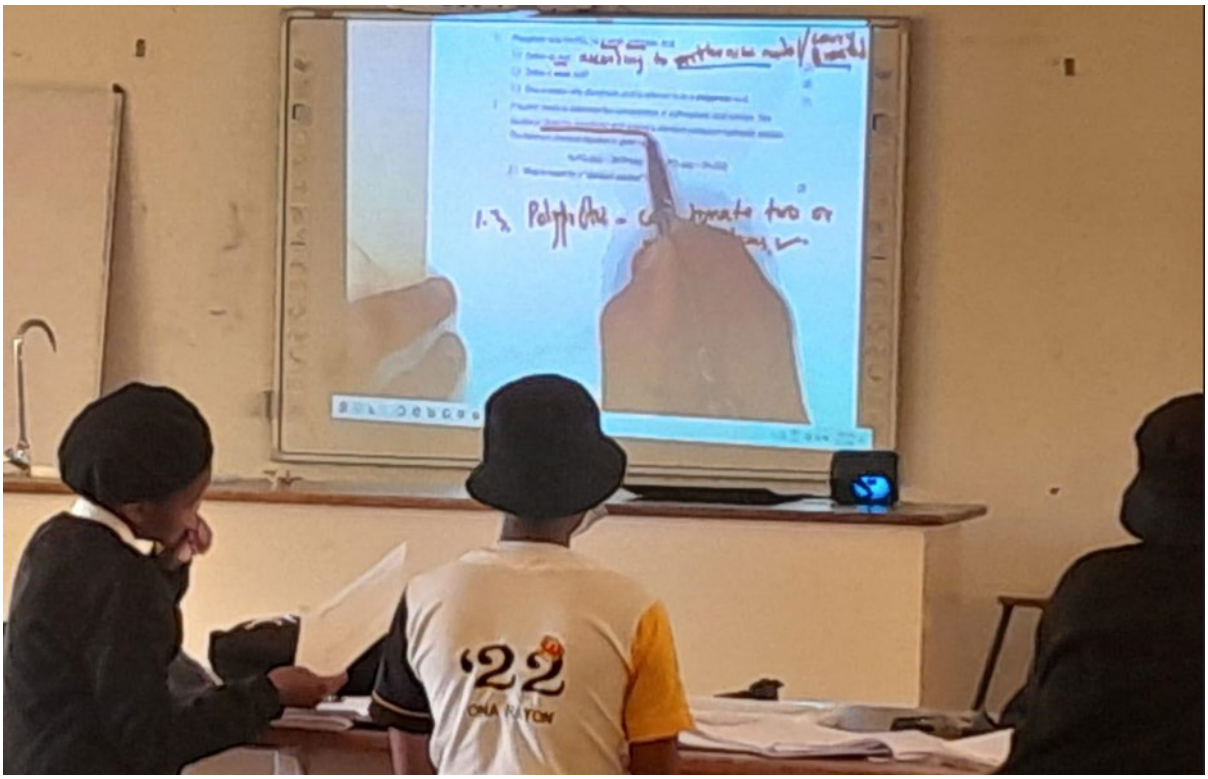

Figure 5.2: A teacher incorporating IBP videos in classroom teaching

The advantage of using of IBP videos is that it teaches learners the content, assesses their understanding of the content and provides feedback on the assessments. This indicates that IBP videos gave learners background knowledge, as they dwelled deeply on the content, as illustrated by the quote above and Figure 5.2 (“teach the content first”). Also, the videos gave learners an opportunity to write an assessment task to evaluate if they understood the presented concept, after which feedback was provided.

However, there is a risk of overreliance on IBP videos. Teachers might possibly rely on the IBP videos to avoid presenting a contact session with learners, especially if teachers find the videos beneficial for students’ academic performance. It is essential that teachers avoid relying on these resources only; instead, they should integrate videos with face-to-face interaction, to make learning meaningful.

5.4.2 Experiences of teachers in the implementation process

The discussion in Section 5.2.1 was predominantly on the use of teaching and learning resources provided by mentors, who enabled teachers to own the resources. That discussion was centred on the implementation of the knowledge and the skills by teachers who had experienced the SUP with colleagues, learners, and preservice teachers. Data analysis of transcripts of participants' contributions revealed three typologies of the knowledge and skills that teachers were implementing in schools:

- Pedagogical content knowledge;
- Communication skills; and
- Technology integration.

The next subsections will briefly explain the typologies.

5.4.2.1 Pedagogical content knowledge

Analysis of the data shows that teachers implemented the acquired PCK independently by emulating their mentors. In Section 5.3.1, data analysis reported that mentors advised teachers to define a concept and its related formula in mathematics and science. In Section 5.4.2.1, data seems to suggest that mentors imparted their PCK and expertise and encouraged teachers to emulate this knowledge as worthy of practice, as expressed in the following excerpts.

> *I often make use of sketches on Euclidean geometry and sketch the theorem I need to explain. Before solving the problem, I define the theorem and write down its related formula. When solving complex problems on Euclidean geometry, I make use of different coloured chalks to highlight each theorem. I also advise learners to use different colours. (Teacher 1)*

> *In my teaching, I explain the definition and write down its formula as instructed by the mentor. The aim is to connect the definition with the correct formula. In this way, learners can understand the application of the formula from the definition. (Teacher 13)*

To explain how the acquired PCK is implemented in the classroom, Teacher 14 expanded that

> *I am using the teaching strategies that I learnt through watching IBP videos. Whenever I teach Euclidean geometry, I make sure that I stick to what I learnt from both the mentor and IBP videos. It has simplified the way I plan my lesson as well as my teaching strategies. (Teacher 14)*

Data suggest that, while teachers emulated their acquired PCK ("I am using the teaching strategies that I learnt through watching IBP videos"), they inevitably aligned this with the cognitive skills that learners need to develop ("I define the theorem and write down its related formula"). This suggests that implementing mentors' instructional strategies enabled teachers to improve the cognitive development skills of their learners. However, this does not imply that teachers have necessarily been successful in developing the cognitive skills of their learners – it shows they have been successful in emulating the acquired PCK. In this complex integration, the aim seems to have been to ensure that learners understand difficult concepts such as Euclidean geometry ("learners can understand the application of the formula from the definition"). The acquired PCK promotes problem-solving skills, as teachers integrate the definition of a concept with its formula, which might assist learners to apply the formula when they solve problems ("learners can understand the application of the formula from the definition").

This study found that teachers also emulated the acquired PCK by sharing instructional strategies with other teachers, which they expressed as follows.

> *I'm a sharing the knowledge and skills I developed from the mentor; I share the approaches with other teachers during workshops. I give teaching advices on Euclidean geometry and share best teaching strategies to teach the concept. In most cases, teachers are interested in these approaches. (Teacher 1)*

> *There is a mathematics cluster where we regularly meet to compile assessment tasks, discuss the memorandum for provincial and national papers. I'm trusted with leading the cluster since I always produce quality*

Grade 12 results. In most cases I share teaching tips with my colleagues and more especially in topics such as Euclidean geometry and other related topics. I should acknowledge the mentor [who] showed different strategies to teach mathematics since she was experienced. I have shared some of the strategies with my colleagues in the cluster. (Teacher 7)

Analysis of data seems to suggest that teachers have realised the usefulness of mentors' instructional strategies, particularly for Euclidean geometry. Data also suggest that workshops and clusters serve as CPD for teachers, and provide opportunities for teachers to exchange ideas on content-related matters ("I give teaching advice on Euclidean geometry and share best teaching strategies to teach the concept"). The benefit of contextualised workshops is the ability to include opportunities, such as participation in professional sharing and dialogue. This finding suggests that teachers might have been successful in implementing the approaches in their own classrooms, hence, they shared the knowledge with their colleagues. Teachers emulated their mentors in contextualised professional development that took the method of workshops or cluster meetings ("I should acknowledge the mentor [who] showed different strategies to teach mathematics").

5.4.2.2 Communication skills

In the discussion in Section 5.4.2.1, teachers professionally shared the knowledge and skills developed though mentoring, which shows that they expanded their social and interpersonal skills through professional knowledge sharing. From classroom observations, teachers expanded their social and interpersonal skills by engaging in activities such as feedback discussions. The findings seem to suggest that teachers expanded their social and interpersonal skills by conveying the knowledge and skills they had acquired to their peers and other immediate education stakeholders, as expressed in the following quote.

I often interact with teachers in start-up workshops or memo discussions about curriculum matters. The dialogue assist teachers in their learning

> *process about how to communicate teaching strategies in different ways. So, the discussion, which is about communication I once shared with the mentor, is now being implemented in a different situation, between me and other teachers. (Teacher 16)*

Data analysis seems to suggest that teacher workshops, cluster meetings, or memo discussions became centres for teachers to convey and expand on their acquired communication skills. Teachers willingly shared PCK through a professional dialogue, this could suggest that teachers used communication skills to share the acquired PCK. The professional sharing of instructional strategies is important for teachers, so that they can refine their knowledge and skills ("The dialogue assist teachers in their learning process"), particularly for teachers who were not part of the SPP.

The empirical data show that some of the participants were encouraged by their mentors to form teacher–teacher collaborations. It seems reasonable to speculate that a teacher–teacher collaboration was encouraged so that teachers could learn from each other and improve the learners' academic performance.

> *He [mentor] encouraged me to collaborate with the teacher at Senakangwedi to teach learners from both schools. This collaboration was done from the start of 2012 and even today it is still taking place. I have improved on my teaching strategies because we tend to learn something new when another teacher is presenting a lesson while you are obser152ythagornd afterwards we engage in a discussion to share experiences. (Teacher 13)*

Teacher 13 seems to suggest that their mentor promoted teacher–teacher collaboration in physical sciences ("he encouraged me to collaborate with the teacher at Senakangwedi"). The participant seems to have improved on their instructional strategies by forming a teacher–teacher collaboration ("I have improved on my teaching strategies"). When this collaboration takes place, collaborating teachers tend to observe each other, on order to acquire new instructional ideas ("we tend to learn something new when another teacher is presenting"). This suggest that teacher–teacher collaboration

enhanced the instructional skills of Teacher 13, and it could also potentially enhance their practice. The findings indicate that, in teacher–teacher collaboration, teachers could learn through observation and by reflecting on new teaching practices in their schools while, at the same time, sharing their distinct knowledge and expertise.

5.4.2.3 Technology integration in classrooms

This study found that teachers integrated technological software in their teaching. In mathematics, GeoGebra and Graph emerged as two software programs that teachers were integrating in their lessons. In physical science, ChemSketch and Crocodile Clips were the only teaching software that teachers integrated during teaching and learning.

> *When I prepare learners for class/home activity in topics such as calculus, statistics, analytical geometry, GeoGebra application is more useful which helps in the construction of diagrams and graphs for these topics. It's quite interesting because as a teacher you tend to choose your own coordinates to plot a graph or any geometry shape. From this diagram, I demonstrate to learners that they can calculate the length of line AB, BC, and AC using distance formula. (Teacher 7)*

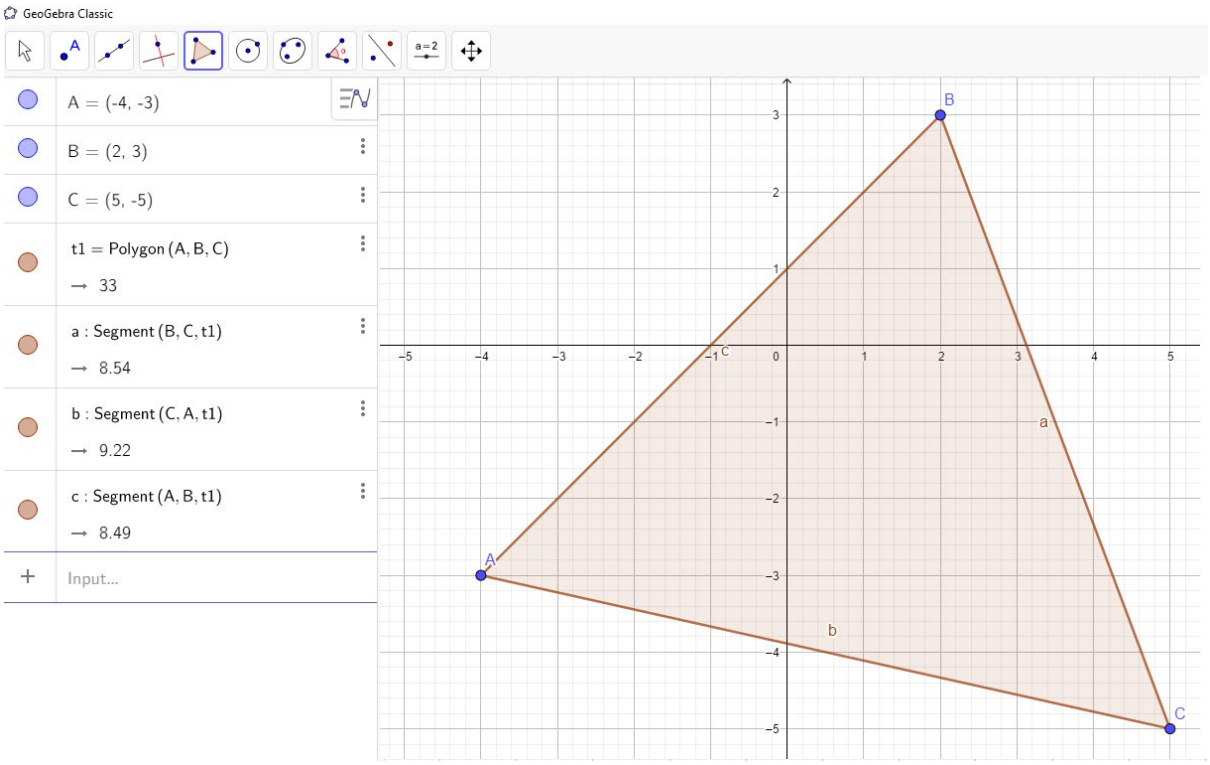

Figure 5.3: Lesson presentation of teacher using GeoGebra for mathematics

Similarly, another mathematics teacher who had been successful in integrating technology in the classroom had this to say:

> *Technology is integrated in the classroom by using Graph application, more especially in analytical geometry. I use Graph application in class to demonstrate to learners the graph of two different equations and as well as how the two lines intersect with each other. From this graph one can determine x and y intercepts and the coordinates of the point of intersection. (Teacher 17)*

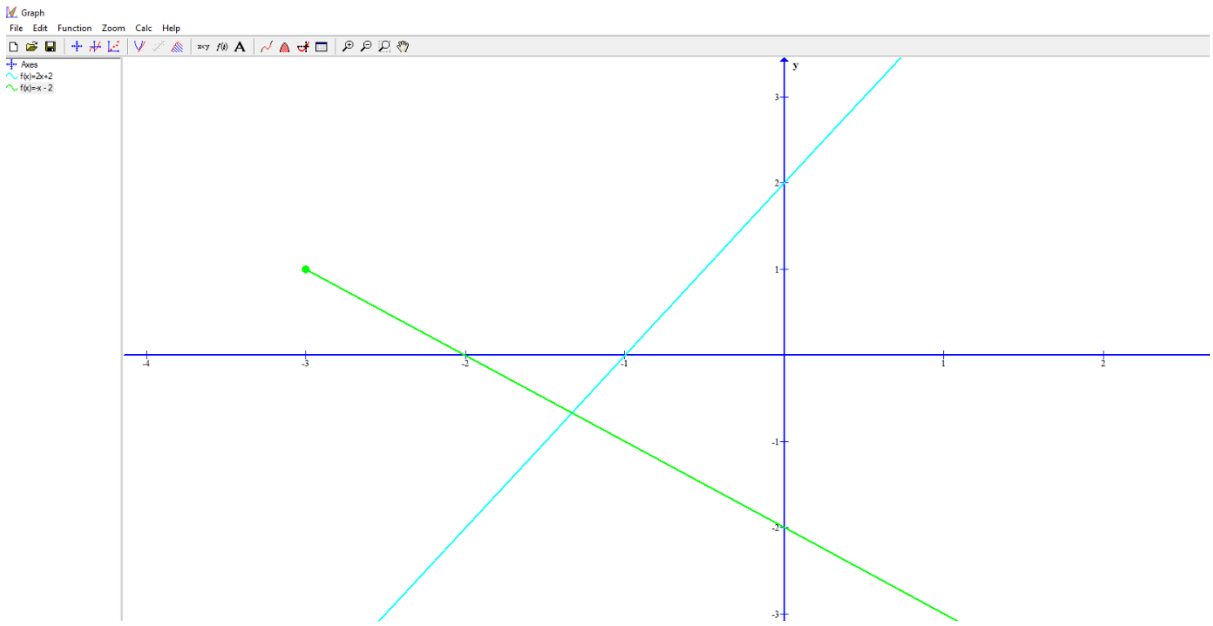

Figure 5.4: Integrating graph applications in mathematics

In physical sciences, Teacher 2 and Teacher 16 acknowledged that the CDs provided had applications such as Crocodile Clips and ChemSketch software, which are technological software teachers can use to teach topics such as electricity and magnetism and organic chemistry.

> *I integrate technology in my teaching by using Crocodile Clips for electric circuits. The application is useful, especially when planning to introduce electric circuits and for learners to know electric circuit components. The application is also important when I prepare for assessment for learners. It becomes easy for learners to understand the difference between parallel and series circuits when using the application. (Teacher 2)*

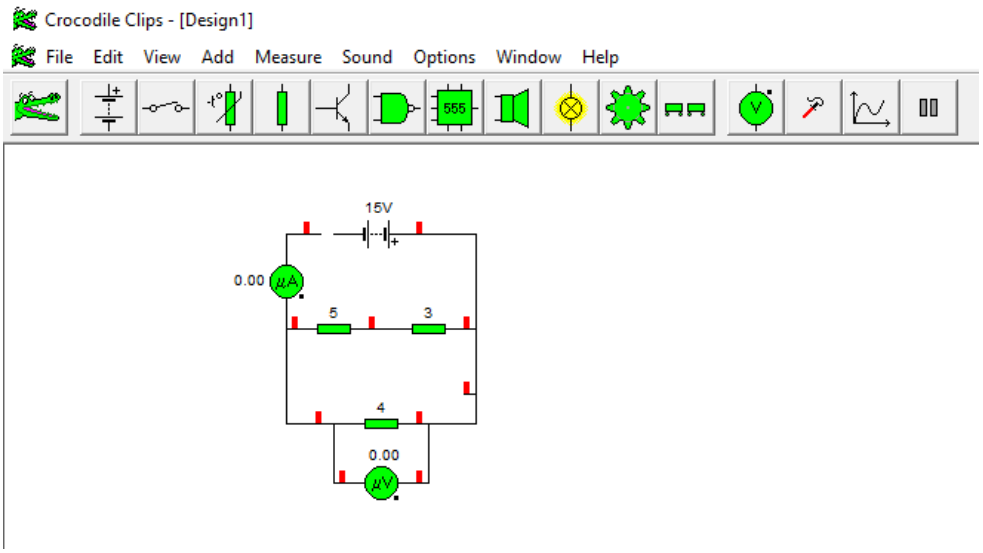

Figure 5.5: Physical sciences teacher demonstration of using Crocodile Clips for teaching electric circuits

Crocodile Clips is the software that was used by the teacher for learners to learn how to make a parallel and series circuit using software. The teacher demonstrated the ability to include the electrical components used for constructing parallel and series circuits. ChemSketch emerged as another physical sciences software that was integrated in teaching, especially in organic chemistry. Teacher 16 explained:

> *In organic chemistry, I give learners different organic compounds using ChemSketch and allow learners to provide the IUPAC name and homologous series to which the compounds belong. Using this software enable learners to visualise the number of bonds each carbon or hydrogen should have or elements such as nitrogen. (Teacher 16)*

From the extracts above I deduced that mathematics teachers demonstrated technological knowledge when they integrated GeoGebra and Graphs software. Data suggest that GeoGebra as a technological software can be used in concepts of calculus, statistics, and analytical geometry (“When I prepare learners for class/home activity in topics such as calculus, statistics, analytical geometry”). The teacher demonstrated the application of GeoGebra in analytical geometry, for which it was used to construct a

triangle with coordinates. The teacher constructs a triangle by choosing the most suitable coordinates ("you tend to choose your own coordinates to plot any geometry shape"). Data seems to suggest that the constructed geometric shape helps the teacher to show how to calculate the length of any line from a geometric shape ("I demonstrate to learners that they can calculate the length of line AB"). Data analysis seems to suggest that Teacher 17 used Graph software to focus on analytical geometry of straight lines that intersect each other. The software helped the teacher to demonstrate the *x* and *y* intercepts to learners ("from this graph one can determine the x and y intercepts").

Similarly, for physical sciences, Teacher 2 suggested that Crocodile Clips helped learners to improve their understanding of electric circuit components ("the application Iuseful ... for learners to know electric circuit components"). Teacher 2 was of the view that Crocodile Clips could also be used to prepare assessment on electric circuits, and the application could help learners to improve their understanding of parallel and series circuits ("it become easy for learners to understand parallel and series circuits"). In organic chemistry, Teacher 16 demonstrated their technological skills when they integrated ChemSketch. The software stimulated learners' understanding of different homologous series, and writing a correct name for an organic molecule ("allow learners to provide IUPAC name and homologous series to which the compounds belong").

From the above discussions, it is clear that technology integration in this study was rather topic-specific, as teachers integrated technology to teach specific concepts. In this study, I regarded this technology integration in a specific topic as technological TSPCK (TTSPCK). This is an extension of the explanation of Mavhunga and Rollnick (2013) of TSPCK; the TTSPCK in this study involves technology integration in a specific topic, to transform knowledge into concepts learners can easily understand. Technology integration in a specific topic gives a teacher the opportunity to deeply engage learners in the content by making use of technological software to ensure that learners have a better understanding of what they learn. Teachers were creative and innovative in that they did not only develop new and appropriate TTSPCK, but they also integrated the software in their instructional strategies.

5.4.2.4 Challenges experienced during implementation

The previous section delineated the successes of the implementation of the knowledge and skills acquired by teachers beyond the SPP. It detailed the instructional strategies that teachers employed while they worked independently of their university-based partners, in their own contexts. This study found that teachers experienced a variety of challenges that affected the implementation process. Data analysis shows that individual, technological, institutional, and professional development factors impeded the actual implementation of new knowledge and skills. Although teachers had developed the knowledge and skills, particularly in technology integration, these factors affected how teachers enacted teaching.

> *I have the basic technological skills, such as PowerPoint presentation and MS Word, but if I have information from the internet, I don't know how to incorporate that on my PowerPoint slide. I don't know how to incorporate animations and link online information in the presentation. Maybe if I can be exposed to a professional development that help teachers to incorporate animations and internet links on the PowerPoint presentation or maybe other colleagues from other schools could assist. (Teacher 15)*

> *In terms of computer skills, I am computer literate, and I can use MS Word, PowerPoint, and Excel. I am confident to apply these skills in mathematics, but one of the issues is to have audios or animations and interlinks on the PowerPoint slides. I lack knowledge on how to incorporate these. (Teacher 6)*

Data analysis of the above excerpts indicate that teachers had basic computer skills for using MS Word, PowerPoint and Excel ("I am computer literate, and I can use MS Word, PowerPoint, and Excel"). Although Teacher 15 and Teacher 6 had basic technological skills, lack of advanced technological knowledge seems to have been an inhibiting factor for incorporating animations and online information in their PowerPoint slides ("I don't know how to incorporate animations and link online information in the presentation"). This

suggests that the technological factor seems to have impacted successful technology integration. In addition to the technology factor, Teacher 15 seems to suggest that a professional development factor impacted technology integration ("Maybe if I can be exposed to a professional development that help teachers to incorporate animations and internet links"). Continued use of technology in teaching and learning was not the result of a single factor, but a combination of a number of factors.

Teacher 9 mentioned a personal factor as one of the factors that inhibited technology integration in teaching. In this regard, the participant said

> *I have the basic computer skills, but I hardly use them in my teaching. I am not confident enough to use technology in my teaching. But at least I can use some of the resources from the CD the mentor provided. (Teacher 9)*

Despite having the ability to integrate technology in teaching, Teacher 9 had low self-confidence regarding technology use ("I am not confident enough to use technology in my teaching"). This could suggest that Teacher 9 needed professional development to promote technology integration in teaching, and this could build their confidence in technology integration. When the teacher first experience of technology corresponds with their belief of a learning process, then they could build their self-confidence regarding technology and will integrate technology in teaching.

In data analysis the school infrastructure emerged as another factor that impacted on the integration of curriculum resources. This study found that some of the schools that participated in the project lacked computer and science laboratories. Teacher 11 said it would help if the university provided them with personal computers and projectors for teaching purposes.

> *The main purpose was that if those CDs were loaded on multiple computers and we get time to bring them [learners] to a venue showing them a way to get to the content and they do it themselves, I think that would have helped a lot, unfortunately we don't have computers to upload the CDs. (Teacher 3)*

> *If the mentor can support or the university provide [us] with a gadget such as the laptop, overhead projector, 'cause in some of the schools like us we are lacking. (Teacher 11)*

Teacher 3 seems to suggest that he was eager to load curriculum resources on school computers, but could only do so if the school had adequate resources ("unfortunately we don't have computers to upload the CDs"). Having computers would be beneficial for learners, as it would enable them to access the resources on their own to learn the content the resources offer. This study found that a lack of school infrastructure inhibited teaching approaches that are learner-centred. This suggests that teachers at these schools had to rely on traditional teaching approaches that are teacher-centred.

In addition to a shortage of computers, data analysis shows that the absence of science laboratories was another institutional factor that inhibited the implementation process. Teachers of physical science were eager to connect the theory and practice, however, a lack of laboratory equipment hindered implementation.

> *If they can try to build laboratory for us, or even if they don't build, it but if they can provide us with apparatus for prescribed experiments so that we can overcome our encountered challenges. Sometimes we have to call people from Thaba Nchu Motheo TVET College to come with apparatus so that we can conduct experiment. We are really lacking resources such as projector, laptops and they can even bring old computers from the university that we can make use of (Teacher 13).*

Teacher 2 shared that,

> *The other things if I can add is that I saw last time when they were here, we were more focused on the theory part, remember physics is theory and practical, if maybe they can bring some experiments, some equipment because some of the schools don't have, like our school we don't have the equipment for physics part, we only have equipment for chemistry part. If they can come with those and try to improve more on the practical part.*

Teacher 13 was of the view that that Department of Education in the province should strive to build laboratories ("If they can try to build laboratory for us"). However, Teacher 13 had an alternative view if building laboratories was not possible. The participant seems to suggest that the Department of Education should at least provide chemicals and equipment to conduct CAPS-prescribed experiments ("even if they don't build it but if they can provide us with apparatus"). Teacher 2 suggested that, when the university formed partnership with the school again, it should endeavour to provide the resources that can help learners connect theory with practice ("if maybe they can bring some experiments"). The participant suggested that the university should provide the resources, particularly for physics, to conduct practical experiments, because their school lacked these resources ("we don't have the equipment for physics part").

5.5 SUMMARY

In this chapter, the results that emerged from the document analysis and empirical data were presented. Since this study analysed the constructed data both deductively and inductively, some of the classifications that emerged from the data had previously been discussed in the theoretical framework Chapter 3. This chapter sought to shed light on whether teachers were implementing the new knowledge and skills beyond the SUP.

The chapter discussed the constructed categories at great length, and provided extracts from the participants' responses to elucidate the findings. In this chapter, four categories were addressed: the activities teachers and mentors engaged in that resulted in knowledge and skills acquisition; the enabling factors associated with the independent implementation of knowledge and skills; and the factors that hindered the successful application of knowledge and skills. From participants' replies, it became clear that teachers and mentors engaged in instructional coaching and role modelling, which involved classroom observations and constructive feedback. Additionally, participants indicated that mentors provisioned essential curriculum resources, such as CDs, IBP videos and content notes, to enhance teachers' PCK. Enabling factors were associated with the availability of contextual resources, such as ICT facilities, and hindering factors were associated with the lack of ICT facilities at some schools.

CHAPTER 6: FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 INTRODUCTION

The adoption of SUPs is not a new idea in CPD interventions for in-service teachers in the South African context. Teachers develop knowledge and the skills through mentoring when they socially interact with university-based partners in SUPs (Mokhele, 2014; Ndlovu, 2011b; Wang & Wong, 2019). SUP researchers have emphasised understanding the value of SUPs for in-service teachers' teaching practice while the partnership is still operational, but have not investigated the long-term effects of an SUP on mathematics and science teaching.

It is against this background that this research contends that understanding the long-term effects of an SUP can help to bring to light teachers' independence in applying and implementing the attained knowledge and skills in their classrooms. I joined this discussion at a time when SUPs aim to equip teachers with new knowledge and skills for teaching mathematics and science. This research intended to add to the professional development discourse on the experience of teachers in implementing the knowledge and skills they acquired from SUPs in South Africa. The crux of the problem is that little is known in South Africa about how teachers implement the knowledge and the skills when they are left to face implementation own their own, after their university-based partners have departed at the end of the SUP.

Therefore, the major objective of this study was to explore how teachers experienced the application of the knowledge and the skills acquired in a SUP, or SPP, in the case of this study. To realise this objective, this study sought to (i) identify the type of knowledge and skills teachers developed in the SPP; (ii) understand the experiences of teachers in implementing the acquired knowledge and skills; (iii) identify the challenges teachers experienced during the implementation; and (iv) identify conducive conditions for knowledge and skills implementation.

To attain the main objective of the study, a case study methodology was chosen, which involved 16 teachers, all of whom had experienced an SPP for mathematics and science

teachers in Thaba Nchu and Botshabelo, in the Mangaung Metropolitan Municipality of the Free State province. Data were gathered through the use of qualitative research methods and from multiple primary sources, which included in-depth interviews, focus group discussions, and document analysis. In-depth interviews with 16 teachers, and group discussions were carried out to examine and understand what teachers say and think about their own knowledge, experiences, and understanding as a result of their participation in the SPP. The document analysis examined the types of knowledge and skills teachers could develop from the project.

This study was guided by Kram's framework of mentoring, which was adopted as a theoretical framework. As discussed in Section 3.3, and reiterated here for clarity, Kram's mentoring theory was adopted since the SPP used mentoring in its approach to CPD. Kram's mentoring theory was instrumental in the analysis of the empirical data that were generated through in-depth interviews and group discussions.

The primary objective of the study was to explore how teachers implemented the knowledge and skills they had acquired through their participation in the SPP. This chapter embark with the aim and objectives of the study, which will be followed by an outline of the previous five chapters. The chapter will also present the findings, organised in accordance with the research questions and their corresponding constructs. The recommendations of the study, as well as the conclusions, will provided to indicate research gaps that this study could not address, and to suggest topics for future research in this area.

6.2 AIM OF THE STUDY

The aim of the study was to explore how teachers implemented the knowledge and the skills they had acquired from an SPP for mathematics and science in Thaba Nchu and Botshabelo. In pursuit to this aim and to answer the research question, the study sought to comprehend the experiences of teachers in relation to the implementation of knowledge and skills from the perspective of teachers' classroom practice, which can be understood by, firstly, exploring what informs such practice.

6.3 SUMMARY OF THE THESIS

Chapter 1 of this study provided background and an orientation to the study topic, as a way of presenting the study to the readership. The chapter introduced the concept of SUP and identified the research gap in the literature, which lead to the synthesis of the problem statement, primary research question, secondary research question and the aim of the study, that is, to explore how teachers independently implement the knowledge and skills they had acquired in an SPP in their classrooms. To justify the need for the study, the chapter explained the significance of the study from my reflexivity, that is, the personal experiences of a researcher in the context of this study. The chapter also described the SPP to contextualise the study. Additionally, the reader was also presented with the research methods, study design and the theoretical framework underpinnings that were used to investigate teachers' knowledge and skills implementation.

A wide range of literature was examined to position the concepts of the current study within the existing research literature, and was reported on in Chapter 2. The chapter reflected critically on SUPs globally, and in the South African context that couched this study, and forms of SUPs and teachers' development of knowledge and skills in SUPs were discussed. Mentoring as a concept pertaining to teachers' knowledge and skills development for mathematics and science teaching was discussed with a view to enhancing convergence of thought of the readership. The literature shows that, although teachers participate in SUPs to develop new content and pedagogical knowledge for CPD, little has been done to investigate teachers' experiences with the implementation of the knowledge and skills they acquired for classroom discourse.

Chapter 3 presented an outline of the theoretical frameworks underpinning this study. To understand how teachers developed knowledge and skills and independently implemented the knowledge and skills in their own contexts, Kram's framework of mentoring was adopted as the primary theoretical framework. However, since Kram's theory could not provide complexity concomitant in mentoring relationships, complex systems theory was adopted as a secondary framework to address the gap that Kram's theory could not explain. In this chapter, the justification for the chosen theoretical frameworks was discussed.

Chapter 4 presented an outline of the research design and methods chosen to generate thick descriptions of how teachers experienced the implementation of the knowledge and the skills developed in an SPP. The choice of the research interpretivist paradigm, qualitative research methods, case study approach and collection of data strategy, their relevance and their compatibility for this study were discussed and justified. It also provided an explanation and description of thematic analysis as a data analysis strategy as used in this study. The chapter also expounded on the criteria used to determine the quality of the study to meet the methodological expectations of the community of scientists.

In Chapter 5 data was presented from the narratives of the participants, the data, in spoken words that were later transcribed into text and presented as extracts, were interpretated. In pursuit of the study aim and to answer the research question, a combination of Kram's theory of mentoring and complex systems theory frameworks were used to analyse mathematics and science knowledge and skills implementation. Through these frameworks, spoken words by the participants were interpreted, to cultivate a better understanding and to compare their experiences to theoretical data gathered from the literature and presented in Chapter 2, to determine if there is conformity and corroboration.

In Chapter 6, the findings of the study will be presented in respect of the four themes that emerged in Chapter 5 during the analysis of the practice of 16 teachers of mathematics and science. This chapter will present synopses of the findings, conclusions regarding the lessons learned, and recommendations. The synopsis of the findings is organised according to the research questions. The chapter will also refer to the gaps in the research and limitations of the study, as indications of future research in the area.

6.4 RESEARCH FINDINGS

This section will present the findings of the study as they emerged during analysis of the data. The following are the findings of the current study emerging from the previous Chapter 5.

1. Mathematics and science teachers develop content and pedagogical knowledge, and curriculum management and assessment skills in SPPs.
2. Teachers use a variety of approaches to implement the acquired knowledge and skills.
3. Individual and institutional factors threaten successful implementation of the knowledge and skills.
4. Diverse strategies used by teachers illuminate conditions that culminate in successful implementation processes.

In the following sections, each finding will be discussed briefly. In the succeeding sections, I will infuse relevant literature and the theoretical frameworks adopted in the discussion.

6.4.1 Mathematics and science teachers develop content and pedagogical knowledge, and curriculum management and assessment skills in SPPs

This study established that, through frequent face-to-face interactions, teachers acquired a plethora of typologies of knowledge and skills from the project. The finding concurs with Wang and Wong (2019), that SUPs, such as the SPP under study, provide a wide range of external sources of academic support and proficiency that teachers can learn from and can apply to advance their teaching knowledge and skills. The findings of this study confirm that of Klinge (2015), who report that adult learners (teachers, in this context) expand new knowledge, which they understand, and then implement in their own work; they evaluate their work, produce new answers to address problems, and evaluate various approaches and solutions to benefit the organisation and themselves. This indicates that collaboration between teachers and university academics (mentors) accelerates teacher learning, thereby enabling teachers to develop the knowledge, skills, beliefs, and practices at an individual, community, and organisational level. The inclusion of mentors in professional development interventions constitutes a driving force for the renewal of teachers' continuing professional knowledge (Akkerman & Bruining; 2016; Coburn & Penuel, 2016; Day & Smethen, 2010).

The research findings indicate that knowledge and skills development does not take place in an isolated system, but rather in a porous complex web of subsystems that fluidly interact with each other. Ettekal and Mahoney (2017) argue that the macrosystem represents a set of values and the culture of the society. The macrosystem influences development within various subsystems and serves as a filter or lens through which an individual understands future experiences (Ettekal & Mahoney, 2017). In mathematics and science, the research findings show that policies such as CAPS and CPD are macrosystem elements that exert colossal influence on events that take place within other subsystems (e.g., microsystem – a classroom). The CPD policy, in particular, mandates teachers to continuously refine their knowledge and skills (content, pedagogical, technological etc.) by participating in professional development programmes (Department of Education, 2007), while the CAPS policy mandates teachers to align their teaching and assessment with the cognitive skills that learners are required to develop within mathematics and science. The research found that knowledge and skills development in the SPP occurred within an exosystem (school environment) and within a microsystem (classroom) (*cf.* 5.3.1*;* 5.3.2). However, the activities that transpired within these subsystems were regulated by macrosystem elements (e.g., CAPS and CPD policies). This suggests that knowledge and skills development occurred within a permeable, complex web, in which the events of the macrosystem influenced the events of both the exosystem and microsystem.

The literature reports that teachers develop various sets of knowledge and skills when they participate in SUPs (Botha & Reddy, 2011; Klein, Weber & Smith, 2019; Bantwini, 2018; Wang & Wong, 2019). Regarding knowledge, the study showed that teachers developed content knowledge, pedagogical knowledge, and PCK. And, regarding skills development, teachers in this study developed curriculum management and assessment skills. The findings imply that SUPs could be implemented to augment the different types of knowledge and the skills teachers need to improve teaching practice (*cf.* 5.3). However, this does not suggest that teachers are necessarily deficient in knowledge and skills for teaching mathematics and science when they do not participate in partnerships. Rather, they should continuously participate in professional development projects to refine the knowledge and skills that will enhance their knowledge and, subsequently, lead to the

enhancement of student academic performance (Department of Education, 2007). Ndlovu (2011b) points out that the knowledge and skills of teachers in rural communities are not defective for teaching mathematics and science, but the teachers need CPD programmes to enhance their knowledge and skills to teach mathematics and science. In the following subsections, the typologies of the s168ythagora the knowledge developed by teachers will be discussed.

6.4.1.1 Content knowledge

The findings of this study show that the SPP created a space for teachers to develop and enhance their content knowledge. The findings suggest that instructional coaching, classroom observation, and constructive feedback were activities mentors engaged in that contributed to teachers' content knowledge (*cf.* 5.3.1; 5.3.2; 5.3.3). Kram (1983) indicates that coaching is one of the career functions used by mentors to mentor their protégés. Coaching is the support by which the mentor suggests specific strategies that teachers could use to meet teachers' work objectives. The findings seem to suggest that instructional coaching was enacted to address the context-specific needs of individual teachers. In this study, instructional coaching can be viewed as a contextualised mentor activity that was exercised to address individual professional development needs of teachers (*cf.* 5.3.1). The study revealed that mentors leveraged teachers' content knowledge by engaging deeply in subject knowledge matter that individual teachers needed to develop (*cf.* 5.3). The findings of this study concur with Desimone and Pak (2017), who argue that instructional coaching stimulates teacher learning, as it enables teachers and mentors to dwell deeply on content knowledge. A professional development activity that involves deep engagement in the subject-knowledge matter increases content knowledge of mathematics and science teachers and changes their belief about teaching (Mokhele, 2014). The findings seem to suggest that instructional coaching as a professional development activity tends to be narrowly focused, often on specific tasks or competences, for example, presentation skills or personal efficiency (*cf.* Chalong *et al.*, 2017).

The findings also suggest that SPP mentors engaged in classroom visits with the intention of observing teachers' lesson presentation and to determine the individual needs of

teachers (*cf.* 5.3.2). Once mentors had identified the professional development needs of teachers, instructional coaching was employed to address content-specific challenges, in the form of constructive feedback or professional dialogue (Gutierrez & Kostogriz, 2020). In deep conversations on content knowledge between teachers and mentors, mentors acted as guides to mentor teachers on the way they experienced content knowledge challenges, and to assist them to address their shortcomings. The findings show that critical discussions between teachers and mentors focused deeply on the content that teachers should develop and enhance (*cf.* 5.3.3).

This finding resonates well with the literature (Russell, Correnti, Stein, Thomas & Speranzo, 2020). Mentors supported teachers by engaging in instructional coaching for key disciplinary ideas and how teachers implement those disciplinary ideas in classrooms. This is the reason why Desimone and Pak (2017) regard instructional coaching "as high-quality professional development" that enhances the content knowledge of teachers.

6.4.1.2 Pedagogical knowledge

The study findings show that mentors imparted various instructional strategies through lesson demonstrations (*cf.* 5.3.2). Mentors helped teachers to improve their pedagogical practices by contextualising alternative instructional strategies while teachers observed mentors in the classroom. This could suggest that mentors implemented the pedagogical ideas in practice through lesson demonstration for teachers, who learned from them and improved their pedagogical knowledge. The pedagogical knowledge was ostensibly essential in mentors' demonstrations, and the ability of mentors to transmit such knowledge to mathematics and science teachers. Through instructional coaching and role modelling (e.g., classroom observations and feedback discussions), teachers extended their content and pedagogical knowledge, which then contributed to and expanded teachers' PCK (*cf.* 5.3).

Ragins and Kram (2007) explain that career and psychosocial functions have different roots and outcomes. However, the findings of this study contrast with this conceptualisation. This study found that career and psychosocial functions have similar

outcomes, as teachers were able to develop content knowledge through instructional coaching and constructive feedback discussions (*cf.* 5.3.1; 5.3.3). This suggests that the psychosocial function (e.g., role modelling) is embedded within career function (e.g., coaching). Similar findings are reported by Israel *et al.* (2014). It could be argued that mentors dance an intricate two-step, of coaching teachers while simultaneously role modelling good practice (*cf.* 3.4.2.3). Although this study could not examine instructional coaching in a sample as large as that of other studies (Russell *et al.*, 2020), it does make a considerable contribution to the knowledge of instructional coaching needed for increasing teacher content and pedagogical knowledge for the teaching of mathematics and science.

The study reveals that role modelling, through classroom observation and feedback discussions, was responsible for enhancing teachers' sense of competence and teacher identify (*cf.* 5.3.2; 5.3.3). However, the findings are in contrast to that of Scandura (1992), who provides evidence that role modelling may not be one of the psychosocial functions, but rather a third distinctive dimension of mentoring, and of career and psychosocial functions. The findings of this study suggest that role modelling is a psychosocial function construct, in which a mentor models good practice through exemplary behaviour. This contention is grounded in the way a mentor models good practice, which could enhance teachers' sense of proficiency, identity, and effectiveness in their professional role (*cf.* 3.4.2.3).

6.4.1.3 Curriculum management and assessment skills

The findings indicate that instructional coaching was not only grounded in content knowledge, pedagogical knowledge, or PCK, but was used to help teachers learn curriculum management skills and assessment skills (*cf.* 5.3.1). This finding suggests that, when mentors realised that teachers struggle to achieve curriculum coverage, the mentors' employed instructional coaching on curriculum management to provide strategies for completing the curriculum within the stipulated timeframes. Although the challenge of curriculum coverage was reported by only a single teacher, it does provide a significant indication to mentors on how instructional coaching can be provided in the education context to help teachers to acquire curriculum management skills.

Regarding assessment skills, some teachers indicated they lacked assessment skills. The findings indicate that, to address some of the shortcomings, mentors advised teachers that assessment of learners should cover all the different cognitive skills in different knowledge areas (*cf.* 5.3.1). For example, in physical science, the emphasis was on ensuring that the assessment included comprehension, interpretation, problem-solving, and high-order questions (*cf.* 5.3.1). The acquisition of assessment skills in mathematics and science meant that teachers could be more oriented to assessing learners' different abilities and they could focus more on testing learners' comprehension, analytical, and problem-solving skills.

6.4.1.4 Advantages and disadvantages of SUPs

This finding of the study suggests that teachers are more prone to take a knowledge consumer perspective when they interact socially with university academics (*cf.* 5.3.1; 5.3.2). It could be that there exists an unbalanced knowledge hierarchy between different professions and, therefore, different knowledge bases, which explains why teachers are subject to this consumerism standpoint. Wang and Wong (2019) found that social interaction between teachers and university academics at the boundary zone prevents teachers from being active participants in SUPs – this is the result of different knowledge bases of partners. Literature that was reviewed conceptualised mentoring in two ways: the "knowledge hierarchical relationship" and "non-hierarchical relationship: (*cf.* Ambrosetti, 2010; Korhonen *et al.*, 2017). A non-hierarchical perspective seems to view mentoring as an equitable social practice that binds teachers and academics to working collaboratively. Teachers and university academics should construct a democratic professionalism in which all partners can echo their perspectives without being any party being marginalised (*cf.* Mockler, 2013). The construction of democratic professionalism could abolish hegemonic structures in SUPs, and enable teachers to be active participants whose perceptions are considered. Most importantly, teachers should rid themselves of the idea that academics' theoretical knowledge should be worshipped. Instead, they should realise that knowledge is significant for their own development, while also taking cognisance of their own knowledge emerging from their professional experience. Therefore, the teaching profession should be embraced in SUPs by all

stakeholders, university partners and the DBE nationally, provincially and across districts. These stakeholders should consider teachers' knowledge and experience when they conceptualise SUPs for teachers' CPD.

Despite teachers' consumerist perspective, the findings of the study suggest that SUPs are especially critical for developing countries, such as South Africa, where professional development programmes are often detached from classroom reality. In most cases, teachers attend professional development in the form of seminars or conferences, which are not part of classroom experiences. It becomes difficult for teachers to translate and contextualise the knowledge and skills they attain in these CPD programmes (*cf.* Ono & Ferreira, 2010; Tsotetsi & Mahlomaholo, 2015). The findings of the study seem to suggest that SUPs fill this critical void, as it is job-embedded professional development (*cf.* 5.3). As the findings show, teachers in different contextual settings experience a variety of content knowledge challenges, especially in rural areas, which have their own characteristics (*cf.* 5.3). The embedded nature of partnerships in classroom reality enables mentors to identify content-specific challenges that teachers experience in the mathematics and science disciplines. Subsequently, university academics can address content-specific challenges, which enables teachers to extend their content knowledge, and explore the ways such content can be translated so that learners can process knowledge. Professional development programmes that are detached from classroom experience lack this critical characteristic. The DBE, nationally and provincially, should accelerate partnership formation as an alternative to CPD programmes. Previous studies point out that teacher learning – a process of developing and enhancing teachers' knowledge and skills – should be organised in the context of partnerships that involve schools and universities (Letloenyane & Jita, 2015). It is under this condition that decontextualised professional development can be transformed into a valuable teacher learning initiative that could comprehensively address context-specific challenges. In other words, improvement of teaching ideas and practices should be informed by evidence and also supported by research (la Velle & Flores, 2018), rather than merely shaped by the criteria given by universities.

6.4.2 Teachers use a variety of approaches to implement acquired knowledge and skills

In this study, the findings show that implementation of the acquired knowledge and skills and the integration of curriculum resources occurred during the cultivation phase, as well as beyond the separation phase (*cf.* 5.4). Separation occurs when the mentor and mentee acknowledge that the relationship is no longer required in its earlier form (Kram, 1983). However, the findings of this study show that the relationship was still needed in its previous form, but was terminated due to financial constraints. The study substantiates the findings of scholars such as Ndlovu (2011b) and Jacobs (2018). These scholars argue that financial sustainability is the main and a critical threat to the success of SUPs in a South African context. What emerges from these findings is that logistical issues, such as financial sustainability of the SPP, had direct implications for teacher knowledge and skills implementation in classrooms. Ragins and Scandura (1997) indicate that most mentoring relationships cease to be sustainable because of physical separation.

The study found that teachers successfully establish173ythagorr own autonomy and independence after the separation phase (*cf.* 5.4). The research findings corroborate findings of scholars such as Ragins and Kram (2007) and Sugimoto (2012). Autonomy, in this study, refers to expression of the self, and the mentee working on their own without immediate support from the mentor (*cf.* Fagenson, 1992; Ragins & Kram, 2007). This implies that SPPs fostered teacher autonomy and responsibility, which enabled teachers to develop a better understanding of what they do in classrooms (Mockler, 2013; Wang & Zhang, 2014). The study reveals that teachers successfully established their autonomy by integrating the provisioned curriculum resources in classroom teaching (*cf.* 5.4.1).

Independence in the integration of curriculum resources brought about satisfaction in mentors, which indicates that a mentor was successful as the archetypal teacher (*cf.* 5.4.1). This finding suggests that mentors model good practice and teachers emulate mentors' archetypal characteristics, which are worthy of emulation. The findings of this study contrast with those of Wang and Wong (2019), who recommend that university academics should strengthen the interaction between curriculum material and teachers. However, mentors in the current study strengthened the interaction between teachers and

curriculum resources, as teachers can implement the resources independently. The study reveals that teachers tend to use curriculum resources for lesson preparation and presentation (*cf.* 5.4), and in this the findings of this study confirm the literature (*cf.* 2.8.2). The use of curriculum resources provided teachers with alternative teaching ideas that were learner-centred, and teachers were lesson facilitators. For instance, Teacher 7 integrated curriculum resources to teach Euclidean geometry, but used a questioning method to get learners attention prior to solving a given problem (*cf.* 5.4.1).

6.4.2.1 Emulation

The findings of this study indicate that teachers implemented the acquired PCK by mimicking alternative instructional strategies, and they shared alternative teaching ideas with other teachers in concepts such as Euclidean geometry in mathematics (*cf.* 5.4.2.1). Emulation is a crucial aspect of role modelling, as suggested by scholars such as Kram (1985) and Weinberg (2019); teachers recognised their idealised selves in their mentors and strived to emulate these aspects (Mitchell *et al.*, 2015). The findings seem to suggest that teachers only emulated the knowledge and skills they regarded as worthy of practice, as reported by Teacher 1 and Teacher 7 in this study (*cf.* 5.4.2.1). Scholars argue that teachers are selective when they enact teaching practice after receiving mentoring; they merely enact and adapt teaching ideas they consider to be worth emulating (Liden, Wayne, Liao & Meuser, 2014). This implies that teachers could only cultivate PCK and implement PCK independently when they engaged in educational discourses such as workshops and memo discussions. The mentor modelled the good practice and teachers mimicked the exemplary teaching methods (Kram 1983; Mitchell *et al.*, 2015; Liden *et al.*, 2014; Weinberg, 2019).

6.4.2.2 Assessment

Most participants reported that they used past examination papers provisioned by mentors to prepare learners for school-based assessment tasks (e.g., tests, practical tests, and examinations), and this practice resonates with findings of scholars such as Bansilal *et al.* (2014) (*cf.* 5.4.1; 5.4.2). The finding of the current study is that teachers felt the need to use past examination papers to expose learners to questions requiring the

application of various cognitive skills learners are required to develop in mathematics and science. In accordance with CAPS documents for mathematics and science, teachers are mandated to expose learners to questions that involve a variety of cognitive skills and ensure that learners can develop the skills. The findings imply that using past examination papers embodies a complex process that is regulated by macrosystem elements, such as CAPS policies (*cf.* 3.5). The implementation of the knowledge and skills is regulated by education policies that mandate teachers to strongly emphasise the development of learners' cognitive skills during classroom teaching (Finn *et al.*, 2014; Spaull & Kotze, 2015). Knowledge and skills implementation beyond an SUP indicates that implementation takes place within a web of subsystems that are interrelated and function together as a unit.

The findings reveal that the provisioned curriculum resources included previous examination papers (*cf.* 5.4.1), and that teachers tended to integrate these papers when preparing learners for school-based assessment tasks. However, teachers' responses relating to the development and implementation of the assessment skills were contradictory. The participants reported to have developed assessment skills during the cultivation phase (*cf.* 5.3.1), however, none of the participants mentioned the implementation of the assessment skills to evaluate learners' understanding at various cognitive levels beyond the partnership. Instead, teachers relied exclusively on ready-to-use past question papers to assess learners' application of the various cognitive skills (*cf.* 5.4.1). This practice gives the impression that teachers may not have developed the assessment skills well enough to create their unique question papers to assess learners at different cognitive levels. If teachers had successfully developed assessment skills, some of them could have integrated the skills independently, instead of relying on ready-to-use previous papers.

6.4.2.3 Technology integration

The findings suggest that some teachers possessed technological knowledge. Some teachers had been successful in integrating technological software such as GeoGebra, Graphs, Crocodile Clips, and ChemSketch (*cf.* 5.4.2.3). The findings of this study concur that of with Willermark (2018), who conceptualised TPACK as technological skills or

competence. This implies that teachers who were successful with the integration of technology-based software in their teaching were skilful or competent in applying technology. Thus, the skills or competence refer to the application of technological knowledge in the teaching situation. However, some teachers were not successful in integrating technology software in their teaching (*cf.* 5.4.2.3). It could be that teachers possessed PCK that exceeded TPACK and might not have been able to integrate GeoGebra or ChemSketch in their teaching. This confirms findings of Liu *et al.* (2015), who report that teachers lacked technological skills, and teachers could not integrate technology in their classroom instruction prior to the partnership. Farjon, Smits and Voogt (2019) found that teachers' lack of technological experience seems to hamper meaningful technology integration in classroom instruction.

The finding of this study was that technology integration was rather topic specific – I referred to this as TTSPCK (*cf.* 5.4.2.3). Teachers in this study integrated technology for topics in, for instance, Euclidean geometry, and analytical geometry in mathematics. Similarly, in physical science, teachers integrated technology in concepts such as organic chemistry and electricity. In essence, I extended Mavhunga and Rollnick's (2013) conception of TSPCK to include technology integration in TSPCK. This could suggest that the ability of teachers in this study to integrate technology was dependent on their TSPCK. However, this study did not investigate the frequency of the integration of technological software, nor did this study evaluate how teachers integrated technological software efficiently to promote and enhance student learning. Some of the teachers demonstrated their technological knowledge by integrating technology in teaching, which suggests that they were creative and innovative (*cf.* 5.4.2.3).

6.4.3 Individual and institutional factors that threaten successful implementation

The findings of the study reveal that contextual factors affect how teachers implement the knowledge and skills they acquired; these factors also affect the integration of curriculum resources during teaching and learning (*cf.* 5.4.3). The factors that influenced the implementation process include individual, institutional, technological, and professional

development factors. The next subsections briefly discuss the factors as they emerged in the study.

6.4.3.1 Lack of advanced technological skills of teachers

The research found that some teachers in the study possessed basic computer skills and could integrate MS Word, PowerPoint, Excel in their teaching (*cf.* 5.4.3). However, some of the teachers lacked advanced technological skills, and could not incorporate animations and audio in their PowerPoint presentations (*cf.* 5.4.3). The SPP was not intended to equip teachers with advanced technological skills, neither was it intended to enhance the technological skills of teachers. Teachers could not optimally integrate technology in their lessons, because they lacked advanced technological knowledge and skills (*cf.* 2.9.4).

However, providing technological resources implies that improving technological skills could have been one of the priorities of the SPP. Doing so would have encouraged teachers to efficiently integrate technology in their teaching; alternatively, their professional development needs regarding technology could have been identified and addressed through instructional coaching or role modelling. The resources supplied were rather conceptual or theoretical, and this concurs with the literature reviewed (*cf.* 2.9.2). The shortcoming of teachers, namely that they did not possess advanced technological skills, suggests that professional development that focuses on advanced technology integration, such as incorporation of animations and audio, would be beneficial. Limited technological skills meant teachers could integrate the resources, though the efficiency of this integration was questionable.

6.4.3.2 Lack of infrastructure

In South African schools, scholars have questioned and critiqued the environment in which teaching takes place (John, 2019; Khumalo & Mji, 2014). The South African education system, particularly in rural areas, has always been plagued by a lack of infrastructure and resources. Infrastructure is a primary component of the learning and teaching context, without which no improvement can be made in communities. The school infrastructure enables students and teachers to have access to a wide range of resources,

services, and resources to support learning and teaching. This study found that the school infrastructure remains a primary institutional factor, and shortcomings can impede the implementation of knowledge and skills in rural schools (*cf.* 5.4.3). The teaching environment remains a prime factor in determining success of the learning process and learner performance. The ability of rural schools to produce quality learner performance lies in the creation and maintenance of a conducive teaching milieu.

Although the poor state of resources and school infrastructure in South African schools has been constantly reported by research studies (John, 2019; Khumalo & Mji, 2014), the status quo lingers. The scientific nature of science subjects, in particular, needs more resources and appropriate infrastructure being made available for schools. Without sufficient resources and infrastructure, teachers cannot adopt learner-centred approaches, but will rather opt to use lecturing, presenting written notes and reading directly from textbooks (*cf.* 5.4.3).

In this study, the implementation process could not be viewed in isolation from the environment in which the implementation took place. It does not help to advance and change teaching practices in rural schools with SUPs that provide CPD, when there are shortages of resources and poor school infrastructure – as the findings of this study suggest (*cf.* 5.4.3).

6.4.3.3 Shortage of science laboratories

Teachers face a variety of challenges that impede the successful implementation of knowledge and skills acquisition during the teaching and learning process (*cf.* 5.4.3). The findings reveal that teachers could not conduct experiments as prescribed by the CAPS for physical/natural sciences, because there were no science laboratories at schools (*cf.* 5.4.3). This suggests that teachers were unbale to make a closer connection between theoretical knowledge and practical experience, especially for concepts that require such a linkage. Science is a theoretical and a practical subject, and if learners are not afforded the opportunity to learn science from a practical standpoint, then learners can only understand science at an abstract level. Learners could perform poorly in practical tasks or tests because their schools lack teaching and learning resources, such as laboratories

for conducting experiments (Ndjangala & Mashebe, 2021). For the sake of compliance with demands related to curriculum coverage, teachers at schools that do not have science laboratories convert practical experiment tasks into tests, assignments or investigations (John, 2019). This practice does not, in any way, enable learners to acquire the practical knowledge and skills required for scientific inquiry, or problem-solving skills, as the experimental tasks should be designed to enable learners to use scientific inquiry skills.

6.4.3.4 Lack of ICT facilities

The study found that some schools in this study lacked ICT facilities (*cf.* 5.4.3). Teachers suggested that ICT facilities, such as computer labs, laptops and overhead projectors, are another institutional factor that impeded the implementation process. The findings revealed that the lack of ICT facilities at some of these schools inhibited teaching approaches that are learner-centred (*cf.* 5.4.3), and prevented learners from accessing SPP curriculum resources on their own, or to construct meaning and understandings of mathematics and science independent of their teachers. When the institution lacks these essential resources, teachers are unable to adopt so-called learner-centred teaching approaches. The issues that were raised by teachers of this study are critical, since school buildings, such as computer laboratories, have been identified as components that play a role in learner performance and wellbeing (Khumalo & Mji, 2014). The implications of the shortcomings identified by teachers from a rural perspective are that there is an pressing need to provide teachers with additional resources, to ensure that they integrate the resources efficiently at schools. The findings were that not all teachers who participated in the SPP were able to integrate technology in their classroom instruction (*cf.* 5.4.3). Teachers developed the technology knowledge and skills that they could integrate (*cf.* 5.3), however, lack of school infrastructure was a hurdle for teachers to integrate technology in classroom instruction.

6.4.4 Teacher traits and school conditions culminate into the successful implementation process

To respond to the last research question, which is about the conditions for successes in the implementation process, this study has identified the traits and conditions that shows these successes. The identified traits and conditions elucidate the circumstances together with the actions teachers take to successfully implement the acquired knowledge and skills. Therefore, this section discusses these conditions as they were applicable in this study.

6.4.4.1 Sharing of pedagogical content knowledge

The findings reveal that teachers implemented the acquired PCK in memo discussions, start-up workshops, and subject cluster meetings, by sharing the acquired PCK with other teachers (*cf.* 5.4.2.1; 5.4.2.2). This contextualised professional development ensured that teachers conveyed the acquired content knowledge, pedagogical knowledge, and PCK by sharing what they had learned with colleagues. In mathematics, for example, the findings indicate that sharing of PCK was done for Euclidean geometry, as this concept was difficult for some teachers to teach and learn. Thus, teachers conveyed topic-specific PCK (TSPCK) (*cf.* 5.4.2.1). The acquisition of TSPCK shifted teachers' underlying beliefs about their practice, which corroborates the findings of Mavhunga and Rollnick (2016). It could be that changes in teachers' underlying beliefs and changes in learners' academic performance trigger teachers to share TSPCK. However, sharing of TSPCK doesn't guarantee successful transmission of TSPCK as teachers that received the knowledge should implement the knowledge independently. It is only when these teachers have been successful in the implementation process that they can change their beliefs, and this could suggest successes in TSPCK transmission.

6.4.4.2 Background knowledge of technology in teaching

The study findings indicate that teachers with a background knowledge of technology in teaching have integrated technological software that include GeoGebra, Graph, Crocodile Clips, and ChemSketch (*cf.* 5.4.2.3). However, the frequency of the utilization of

technological software remains a primary apprehension, as this study did not venture into this aspect. Nevertheless, the findings could suggest that the background knowledge of teachers in technology was an individual factor as teachers were able to integrate the software in their teaching (*cf.* 5.4.2.3).

6.4.4.3 Willingness of teachers to use personal resources

The study revealed that, despite lack of computer laboratories in School A, a physical sciences teacher has successfully attempted to incorporate IBP videos in his lessons using personal laptop (*cf.* 5.4.1). This indicates that Teacher 2 valueed and understood the significance of alternative content-focused teaching methods that expose learners to the depth of the same content discussed in the classroom, but with a different teaching method. This also indicates teachers' willingness to consider alternative approaches that accommodate available resources at their disposal. The findings show that, in schools where teachers lacked resources related to technological tools, such as computers, teachers' willingness to apply personal resources seems to have been an individual factor that culminated in successful implementation (*cf.* 5.4.1).

6.4.4.4 School leadership motivation

The study findings showed that, in some schools, the school management team encouraged teachers to integrate the curriculum resources that were provided by the university (*cf.* 2.6.4; 3.5, 5.4.2). This indicates that integration of curriculum resources was influenced by elements of the exosystem within a complex system (*cf.* 3.5). The exosystem influence implementation through other people involved in individuals' (teachers) lives (Ettekal & Mahoney, 2017). This suggests that school leadership influenced the implementation process by encouraging teachers to integrate the resources in their classrooms. This concurs with Marsh and Farrell (2015), who report that school leadership influences the continuous use of curriculum resources after a SUP has terminated, by providing motivation.

6.4.4.5 Teacher–teacher collaboration

The study findings show that some teachers were encouraged by their mentors to form teacher–teacher collaborations (*cf.* 5.4.2.2). It was revealed that teacher–teacher collaborations enhance the instructional strategies of teachers, especially when a teacher observes another teacher in action (*cf.* 5.4.2.2). Classroom observation seems to have been a key strategy that teachers used when they collaborated with each other. The findings of this study concur with that of Bantwini (2018), who explains that teacher–teacher collaboration is a powerful instrument in teachers' continuing professional learning. This study had similar findings, as teachers in this study collaborated with each other to learn new instructional ideas from each other, with the view of enhancing their teaching practice (*cf.* 5.4.2.2).

6.5 LIMITATIONS OF THIS STUDY

Limitations in this study are provided for possible improvements when other researchers conduct similar studies in the future.

A case study design was adopted to investigate how teachers implemented the knowledge and skills acquired from the SUP beyond the partnership. Therefore, the findings of this study cannot be generalised to many other contexts. The confinement of this study was only to mathematics and science teachers that participated in the SPP in only two areas of one District. Studies on other subjects within the same SPP might yield similar or different findings. The study collected data from sixteen teachers in mathematics and science, and only eight teachers participated in focus group discussions. The inclusion of mentors' and school principals' perceptions on the implementation part in other studies might yield different or similar outcomes.

Another limitation was that of professional bias. Teachers that participated in the study knew I was one of the physical science teachers in the district. This professional bias might have impacted on how genuinely participants responded to the questions. To minimize the professional bias, I encouraged the participants to be honest as possible in their responses and that they should be comfortable when they respond to questions. I

also explained to the participants that their honest answers were essential to enable me to answer the research questions.

6.6 VALUE OF THE STUDY

I strongly believe that the findings of this study will contribute meaningfully to expanding our understanding and knowledge of the way teachers implement the knowledge and skills they acquire in SUPs, or from any form of classroom-embedded professional development programme. South African teachers, particularly in rural areas, need this form of ongoing classroom-embedded professional development to contextualise CPD.

I believe that the recommendations put forward in this study will benefit universities and teachers' CPD programmes, and guide the way teachers' knowledge and skills are developed and implementation encouraged. Universities could include SUPs on social responsibility or community engagement policies as a social responsibility project for teachers' CPD. I believe that relevant stakeholders in the university community will take note of the recommendations of this study, and implement them. The implementation should focus on equipping teachers with current developments in mathematics and science teaching, and ensuring that teachers are able to implement these innovative approaches in education autonomously.

6.7 RECOMMENDATIONS OF THE STUDY

To ensure that teachers implement the knowledge and skills they acquired in SUPs effectively, the following recommendations are made.

6.7.1 Recommendations for universities

This study revealed that university academics used their intellectual capital to generate curriculum resources that can be integrated in mathematics and science teaching. The curriculum resources tended to be conceptual or theoretical, therefore, this study recommends that university academics learn how to strengthen the interaction between curriculum material and teachers to ensure that teachers use the resources with ease.

Therefore, the provisioning of curriculum resources in SUPs should be accompanied by an induction process on how teachers should utilise the resources efficiently.

This study revealed that some teachers use technological resources provisioned by university academics, while teachers at other certain schools find it challenging to integrate the resources in classrooms. University academics should attempt to induct teachers on how to use technological software, such as GeoGebra, Graph, Crocodile Clips and ChemSketch. Additionally, the study recommends that university academics conceptualise professional development projects with teachers to assist teachers in developing their technological skills for integrating technological software in teaching.

6.7.2 Recommendations for teachers' continuous professional development

This study reveals that teachers develop and enhance a plethora knowledge and skills in mathematics and science education by participating in an SUP. Therefore, this study recommends that the Department of Education should consider SUPs as an alternative professional development intervention for teachers. Once-off professional development programmes, such as workshops or seminars, are detached from classroom reality and are, in most cases, general, as they take place in a confined environment. This study reveals that teachers had different professional development needs in terms of knowledge and skills enhancement – even if they teach the same subject. Therefore, ongoing job-embedded professional development will enable teachers to deepen their content knowledge and instructional strategies, particularly in difficult, topic-specific areas.

University academics can provision curriculum resources, such as content notes, IBP videos, and technological resources; however, if schools lack resources, such as ICT facilities and science laboratories, teachers cannot implement the acquired knowledge and skills, or integrate technological resources in classroom teaching. The university fulfils its social responsibility agenda as envisaged in the White Paper (DOE, 1997). The challenge lies with the Department of Education's response, which should ensure that the context in which teaching take place, that is, the classroom, is conducive to teachers implementing education innovations in mathematics and science pedagogy. This study

recommends that the Department of Education accelerates the school infrastructure project, especially in rural schools, which have distinct characteristics.

6.7.3 Recommendations for further research

This study provide the following recommendations for further research on this topic:

- Scholars should develop strategies that enable teachers in physical sciences to integrate technological software, such as ChemSketch and Crocodile Clips, through action research.
- Teachers indicated that the assessment skills they developed in the professional development project were not being implemented. This study recommends that participatory action research is undertaken to develop mechanisms that will emancipate teachers, so that they develop their own question papers, instead of relying on previous examination papers.

6.8 CONCLUSION

This study described mathematics and science teachers' experiences of the implementation of the knowledge and skills they had gained in an SPP. Their implementation is linked to success indicators, such as a conducive environment for teaching and learning, the availability of resources to enable efficient implementation, and knowledge and skills of provisioned resources. To this end, the availability of resources at some schools, and lack of infrastructure at other schools were cited as success or constraining factors. In addition to the enablers of knowledge and skills implementation, the ability of teachers to efficiently use provisioned resources, adapt their acquired pedagogical and content knowledge in teaching, and share the resources with other colleagues were thoroughly discussed.

The research contributes by identifying the activities that lead to the acquisition of knowledge and skills by teachers when they are being mentored. This research also contributes by explaining how the acquired knowledge and skills are applied in practice.

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APPENDIX A

LETTER FROM LANGUAGE EDITOR

Declaration

23 November 2022

PO Box 4
Otjiwarongo
Namibia
+264 813359120
hettie.human@gmail.com

Doctoral thesis: Exploring teachers' implementation of knowledge and skills beyond a school-university partnership

Student: Pakiso James Moeti

I confirm that I edited the thesis, checked the references and recommended changes to the text.

MA Language Practice

APPENDIX B

LETTER FROM ETHICS COMMITTEE

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

06-Nov-2020

Dear Ms Van Den Heever, Cornelia CM

Amendment Approved

Research Project Title:
The impact of the South Campus Schools Partnership Projects

Ethical Clearance number:
UFS-HSD2019/1090/0505

We are pleased to inform you that your amendment application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for notifying the ethics committee of the changes/amendments that have been made to your study; we wish you the best of luck and success with your research.

Mr Pakiso Moeti, student number: 2008046928 is doing his PhD on this study, therefore he is added to the study, together with his two supervisors. the title of his research is as follows: **Teachers Experience of a School Partnership Project on Teachers Continuous Professional Development**

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

205 Nelson Mandela Drive
Park West
Bloemfontein 9301
South Africa

P.O. Box 339
Bloemfontein 9300
Tel: +27 (0)51 401 9337
duplessisA@ufs.ac.za
www.ufs.ac.za

APPENDIX C

INFORMED CONSENT

University of the Free State - Doctoral research

Researcher: Mr Pakiso Moeti (Student number: 2008046928, contact details: 081 439 5063)

Supervisors: Dr Ramohai and Dr Stott

Dear Participant

I, Pakiso Moeti, am a PhD student at University of the Free State. You are cordially invited to participate in a research project entitled: **Exploring teachers' implementation of knowledge and skills beyond a school-university partnership**

The aim of the study is to: **gain insight of the implication of the School Partnership Project (SPP) on teachers' knowledge and skills implementation. The study endeavour to find out this from participants' perceptions, experiences, and understandings of the everyday lived experiences in schools**.

The outcome of this research is intended to contribute to the existing body of knowledge on school-university partnership in the field of higher education and in-service teacher continuous professional development.

Your participation in this study is voluntary and therefore you may refuse to participate or withdraw at any time with no consequences. There will be no monetary gain from participating in this study. Confidentiality and anonymity of records identifying you as a participant will be maintained by the researcher and University of the Free State. If you have questions or queries regarding the research or your participation in the study, kindly contact me at any time on the number listed on this leaflet.

The interviews will last for approximately 1 hour and I might be required to do follow-up interviews. I trust that you are willing to participate in this study.

Sincerely

Researcher: Pakiso Moeti

This page is to be retained by the participant

CONSENT TO PARTICIPATE IN THIS STUDY

I do understand the contents described in this research project. I hereby authorize /do not consent (please underline) to take part in this research project.

I am willing to share further information through taking part in the interviews:	YES	NO

Full Names of Participant: _____

Signature of Participant: _____Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____

APPENDIX D

INTERVIEW PROTOCOL

EXPLORING TEACHERS' IMPLEMENTATION OF KNOWLEDGE AND SKILLS BEYOND A SCHOOL-UNIVERSITY PARTNERSHIP

This study aims to gain a deeper **understanding of teachers' experiences in implementing the knowledge and skills acquired in the University of the Free State School Partnership Project** in which they were participants. An understanding of these experiences could be used as an improvement departure for the project or similar projects at the university or elsewhere.

This study followed sixteen teachers who were part of the University of the Free State School Partnership Project (SPP) in mathematics and science. In this study, I explored the implications of the UFS SPP from the teachers' perceptions in their everyday lived classroom experiences.

1. How and why did you become a participant in this project?
2. Please share your expectations when you joined the project.
3. How has the project and your involvement met (or not) your expectations and the project outcomes? [please use concrete examples and refer to skills development in content, assessment and delivery in your subject]
4. What role did the mentors play in ensuring that your participation in the project becomes successful? [share concrete examples]
5. Where you ready to stop receiving mentoring from the UFS SPP mentors? Explain why you say so.
6. How did you feel after the UFS SPP mentoring relationship was ended? [please share personal and professional feelings]
7. Did you continue talking to your mentor after the project has ended? If so what did you or are you discussing?

APPENDIX E

FOCUS GROUP DISCUSSION PROTOCOL
GUIDING QUESTIONS

1. What are your opinions regarding the use of technology in mathematics/science teaching?
    a. In what ways do you think SPP helped you to develop knowledge and skills of integrating technology in mathematics/science teaching?
    b. To what extent is your school management supporting the idea of technology integration in your classroom teaching?
2. How often do you use the provisioned resources such as IBP videos, CDs, and textbooks in your teaching?
    a. For what purposes do you use these resources?
3. Which teaching strategies you learnt from the provided resources are you implementing in your teaching?
    a. How are you implementing the teaching strategies?
    b. How did the resources improve your content knowledge?
4. How do you align the content knowledge in the notes with the annual teaching plan in your subject?
    a. How does the content in the notes help you in your teaching?
5. How do you apply the knowledge you gained in mentoring during teaching practice when you mentor student teachers?