

**EXPLORATION OF USE OF THE SCIENCE RESOURCE CENTRE BY
PHYSICAL SCIENCES TEACHERS**

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by

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Declaration

This dissertation presents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others, it is duly acknowledged in the text and in the list of references.



Nokuthula Pamela Xulu

13 January 2012

Date

This dissertation has been read and approved for submission.

Supervisor: Dr Ronicka Mudaly

Date

Dedication

This work is dedicated to my three children, Sinenhlanhla, Vukani and Thuthuka.

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ABSTRACT

Science Resource Centres (SRCs) were initiated by an educational non-governmental organisation in various districts of the province of KwaZulu-Natal in South Africa. These SRCs were intended to assist with professional development of Physical Sciences and Mathematics teachers, and to assist the under-resourced schools of KwaZulu-Natal with science resources, including Physical Sciences experiment kits, physics and chemistry apparatus and other educational resources. Science resources encompassed specialists, objects, policies and facilities to enhance the teaching of Physical Sciences. These science resources were usually coupled with professional development programmes that addressed content knowledge and effective use of science equipment through workshops on specific science topics and classroom support to teachers. Workshops were funded by the SRCs, and the focus was on physics and chemistry topics that teachers found challenging to teach. This study explored the use of the SRC by Physical Sciences teachers of the Empangeni education district in KwaZulu-Natal, and also aimed to determine whether the SRC was serving its intended purpose.

In gathering data this qualitative study utilised individual interviews with Physical Sciences teachers whose schools were affiliated to the SRC. Document analysis produced data with regard to the frequency of loaning of science equipment by Physical Sciences teachers.

The findings of this study revealed that the level of pedagogical content knowledge (PCK) development of Physical Sciences teachers was one of the key factors that influenced the use of science resources in science teaching.

This emerged through an analysis of teachers' PCK, specifically using the frames of Content Representations (CoRes) and Pedagogical and Professional experience Repertoires (PaP-eRs). Lack of support from school management, lack of funding for affiliation and shortage of resources at the SRC were some of the factors that had an impact on use of the SRC by Physical Sciences teachers.

| Table of Contents | Page |
|--------------------------|-------------|
| Declaration | ii |
| Dedication | iii |
| Acknowledgement | iv |
| Abstract | v |

Chapter 1: Orientation to the study

| | | |
|-----|--------------------------------|---|
| 1.1 | Introduction..... | 2 |
| 1.2 | Rationale for the study..... | 3 |
| 1.3 | Significance of the study..... | 6 |
| 1.4 | Aim of the study..... | 7 |
| 1.5 | Research questions..... | 7 |
| 1.6 | Summary..... | 7 |

Chapter 2: Literature review

| | | |
|-----|---|----|
| 2.1 | Introduction..... | 10 |
| 2.2 | The state of Physical Sciences in South Africa..... | 11 |
| 2.3 | The National Curriculum Statement..... | 16 |

| | | |
|-----|--|----|
| 2.4 | Science teachers' pedagogical content knowledge..... | 19 |
| 2.5 | Constructivism in learning to teach science..... | 24 |
| 2.6 | Summary..... | 28 |

Chapter 3: Research design and methodology

| | | |
|-------|-----------------------------|----|
| 3.1 | Introduction..... | 30 |
| 3.2 | Research design..... | 30 |
| 3.3 | Context of the study..... | 32 |
| 3.4 | Sampling..... | 33 |
| 3.4.1 | Sampling strategy..... | 34 |
| 3.4.2 | Sample size..... | 35 |
| 3.5 | Data collection..... | 36 |
| 3.6 | Ethical considerations..... | 39 |
| 3.7 | Validity..... | 40 |
| 3.8 | Summary..... | 41 |

Chapter 4: Data presentation and analysis

| | | |
|---------|----------------------------------|----|
| 4.1 | Introduction..... | 43 |
| 4.2 | The teachers..... | 43 |
| 4.3 | The interview process..... | 50 |
| 4.4 | Analysis of results..... | 51 |
| 4.4.1 | Construction of the CoRes..... | 52 |
| 4.4.2 | Discussion of the CoRes..... | 56 |
| 4.4.3 | Construction of the PaP-eRs..... | 59 |
| 4.4.4 | Discussion of the PaP-eRs..... | 61 |
| 4.4.4.1 | Practices before teaching..... | 61 |
| 4.4.4.2 | Practices during teaching..... | 64 |
| 4.4.4.3 | Practices after teaching..... | 67 |
| 4.5 | Summary..... | 70 |

Chapter 5: Findings and recommendations

| | | |
|-----|----------------------------------|----|
| 5.1 | Introduction..... | 73 |
| 5.2 | Overview of the study..... | 73 |
| 5.3 | Discussions of the findings..... | 74 |

| | | |
|-------|---|---------------|
| 5.3.1 | How do Physical Sciences teachers use the SRC?..... | 77 |
| 5.3.2 | Why do Physical Sciences teachers use the SRC?..... | 79 |
| 5.4 | Limitations of the study..... | 80 |
| 5.5 | Recommendations..... | 80 |
| 5.6 | Directions for future research..... | 81 |
| 5.7 | Conclusion..... | 81 |
| | References..... | 83 |
| | Appendices..... | 89 |
| | Appendix A: Ethical approval letter..... | 90 |
| | Appendix B: Consent letter for teacher..... | 91 |
| | Appendix C: Consent letter for principal..... | 93 |
| | Appendix D: Interview Schedule..... | 95 |
| | Appendix E: Lesson Plan (Teacher D)..... | 96 |
| | Appendix F: Lesson Plan (Teacher A)..... | 98 |
| | Appendix G: Turnitin Certificate..... | 99 |
| | Appendix H: Editor’s Certificate..... | 100 |

List of Tables

| | |
|--|----|
| Table 3.1: Data generation strategy to respond to critical question 1..... | 36 |
| Table 3.2: Data generation strategy to respond to critical question 2..... | 37 |
| Table 4.1: Teachers' biographical details..... | 44 |
| Table 4.2: Average passes of selected schools in Physical Sciences..... | 45 |
| Table 4.3: CoRe for three teachers on wave phenomena..... | 54 |

Figure

Figure 1: Practical work: Linking two domains of knowledge

| | |
|--|----|
| (adapted from Millar, 2004, p. 8)..... | 58 |
|--|----|

CHAPTER 1
ORIENTATION TO THE STUDY

| CONTENTS | PAGE |
|------------------------------------|-------------|
| 1.1 Introduction..... | 2 |
| 1.2 Rationale for the study..... | 3 |
| 1.3 Significance of the study..... | 6 |
| 1.4 Aim of the study..... | 7 |
| 1.5 Research questions..... | 7 |
| 1.6 Summary..... | 7 |

1.1 Introduction

The improvement of science education is perceived as a priority for any developing country in order to advance long-term economic development of that country (Rogan & Grayson, 2003). Many initiatives have been engaged with by the governments of developing countries in order to improve science education in schools (Johnson, Hodges & Monk, 2000; James, Naidoo & Benson, 2008; Hewson, 2007; Jita & Mokhele, 2008; Mji & Makgato, 2006; Rogan & Grayson, 2003). In South Africa such initiatives include the development of educational non-governmental organisations (NGOs), which originated in the early 1970s and 1980s (Rogan & Grayson, 2003). NGOs in South Africa aimed at stimulating innovation and embarking on professional development of teachers, particularly in black schools (Rogan & Grayson, 2003). According to Rogan and Grayson (2003, p. 1191), NGOs in South Africa also “acted as conduits for local and international donors who wished to assist with the improvement of education but did not want to be associated with the government”.

This study aimed at exploring how Physical Sciences teachers used the Science Resource Centre (SRC) which was initiated by an educational NGO. The purpose of the SRC was to assist with professional development of Science and Mathematics teachers, and to assist the under-resourced schools of the Empangeni education district in the province of KwaZulu-Natal with science resources. Science resources mainly included physical sciences experiment kits, physics and chemistry apparatus and other educational resources, and also encompassed specialists, objects, policies and facilities to enhance teaching of Physical Sciences. These science resources were

usually coupled with professional development programmes that addressed content knowledge and effective use of equipment through workshops on specific science topics and classroom support for teachers. Workshops were funded by the SRC, the focus of which was on physics and chemistry topics that teachers found challenging to teach.

In this chapter the scene is set by presenting the motive for this study, including how its outcomes may be useful. After imparting the intention for the study, the critical questions underlying the study are introduced, followed by the aim of the study and the critical questions around which the study is framed.

1.2 Rationale for the study

The poor quality and/or lack of education in certain areas of South Africa have resulted in limited access to scientific knowledge and undervaluing of indigenous scientific knowledge (Department of Education (DoE), 2003). The DoE attempts to address this challenge in various ways. The curriculum of Physical Sciences in particular must ensure increased access to scientific knowledge and scientific literacy. It is my contention that in order to increase access to scientific knowledge and scientific literacy, schools could engage with various SRCs throughout South Africa.

A study which was conducted by du Toit (2010) to determine whether science centres can support and improve chemistry education in South Africa yielded positive results. It revealed that if Science Centres are supported financially

and academically, they can support and improve the quality of chemistry education (du Toit, 2010). This is particularly significant in the South African context where there is currently a nationwide concern about science teaching. This has been considered during the reformulation of the school curriculum, which is underpinned by the National Curriculum Statement (NCS) (DoE, 2003).

The NCS enshrines curriculum policy in South African schools and includes Learning Outcomes, which are “statements of intended results of learning and teaching. It describes knowledge, skills and values that learners should acquire by the end of the Further Education and Training band” (DoE, 2003, p. 7).

Learning Outcome 1 of the NCS emphasises the practical scientific inquiry aspect in the teaching and learning of Physical Sciences (DoE, 2003). Through this Learning Outcome, Physical Sciences teachers should design learning activities that “offer learners opportunities to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts” (DoE, 2003, p. 108). In poorly resourced schools such activities that are envisaged by this Learning Outcome can be possible if Physical Sciences teachers use the science resources available at the SRCs.

Since I began working at an SRC two years ago as a project manager and a science facilitator I have noticed that most schools that affiliate to the SRC in order to use the science resources available at the centre still produce poor Physical Sciences matric results. (In South Africa ‘matric’ is a term commonly

used to refer to the final year of high school and the qualification received on graduating from high school. It means the exit year of secondary school at Grade 12 level.)

Among the factors leading to poor performance in Physical Sciences is the lack of science resources in schools. For example, statistics show that only 15% (i.e. 3772 out of 24 793) of the schools in South Africa have science laboratories, and in KwaZulu-Natal in particular there are only 12% (i.e. 719 out of 5931) schools that have science laboratories (Department of Basic Education, 2011b).

These statistics provide evidence that only a small percentage of Physical Sciences teachers have access to physical sciences resources that they can use in their teaching of the subject. This is also confirmed by the report of the KwaZulu-Natal provincial moderator which states that “investigations are an area that is neglected in the teaching in Physical Sciences, and there is an urgent need for content development workshops/interventions across all knowledge areas in terms of the requirements of Learning Outcome ONE (LO 1) of the National Curriculum Statement” (DoE, 2009, p. 14).

Learning Outcome 1 of the NCS proposes that “learners’ understanding of the world will be informed by the use of scientific inquiry skills like planning, observing and gathering information, comprehension, synthesising, generalising, hypothesising and communicating results and conclusions” (Department of Basic Education, 2011a, p. 108). The acquisition of such skills is possible through the effective use of science resources in science lessons.

The subject statement for Physical Sciences also stipulates that practical work is essential in the teaching of science concepts. Therefore it has become necessary for Physical Sciences teachers to make a shift from traditional, teacher-centred strategies to learner-centred practices (DoE, 2003). Teachers who use concrete resources enable their learners' construction of meaningful concepts (Wellington & Ireson, 2008).

Taking into consideration the importance of practical work in the teaching of science concepts, I decided to explore how Physical Sciences teachers from schools which are affiliated to the SRC use this centre in their teaching.

1.3 Significance of the study

The findings from this research could be useful to:

- Physical Sciences teachers of under-resourced schools who have inadequate resources for teaching;
- Physical Sciences teachers who want to improve their instructional strategies; and
- Curriculum development specialists who support Physical Sciences teachers, since it will provide valuable feedback to Physical Sciences teaching and learning.
- Science Resource Centre to function more effectively by developing programmes based on empirical evidence of teachers needs in Physical Sciences classroom.

- Deepen the Science Resource Centre personnel's understanding of what teachers need in terms of material and human resources.

This study will assist in determining whether the SRC is accomplishing its purpose of providing access to quality educational resources, continuing teacher professional development opportunities and school-based support. Although this is not the purpose of the study, it is one of the ways in which the study becomes significant.

1.4 Aim of the study

The aim of the study is to explore how eight Physical Sciences teachers from eight rural high schools which are affiliated to the SRC use science resources in their teaching of Physical Sciences.

1.5 Research questions

The research questions that guide this study are:

- 1 Why do Physical Sciences teachers use the Science Resource Centre?; and
- 2 How do Physical Sciences teachers use the Science Resource Centre?

1.6 Summary

The rationale for the study was based on findings from other studies about the usefulness of SRCs in teaching. It was also derived from personal experience

of working with Physical Sciences teachers as a SRC Manager which highlighted a clear need for the research.

Chapter 2 provides an outline of the theoretical framework and relevant literature with regard to the use of science resources in the teaching of Physical Sciences. The interpretive paradigm which shapes the study is argued for in Chapter 3, and the qualitative methodology which was employed to design this study is described. The use of interviews as well as the sampling procedure and issues of access are also detailed.

Chapter 4 describes the teachers' views about why and how they use Physical Sciences resources from the SRC. It focuses on two frames which are embedded in pedagogical content knowledge (PCK), namely Content Representations (CoRes) and Pedagogical and Professional experience Repertoires (PaP-eRs), which are employed as analytical tools.

Conclusions generated from this study are captured in Chapter 5, which includes recommendations related to the future research agenda in the teaching of Physical Sciences.

CHAPTER 2
LITERATURE REVIEW

| CONTENTS | PAGE |
|--|-------------|
| 2.1 Introduction..... | 10 |
| 2.2 The state of Physical Sciences in South Africa..... | 11 |
| 2.3 The National Curriculum Statement..... | 16 |
| 2.4 Science teachers' pedagogical content knowledge..... | 19 |
| 2.5 Constructivism in learning to teach science..... | 24 |
| 2.6 Summary..... | 28 |

2.1 Introduction

This chapter begins with an overview of the state of Physical Sciences in South Africa in terms of performance of learners, as reported by the Third International Mathematics and Science Study (TIMSS). I then look at the South African Physical Sciences curriculum as proposed in the NCS. Learning Outcome 1 of the NCS is explored because it emphasises the practical scientific inquiry aspect in the teaching and learning of Physical Sciences (DoE, 2003).

Through Learning Outcome 1 Physical Sciences teachers should design learning activities that would enable learners to use a variety of skills necessary for critical thinking and scientific reasoning, and various strategies that would assist them to solve problems related to technological, environmental and everyday challenges (DoE, 2003). For poorly resourced schools the activities that are envisaged by this Learning Outcome are possible if Physical Sciences teachers can use the science resources that are available at the SRC.

This chapter includes a discussion of the science teachers' PCK, as drawn from various research studies. The constructivist theoretical framework will inform this study. Research studies in the teaching and learning of science in schools are also reviewed. Science resources encompass a variety of people, objects, policies and facilities to enhance the teaching of Physical Sciences. However, in this particular study science resources refer to science equipment used in the teaching and learning of Physical Sciences in South African secondary schools.

2.2 The state of Physical Sciences in South Africa

This study sheds light on how and why teachers use science resources in the teaching of Physical Sciences. The use of science resources has an influence on learner performance in Physical Sciences (Bybee & Fuchs, 2006). Learner performance is therefore a vital indicator of the state of Physical Sciences.

TIMSS is designed to help countries all over the world improve student learning in mathematics and science. The study was first conducted in 1995 and collected educational achievement data from learners who were in Grades 3, 4, 7, 8 and 12. The purpose of these data was to provide information about trends in performance over time together with detailed background information to address concerns about the quantity, quality and content of instruction. Data were generated from tests, questionnaires, curriculum analyses, videotaped classroom observations, and policy issue case studies. Learners were assessed in mathematics and science, and broad information about the teaching and learning of these subjects was collected from learners, teachers, and school principals (Beaton, *et al.*, 1996).

TIMSS supplies valuable information to developers of education policies and allows identification and monitoring of educational equity. Learners from approximately 50 countries around the world participated in TIMSS 2003 (Howie, 2003). The first study was conducted in a four-year cycle in 1995, the second cycle was in 1999 and the fourth cycle was in 2007 (Martin, Mullis, Gonzalez, & Chrostowski, 2004).

Mathematics and science curricula of the participating countries were examined through curricula guides, textbooks and other curricular materials. A

series of reports about the performance of the participating countries in the TIMSS study were released in 1996 and 1997 (Martin, *et al.*, 2004). These reports contained valuable information for policy makers and practitioners in the participating countries.

A study conducted by Howie (2003) reported that South African learners had the lowest marks in Physical Sciences compared to other countries that took part in the Third International Mathematics and Science Study (TIMSS) conducted in 1985. The science mean score for South African Grade 12 learners was significantly lower than the international benchmark of 500 (Howie, 2003). The study further reveals that South African learners from Grades 8, 9 and 12 performed poorly in any individual science topic in the TIMSS test (Howie, 2003).

The International Association for Educational Achievement sponsored the repeat study of TIMSS, the TIMSS-Repeat (TIMSS-R) (Martin, *et al.*, 2004). Grade 8 learners from 38 countries took part in the TIMSS-R, which was undertaken in 1998/1999. The purpose of the TIMSS-R was to determine whether any developments had occurred since 1995. The Human Science Resource Council funded and conducted a study in South Africa in which more than 8000 pupils from 200 schools participated. South African learners also performed the lowest in mathematics and science in the latest TIMSS-R study, in which 38 countries participated (Martin, *et al.*, 2004).

A number of developing and newly developed countries participated, such as Thailand, Chile and African countries like Morocco, Tunisia and South Africa. The performance of South African learners in mathematics and science topics

was again the lowest compared to other countries that took part (Howie, 2003), with less than 40 learners from South Africa among the top-level pupils. The study indicated that internationally boys outperformed the girls in both mathematics and science but no such difference was found in South Africa (Howie, 2003).

The study also revealed that most South African learners experienced challenges with regard to communication of scientific conclusions in the English and Afrikaans languages which are currently used for matriculation examinations (TIMSS, 2003). Second-language learners could not articulate their answers to open-ended questions, and had trouble with the comprehension of several others. In addition, acquisition of basic knowledge of mathematical and scientific concepts that would be expected at Grade 8 level was lacking in the Grade 8 South African learners (Martin, *et al.*, 2004).

A study conducted by Mji and Makgato (2006) reported that the TIMSS-R study conducted in 1999 revealed that South African Grade 8 learners once again performed poorly, with a mean score of 275, which was lower than the international mean of 487. A later TIMSS-R conducted in 2003 indicated no improvement by South African science learners (Mji & Makgato, 2006).

The above research statistics reveal that South Africa faces a huge challenge in the teaching and learning of Physical Sciences. The TIMSS results have generated numerous discussions and concerns internationally and nationally. The information supplied by the TIMSS results also compels us to question our approach to science teaching. Howie (2003) points out that there are numerous challenges facing South Africa in reforming science education.

Apart from inadequate infrastructure, most South African schools lack the basic requirements necessary for effective teaching and learning of science in schools, such as science textbooks, laboratories and science equipment (Howie, 2003). This is reflected by the statistics that were alluded to earlier, which reflected the number of South African schools with access to laboratories. This also resonates with the findings of James, Naidoo and Benson (2008) that some schools in South Africa have neither well-trained science educators nor science resources and laboratories.

South Africa has passed through a period of political change during the past two decades. The South African Government is committed to addressing issues of equity and justice amongst all its citizens (Johnson, Hodges & Monk, 2000). Among the changes which are of priority in South Africa is the transformation of education; this saw a new curriculum being ushered in as a means to effect social change. Introduction of the new curriculum in South African schools is among the attempts that have been made to address the previous and current states of science in schools. However, much work still needs to be done on implementation issues in South Africa in order for the promises of the new curriculum to make an impact in schools, and to provide the next generation with a better education (Rogan & Grayson, 2003).

Research studies (World Science Forum, 2007; James, Naidoo & Benson, 2008) indicate that there is a direct correlation between a nation's wealth and its scientific and technological capacity. Currently, South Africa does not have the capacity to participate in the technologically advancing global village (Mji & Makgato, 2006; Pratzner, 1994; Frantz, Friedenber, Gregson & Walter, 1996; Ramsuran, 2005; Gardner & Hill, 1999; Department of Arts, Culture, Science

and Technology, 1996). In South Africa there is a need to make a national effort to promote science and technology as a means to improve living standards (James *et al.*, 2008). According to James *et al.*, (2008), South Africa is in need of scientifically and technologically qualified individuals who are passionate about science and technology and would be able to use their skills to advance this country economically.

Several reports (World Science Forum, 2007; Johnson *et al.*, 2000; Mji & Makgato, 2006; Rogan & Grayson, 2003) suggest that the current situation in South Africa is aggravated by a number of challenges. These include a large number of under-qualified and/or unqualified teachers, low teaching standards, outdated teaching practices and under-resourced classrooms (Mji & Makgato, 2006). A major problem in South Africa is a lack of subject matter knowledge (SMK) of some teachers (Rogan & Grayson, 2003). Rogan and Grayson (2003, p. 1175) also state that “more than 60% of practising science teachers has had no formal training in science”. Johnson *et al.*, (2000), also state that science teachers who received poor academic training also lack in the mastery of science content.

Some schools that offer science do not have the facilities and equipment to promote effective teaching and learning (Johnson *et al.*, 2000; James *et al.*, 2008). This situation has resulted in the teaching of Physical Sciences at a theoretical level, without any experiments to enhance understanding and application of knowledge (Mji & Makgato, 2006; Johnson *et al.*, 2000, p. 141). Johnson *et al.*, (2000, p. 141) further argue that in science education “the lack of resources (such as science equipment, chemicals and specimens) and the limitations it imposes on teachers’ activities is more striking than it is with other

non-technical subjects such as mathematics, languages, social studies or expressive arts”. However, Mji and Makgato (2006) and James *et al.*, (2008) affirm that the lack of resources in schools could be addressed by the provisioning of resources.

Johnson *et al.*, (2000) argue that the new national curriculum of South Africa will be delivered differently because of the differences that are a legacy of apartheid. Johnson *et al.*, (2000) point out that outdated teaching strategies are the result of conditions in which teachers work. Rural school teachers are still faced with conditions such as overcrowded classrooms, lack of and/or insufficient books, lack of science resources and equipment, and so on. Johnson *et al.*, (2000, p. 183) further state that the physical environment of the classroom has a bearing on what teachers can attempt to do: “Professionalism is not differentially distributed because of the inadequacies of individuals within the system but it is differentiated because of the variety of systems within which individual teachers work”. The teachers of Physical Sciences are faced with multiple challenges and are expected to implement the curriculum, at the core of which is the NCS.

2.3 The National Curriculum Statement

The Constitution of South Africa provided a basis for curriculum transformation and development. The necessity to transform South African society by making use of various transformative tools stems from a need to address the legacy of apartheid in all areas of human activity, and in education in particular (DoE, 2003). One of the aims of the Constitution is that “everyone has a right to

further education which the state, through reasonable measures, must make progressively available and accessible” (DoE, 2003, p. 1).

The NCS Grades R - 12 stipulates policy on curriculum and assessment in the schooling sector (DoE, 2003), and consists of an Overview Document, the Qualifications and Assessment Policy Framework, the Subject Statements and the Learning Programme Guidelines.

The Subject Statements explain development from one grade to another, and a Learning Programme specifies concepts to be learnt for the three grades (10 - 12) and assessment thereof in the Further Education and Training (FET) band (DoE, 2003). Outcomes-based education (OBE) strives to enable all learners to reach their maximum learning potential by setting the Learning Outcomes to be achieved by the end of the education process (DoE, 2003). The use of science resources in science lessons would create the opportunity for the achievement of Learning Outcome 1.

To improve implementation, the NCS was amended, these amendments are due to come into effect in the foundation phase and grade 10 in January 2012. A single comprehensive Curriculum and Assessment Policy Statement (CAPS) document was developed for each subject to replace Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grades R - 12 (Department of Basic Education, 2011a).

The NCS for Physical Sciences defines Physical Sciences as an investigation of physical and chemical phenomena. According to the NCS, Physical Sciences should aim at promoting knowledge and skills in scientific inquiry and problem solving; the construction and application of scientific and

technological knowledge; and an understanding of the nature of science and its relationships to technology, society and the environment (Department of Basic Education, 2011a).

The CAPS for Physical Sciences requires that “practical investigations and experiments should assess performance at different cognitive levels and focus on process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts” (Department of Basic Education, 2011a, p.108). The CAPS outlines several practical activities for formal and informal assessment that must be integrated with theory to strengthen the concepts being taught in Grades 10 - 12.

According to the CAPS, formal assessment in Physical Sciences includes all assessment tasks that make up a formal programme of assessment for the year. Formal assessment tasks are marked and formally recorded by the teacher for progression and certification purposes. They are subject to moderation to ensure that quality and appropriate standards are maintained. Informal assessment is a daily monitoring of learners’ progress which is done through observations, discussions, practical demonstrations, and so on, and does not need to be recorded. In both formal and informal assessments regular feedback should be provided to learners to enhance the learning experience (Department of Basic Education, 2011a). According to the new curriculum, when assessment indicates lack of progress, teaching and learning approaches should be changed accordingly (DoE, 2003).

Although the new curriculum places emphasis on new teaching strategies, Johnson, *et al.*, (2000, p.186) argue that unless the environment in which teachers work changes, training teachers will not permanently change their practice: “Changing the environment will enable teachers who have the appropriate pedagogical content knowledge to use different teaching strategies”. Research by Johnson *et al.* (2000) further indicates that a change in classroom practice involves a combination of both changes of the circumstances within which a teacher works and to each individual teacher’s PCK.

2.4 Science teachers’ pedagogical content knowledge

PCK is a theoretical construct that was introduced by Shulman (1986, 1987), who (1986, p. 9) describes it as the “particular form of content knowledge that embodies the aspects of content most germane to its teachability and that comprises the ways of representing and formulating the subject that make it comprehensible to others” (Bucat, 2004a, p. 217). According to Bucat (2004b) PCK refers to the ability to know about the particular teaching and learning demands of a particular topic. Bucat (2004a, p. 217) further defines PCK as “knowledge about the teaching and learning of a particular subject matter that takes into account the particular learning demands inherent in the subject matter”. De Miranda (2008) refers to PCK as those strategies employed in teaching that bring about the best learning experience for every learner.

PCK has been identified as an important aspect in terms of the impact science teachers may have on improving performance in Physical Sciences (Mji &

Makgato, 2006). Loughran, Mulhall and Berry (2008) suggest that the development of PCK in science teachers not only increases their confidence about teaching science but also provides them with a useful framework for preparing meaningful science lessons. This view is confirmed by the fact that the science student teachers in the study conducted by Loughran *et al.* (2008) who used PCK in their practice teaching benefited. They were able to challenge the traditional science teaching practices in schools (Loughran *et al.*, 2008). Johnson *et al.* (2000, p. 185) say that “The actual classroom practice each teacher uses for a particular topic can only be selected from the teacher’s stock of pedagogical content knowledge”.

Various studies (Loughran *et al.*, 2008; De Miranda, 2008; Bucat, 2004a) have been conducted on PCK and its impact on science teaching. These studies view PCK as an academic construct that bridges the gap between theory and practice by allowing teachers to have more control over their teaching practice.

Other researchers (Abell, 2007; Soonhye & Oliver, 2007) elaborated on Shulman’s (1986) ideas and described PCK as consisting of five components of teacher knowledge which develops over time. These five components are discussed briefly below.

- *Orientation*

This involves knowledge of the general way of conceptualizing science teaching, which includes approaches used by science teachers to teach certain science concepts (Abell, 2007). This component refers to each individual teacher’s beliefs about the

purposes and goals for teaching science at different grade levels (Soonhye & Oliver, 2007). According to Soonhye and Oliver (2007), orientations serve as a guide to instructional decisions and particular curricular materials and instructional strategies to be used during science teaching.

- *Requirements for learning certain concepts*

This component refers to knowledge of teaching strategies to be used to deal with learners' misconceptions. This means that teachers must have knowledge about what learners know about a topic, and what learning difficulties they have. Teachers should understand areas of likely difficulty and should be aware that learners have a variety of learning styles.

- *Curriculum knowledge*

Curriculum knowledge is concerned with knowledge of specific curriculum goals and objectives as stipulated by the national standards. It refers to teachers' knowledge of materials available to teach particular science content.

- *Knowledge of science instructional strategies*

This component includes knowledge of teaching methods and strategies to be used in teaching certain science topics. It includes subject-specific strategies which are the general approaches to teaching instruction, and strategies which are specific to teaching

particular science topics.

- *Science assessment*

Science assessment refers to teachers' knowledge and understanding of assessment strategies used in science and how to design assessment activities as required by the national curriculum and assessment policy.

Soonhye and Oliver (2007) state that teachers who integrate all five components of PCK transform a challenging situation during teaching into a teachable moment. This implies that effective teaching occurs when teachers integrate these five components within a given context. According to Soonhye and Oliver (2007), complementing and readjusting both 'reflection-in-action' and 'reflection-on-action' facilitates changes in teaching practice. Each of these terms is defined below.

Soonhye and Oliver (2007) further state that knowledge-in-action is knowledge that is developed and endorsed during the teaching process through 'reflection-in-action', while 'knowledge-on-teaching' refers to knowledge developed after teaching, 'reflection-on-teaching'. Both these features of PCK are salient during teaching. This assertion also supports the idea that teachers do not simply receive knowledge that others create to teach, but produce knowledge for teaching through their own experiences (Soonhye & Oliver, 2007).

Cochran, DeRuterr and King (1993) maintain that both teachers' pedagogical knowledge and their SMK are essential for good science teaching. According to Cochran *et al.* (1993), the integration of pedagogical knowledge with SMK constitutes PCK. Cochran *et al.*, (1993) further state that science teachers differ from scientists due to the fact that they possess organized knowledge which is used as a basis for developing new knowledge in the field of science teaching. However, Cochran *et al.* (1993) argue that novice teachers tend to rely on unmodified SMK and often find it difficult to articulate the relationships between pedagogical ideas and subject matter concepts. PCK is much more than SMK and develops over time as a result of teaching experience.

The development of PCK is embedded in individual teachers' classroom practice (Loughran, Mulhall & Berry, 2004, 2006, 2008; Padilla, Ponce-de-León, Rembado & Garritz, 2008). Mulhall, Berry and Loughran, (2003) further state that novice teachers and teachers who have not taught a particular topic before may have little or no PCK in that specific learning content. According to Mulhall *et al.*, (2003), successful teachers in a given content area have a well-developed PCK. To illustrate successful teachers' PCK, these researchers have used two integrated formats, namely Content Representation (CoRe) and Pedagogical and Professional-experience Repertoires (PaP-eRs).

Mulhall *et al.*, (2003) define CoRe as an overview of the particular content which has to be taught when teaching a topic, and PaP-eRs as the accounts of practice intended to illuminate aspects of CoRe in a particular classroom context. According to Mulhall *et al.*, (2003, p. 9), CoRes "provide some insights into the decisions that teachers make when teaching a particular

topic, including the linkages between the content, the students and the teachers' practice".

PaP-eRs represent the "thinking and actions of a successful science teacher in teaching a specific aspect of a science topic" (Mulhall *et al.*, 2003, p. 9). Mulhall *et al.*, (2003) believe that this exploration of aspects of PCK may be helpful for experienced and practising teachers, because they are able to make a deeper interpretation of events within the context in which they teach. To affirm this assertion, Bucat (2004a, p. 9) states that a "pedagogical-content knowledgeable teacher is better placed than otherwise to make sound choices between alternative courses of action based on content-specific reasoning, in order to maximise the richness of learning". Bucat (2004a) refers to a "pedagogical-content knowledgeable teacher, a constructivist teacher" who creates situations that would enable learners to link new knowledge with pre-existing knowledge. This kind of learning is in accordance with the constructivist view of learning.

2.5 Constructivism in learning to teach science

Gray (1997) defines constructivism as a view of learning based on the belief that knowledge is constructed through an active, mental process of development. According to Gray (1997), constructivism draws on the developmental work of Kelly (1991). Twomey (1989) defines constructivism by making reference to four principles of learning: constructivism is that kind of learning which depends on what we already know; new ideas occur as we adapt and change our old ideas; learning involves inventing ideas rather than

mechanically accumulating facts; and meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with our old ideas.

The NCS for Physical Sciences envisages teachers who are researchers and lifelong learners to become competent science teachers (DoE, 2003). This view is in accordance with the proposition made by Gray (1997) that teachers need to make a shift in their thinking and become constructivist teachers. This view resonates with Kelly's (1991) personal construct theory. According to Gray (1997), the constructivist theory proposes that science teachers should continually be able to hypothesize about experience, and then formulate expectations according to the pattern of reality they have created through their experience and reflection on their teaching. Through accumulated experience teachers come to believe something, and then interpret experience according to those beliefs. A belief that knowledge is constructed by human beings enables teachers to teach in a constructivist way (Lester & Onore, 1990).

Forster (2006) also states that the theoretical framework of constructivism assumes that a person constructs his/her own reality. This means that a person makes sense of phenomena by interpreting what is happening and acting on that interpretation. A person does not observe things in a strictly objective manner, the way those things really happen. Instead, individuals develop unique personal constructs or personalized perspectives, which they use to interpret what comes to their attention.

Teachers' personal beliefs about teaching, namely, the construct systems, explain the kinds and extents of change that teachers are able to make in their teaching practice (Lester & Onore, 1990). According to Lester and Onore (1990) teachers are able to view their situations through their personal construct systems; teachers' beliefs about teaching and learning account for their thinking and actions as teachers. Lester and Onore (1990, p. 41) propose that "genuine learning or change comes not from disregarding all prior learning in order to relearn, but from questioning or reassessing our existing beliefs about the world". This view holds that learning can occur through having experiences that present and represent alternative systems of beliefs, and trying to find a place for new experiences to fit into already existing beliefs.

Mezirow (1990) explains that the ability to cross the bridge in the way one thinks and believes about teaching is possible by reflecting on one's teaching practice. According to Mezirow (1990), individual teachers who reflect on their teaching are able to change their teaching practice from transmission type of teaching to a constructivist and translational one. This type of practice might be a problem to novice teachers and other inexperienced science teachers, but transactional and constructivist practices can be modelled through workshops and other teacher training programmes (Mezirow, 1990; James *et al.*, 2008). Teacher in-service programmes can also create opportunities for issues and other teacher concerns to be discussed as teachers begin to make their transition to constructivist teaching (Mezirow, 1990).

Information about constructivist philosophy and practices written in a non-threatening style that complements teachers' current personal and practical

knowledge would perhaps make personal and professional development towards a constructivist practice interesting (Mezirow, 1990). Mezirow (1990) adds that teachers may be confident to embark on professional development programmes, and may be encouraged to be less reserved to risk innovative practices if information is presented in a friendly and creative style. This view resonates with the South African Government's view of teaching - hence the introduction of CAPS.

Another way of constructivist thinking is explained by Giroux (1986) when he advises that teachers must be more than technicians but transformative intellectuals engaging in a critical dialogue among them. Changing the traditional ways of teaching without changing how one thinks about teaching and learning is, according to Lester and Onore (1990), insufficient to change one's teaching practice.

Given the theories about constructivism in science education and science teachers' pedagogical content knowledge, there are facilities to assist in science teacher development. Locally, Science Resource Centres aim to "address historical, systemic imbalances inherent in the South African education system by improving and sustaining the quality and accessibility of Mathematics and Science education" (James, et al., 2008, p.1). The Science Resource Centre being studied here is a teacher development unit which attempts to address teachers' cognitive and pedagogical development by providing school based support and resources for Mathematics and Science teachers in poorly resourced teaching communities (James, et al., 2008). It is not a Science Centre as in the South African context; Science Centres offer an

interactive learning space for learners. Science Resource Centres differ because their main purpose is professional development of teachers.

Internationally, Science Resource Centres appear to cater for a wider audience which includes teachers, learners, administrators and public in general. In the United States of America three Science Resource Centres are used to give insight into this facility. Firstly the Science, Technology, Engineering and Mathematics (STEM) Education Coalition represents all sectors of the technological workforce. Secondly, the Science Education Resource Centre (SERC) houses inventory books, videos, science equipment and live animals to supplement and enrich the school curriculum. Thirdly, the National Science and Resource Centre (NSRC) also houses a collection of earth science maps, rocks and minerals, science materials, astronomy materials about the solar system and constellations. A brief overview of the purpose of Science Resources Centres locally and internationally was highlighted.

2.6 Summary

This chapter examined a range of factors pertaining to science education in South Africa as well as key concepts related to science teaching. The findings of TIMSS studies as well as the various challenges encountered by Physical Sciences teachers were explored. The development of the NCS as the Government's response to the challenge was outlined. Ways in which PCK is conceptualized by different researchers were detailed. The view of a pedagogical content knowledgeable teacher as one who embraces the tenets of constructivism in becoming an effective teacher was discussed.

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

| CONTENTS | PAGE |
|---------------------------------|-------------|
| 3.1 Introduction..... | 30 |
| 3.2 Research design..... | 30 |
| 3.3 Context of the study | 32 |
| 3.4 Sampling..... | 33 |
| 3.4.1 Sampling strategy..... | 34 |
| 3.4.2 Sample size..... | 35 |
| 3.5 Data collection..... | 36 |
| 3.6 Ethical considerations..... | 39 |
| 3.7 Validity..... | 40 |
| 3.8 Summary..... | 41 |

3.1 Introduction

This chapter provides details of the research process. It covers the research design, context of the study, methodology and sampling strategy used as well as the paradigm framing the study, and reasons for employing that particular paradigm. The research sites, data collection methods and procedures followed to meet ethical requirements are also explained. The chapter concludes by presenting how the issues of validity were addressed when the study was undertaken.

3.2 Research design

This qualitative study which explored the use of an SRC by Physical Sciences teachers was located within the interpretive paradigm. Qualitative research uses a naturalistic approach to understand the phenomena being studied (Patton, 1990). This means that in the qualitative approach, the researcher attempts to observe, describe and interpret settings as they are (Strauss & Corbin, 1990), thus allowing the social world to be studied in its natural state, without intervention or manipulation by the researcher (Cohen, Manion & Morrison, 2007). In addition, the qualitative approach has an interpretive character which is aimed at discovering the meaning that events have for the individuals who experience them, and the interpretations of those meanings by the researcher (Eisner, 1991).

The interpretive paradigm strives to understand and interpret the world in terms of its participants, and how the participants themselves define the social

reality (Cohen *et al.*, 2007). Interpretation of reality, according to Cohen *et al.* (2007), involves giving meaning to data from the point of view of the people being studied. By using a qualitative research strategy I aimed to allow data to emerge from the research itself (Eisner, 1991).

A qualitative case study approach was used in this study. According to Cohen *et al.* (2007, p. 254), case studies are “descriptive and detailed since they involve looking at a phenomenon in its real-life context, and seek to portray thick descriptions of participants’ lived experiences of, thoughts about and feelings for a situation”. A case study design was therefore significant for my study since case studies allow situations to speak for themselves rather than being largely interpreted, evaluated or judged by the researcher (Cohen *et al.*, 2007). In addition, case studies are preferred strategies when ‘why’ and ‘how’ questions are being posed (Bassegy, 1999; Yin, 2009). This made case study methodology relevant to engage with the following research questions:

1. Why do Physical Sciences teachers use the Science Resource Centre?
2. How do the Physical Sciences teachers use the Science Resource Centre?

I was, however, aware that case studies have been criticized for their inability to allow one to generalize from the findings, but Wellington and Ireson (2008) state that people reading from case studies can often relate to them, even though they cannot always generalize from them.

3.3. Context of the study

The Physical Sciences teachers who were the participants in the study came from eight high schools in the Empangeni education district of the province of KwaZulu-Natal in South Africa. The schools were affiliated to the SRC. Seven of the eight schools were situated in rural parts of Empangeni and were under-resourced in terms of science equipment. The eighth school, although located in a semi-urban township and not as rural as the other seven schools, also lacked science resources. These were the ex-Department of Education and Training (DET) schools that were (and are still) historically disadvantaged. Ex-DET schools are schools which were designed for learners from the black race group during the apartheid era. Implicit in the design of these schools was a mechanism to ensure a low quality of education in general and science education in particular. Physical Sciences was taught, but at a theoretical level without any experiments to enhance understanding and application of knowledge, which Mji and Makgato (2006) view as important. None of the schools had a fully equipped science laboratory.

The schools were among the poorest schools because the parents of the learners were unemployed and could not afford to pay school fees. As a result of unemployment within the parent community, the schools were ranked as 'no-fee schools' by the DoE (Sayed & Motala, 2009). The South African Government introduced the no-fee school policy to end the marginalization of poor learners, as per the country's Constitution that states that every citizen has a right to basic education. The no-fee policy empowers the Minister of Education to exempt certain schools from charging fees, based on poverty levels of the area they serve (Gadebe, 2006). Although the new Government

is now in its fourth term of office, the old inequalities of apartheid remain in the provision of education in other South African schools (Johnson *et al.*, 2000).

The SRC is situated in Richards Bay, a town which is about 15 km from Empangeni. The SRC is equipped with resources for Physical Sciences and Life Sciences. The Physical Sciences resources include portable physics and chemistry kits that could be used for most of the Physical Sciences topics. Schools therefore affiliate to the SRC by paying a minimum fee of R150 per annum so that teachers can have access to the science resources available there. This study focused on how teachers in Empangeni education district, who had access to the SRC, used the Centre.

3.4 Sampling

According to Cohen *et al.* (2007), sampling is a procedure used by the researcher to select a smaller group of people, places, or things to study from a population of interest. Factors such as expense and time should also be considered when a researcher chooses a sample, because these factors frequently prevent researchers from gaining information from the whole population. This smaller group, called a sample, will be a representation of the whole population. Cohen *et al.*, (2007) identify key factors to be considered by the researcher in sampling, which include the sample size, representativeness and parameters of the sample, access to the sample and the sampling strategy.

3.4.1 Sampling strategy

Sampling strategy is the plan a researcher sets forth to be sure that the sample used in a research study represents the population from which one drew a sample (Denzin & Lincoln, 2000). Cohen *et al.* (2007) state that the quality of a piece of research lies not only in the appropriateness of methodology or instrumentation, but also on the suitability of the sampling strategy adopted. As explained by Denzin and Lincoln (2007), selection of a sample can either be random or non-random. In a non-random sample (also known as a non-probability sample) some members of the wider population will be deliberately (or purposefully) excluded and others will be included (Cohen *et al.*, 2007).

Cohen *et al.*, (2007) state that although non-probability samples are not representative enough, they are often used in small-scale studies because they are far less complicated to set up and are less expensive. Qualitative and interpretive studies usually use several types of non-probability samples which include, among others, convenience sampling, quota sampling, snowball sampling and purposive sampling (Van Driel, Verloop & de Vos, 1998).

This study adopted a qualitative approach; therefore a purposive non-probability sampling strategy was used to select the sample. According to Cohen *et al.*, (2007), purposive sampling is used in order to access data from people who have in-depth knowledge about a particular issue. The participants in the study were the Physical Sciences teachers whose schools

were affiliated to the SRC. For this reason, the participants chosen were in a position to give information on how and why they use the SRC.

3.4.2 Sample size

According to Cohen *et al.*, (2007) sample size depends upon various factors. These factors include the purpose of the study, the nature of the population studied and, most importantly, what the researcher wants to know. In general, larger samples are better because they increase the reliability of the research data; however, in qualitative research sample size is usually small (Cohen *et al.*, 2007). Cohen *et al.*, (2007, p. 101) state that “researchers need to think out in advance of any data collection the sorts of relationship that they wish to explore within subgroups of their eventual sample”.

Cohen *et al.*, (2007) further state that determining the size of the sample should take account of non-response, attrition and participant mortality, since some participants will leave the research, fail to return questionnaires or return incomplete or spoiled questionnaires. This said, Gorard and Taylor (2004) state that it is advisable to over-estimate rather than under-estimate the size of the sample required.

In this study a sample of eight Physical Sciences teachers whose schools were affiliated to the SRC was chosen because my primary concern was to acquire in-depth information on how and why they use the SRC in their teaching of Physical Sciences. Also, access to sample participants was going

to be possible since these teachers visited the SRC where I, the researcher, am employed.

3.5 Data collection

Qualitative studies collect data via interviews, observations and focus groups. The table below indicates the data collection procedures that were used in this study.

Critical Question 1: Why do Physical Sciences teachers use the Science Resource Centre?

Table 3.1: Data generation strategy to respond to critical question 1

| GUIDING QUESTIONS TO GENERATE DATA | JUSTIFICATION FOR STRATEGY TO GENERATE DATA |
|--|---|
| 1) What information do I want? | Reasons why Physical Sciences teachers use the SRC. |
| 2) Why do I need this information? | To determine why Physical Sciences teachers use the SRC. To determine why Physical Sciences teachers use chosen ways to use the SRC. |
| 3) What is the source of this information? | Physical Sciences teachers and policy documents. |

| | |
|---|---|
| 4) How would I collect this information? | Eight Grade 12 Physical Sciences teachers from eight rural high schools were interviewed using face-to-face semi-structured interviews. Interviews were tape-recorded. |
| 5) Why do I think that this instrument is the most appropriate instrument to use to collect the data? | Face-to-face individual interviews were able to provide direct evidence of Physical Sciences teachers' intentions and usage of the SRC. Semi-structured interviews created opportunity for teachers to give information which I would not have thought of or tried to capture using any of the instruments. |

Critical Question 2: How do Physical Sciences teachers use the Science Resource Centre?

Table 3.2: Data generation strategy to respond to critical question 2

| GUIDING QUESTIONS TO GENERATE DATA | JUSTIFICATION FOR STRATEGY TO GENERATE DATA |
|--|--|
| 1) What information do I want? | Ways in which Physical Sciences teachers use the SRC. |
| 2) Why do I need this information? | To understand how Physical Sciences teachers intend to use the SRC and how they actually use the SRC in their teaching of Physical Sciences. |
| 3) What is the source of this information? | Physical Sciences teachers and policy documents. Lesson plans. |

| | |
|---|---|
| 4) How would I collect this information? | <p>Examining a selection of lesson plans.</p> <p>Conducting individual interviews with teachers who teach Physical Sciences.</p> |
| 5) Why do I think that this instrument is the most appropriate instrument to use to collect the data? | <p>The semi-structured face-to-face individual interviews offered greater flexibility and freedom to the participants. It was going to be easy to compare the response because the participants answered the same questions. This was going to facilitate organisation and analysis of data (Cohen <i>et al.</i>, 2007).</p> <p>Semi-structured individual face-to-face interviews gave me the opportunity to probe and expand interviewees' responses. Furthermore, due to the fact that I was familiar to all my participants, such interviews contributed to an informal, comfortable and non-threatening environment for my participants (Fraenkel & Wallen, 1990).</p> |

Tables 3.1 and 3.2 indicate that semi-structured face-to-face individual interviews were conducted at the schools where each participant taught. The duration of each interview was approximately 45 minutes. An interview schedule was prepared beforehand to ensure that the participants were asked similar questions and also to maintain consistency. Open-ended questions were selected to formulate the interview schedule. The advantages of using open-ended questions is that they are flexible and allowed me to probe deeper into my participants' responses if I needed to (Cohen *et al.*, 2007). In addition, they would allow participants to talk freely about their own experiences. I also

tried to talk less so as to avoid a situation where I would end up imposing my own views.

I believed that a semi-structured and open-ended framework was going to encourage cooperation and help strengthen the rapport between myself and my participants. All interviews were audio-taped with consent from the participants and later transcribed. Tape-recording was done to ensure completeness of the verbal interactions. All questions were in English and all participants were expected to answer in English. Ethical aspects of interviewing were adhered to, as discussed in the following section.

3.6 Ethical considerations

An application for ethical clearance was made to the Ethics Committee of the University of KwaZulu-Natal and was obtained before the study commenced. A written consent form which described the study and its purpose was presented and explained to each participant before the data were gathered. Participation in the study was voluntary, and the participants were informed that they could withdraw from the project at any time without any negative consequences. Consent letters specified the voluntary, autonomous engagement of participants. In this way the ethical requirements and tenets of informed consent were met. The participants signed the letters before participating. In addition, although the school principals and SRC director were not going to be participants, they were also informed about the study. To ensure anonymity, pseudonyms were used instead of the school names, and alphabetical letters (A - H) were used instead of the participants' real names.

3.7 Validity

According to Denzin and Lincoln (2000), validity has to do with the degree of capturing the reality of the situation under investigation. Cohen *et al.* (2007) state that validity is an important key to effective research, and there are key aspects that researchers should consider as a way of addressing it, particularly in qualitative research. Some of these aspects include honesty, depth, richness and scope of the data generated, while others include how the participants were approached and the extent of the triangulation of data.

Lincoln and Guba (1985) point out that trustworthiness of a research study is important in evaluating its worth, which involves establishing credibility, transferability, dependability and confirmability. Denzin and Lincoln (2000) define each of these terms as important issues in validating case studies. Credibility refers to confidence in the 'truth' of the findings. Transferability is a means of showing that the findings have applicability in other similar contexts; it intends to establish the extent to which findings from the study can be used by another researcher. Another important issue of validating the data in naturalistic studies is dependability, which concerns the issue of whether the process and findings of the study are consistent with time and across other researchers, and could be repeated. Finally, confirmability involves a degree of neutrality or the extent to which the findings of a study are shaped by the participants, and not by researcher bias.

In the light of the above discussion, trustworthiness of the data was ensured by returning the transcripts to interviewees to read and verify the accuracy of what had been stated as having been said by the participant. Validity can be

enhanced by having participants read the data and contact the researcher should they wish to clarify their verbal comments. Validity was addressed by selecting the Physical Sciences teachers who knew about the SRC and its purpose to be participants rather than any Physical Sciences teachers who might have no idea about the SRC. Cohen *et al.* (2007) point out that the researcher should locate discussions of validity within the research paradigm that is being used by the researcher.

3.8 Summary

This chapter discussed the research design that informed the study process. The relevance of the case study approach to the study was also described and argued for. The qualitative methodology used as well as the paradigm it adopted were described. The type of data collection procedures that were followed, including the sampling strategy, a description of the research site and the research participants, and using interviews were strategies employed to increase the trustworthiness of the data which were generated, and were all discussed.

CHAPTER 4
DATA PRESENTATION AND ANALYSIS

| CONTENTS | PAGE |
|--|-------------|
| 4.1 Introduction..... | 43 |
| 4.2 The teachers..... | 43 |
| 4.3 The interview process..... | 50 |
| 4.4 Analysis of results..... | 51 |
| 4.4.1 Construction of the CoRes..... | 52 |
| 4.4.2 Discussion of the CoRes..... | 56 |
| 4.4.3 Construction of the PaP-eRs..... | 59 |
| 4.4.4 Discussion of the PaP-eRs..... | 61 |
| 4.4.4.1 Practices before teaching..... | 61 |
| 4.4.4.2 Practices during teaching..... | 64 |
| 4.4.4.3 Practices after teaching..... | 67 |
| 4.5 Summary..... | 70 |

4.1 Introduction

This chapter presents data produced from interviews with Physical Sciences teachers from eight rural high schools in the Empangeni education district. It is a descriptive account of what they said regarding the use of science resources in their teaching of Physical Sciences in their schools.

The chapter begins by looking at the teachers' biographical details. This is followed by literature about Physical Sciences teachers and their capacity to teach Physical Sciences in the South African context. The interview process, dialogue and ethics of interviewing are also discussed. Finally, results are analysed by portraying the PCK of the eight teachers on the use of science resources by science teachers, as identified by Loughran *et al.* (2004), called CoRes and PaP-eRs.

4.2 The teachers

The participants were Physical Sciences teachers with varying experience in Physical Sciences teaching, as reflected in Table 4.1 below. All eight participants were appropriately qualified to teach Physical Sciences. The situation in these schools differed from the situation in other rural schools, where most science teachers are under-qualified or unqualified to teach Physical Sciences (Mji & Makgato, 2006).

Table 4.1: Teachers' biographical details

| Teacher | School | Gender | Age (yrs) | Teaching experience (years) | Science teaching experience (years) | Qualifications |
|---------|---------|--------|-----------|-----------------------------|-------------------------------------|--|
| A | Mukuza | M | 39 | 10 | 8 | Bachelor of Education degree |
| B | Dima | F | 38 | 12 | 12 | Bachelor of Education degree |
| C | Mango | F | 48 | 15 | 7 | Secondary Teachers Diploma, Higher Diploma in Education |
| D | Zimkhwa | M | 46 | 16 | 10 | Secondary Teachers Diploma |
| E | Motso | F | 38 | 12 | 4 | Secondary Teachers Diploma |
| F | Dlame | F | 38 | 10 | 6 | Secondary Teachers Diploma |
| G | Mathe | F | 40 | 12 | 8 | Secondary Teachers Diploma, Further Diploma in Education |
| H | Mngoza | F | 47 | 17 | 2 | Secondary Teachers Diploma |

Teachers E and H were novice teachers in Physical Sciences, particularly in Grade 12. Teacher E had been teaching Natural Sciences in Grades 8 and 9 for 8 years in her previous school before transferring to Motso High School. The reason for her transfer was to be closer to her home and to teach Physical Sciences in Grades 11 and 12. Teacher H had been teaching Mathematics to Grades 10 - 12 at Mngoza High School for 15 years. At the time of this study she was teaching both Mathematics and Physical Sciences to Grades 10 - 12 because the Physical Sciences teacher had resigned.

Although Mathematics and Physical Sciences were both her major subjects, she had a passion for Mathematics due to her greater experience in teaching it. The other six teachers had extensive Physical Sciences experience. However, Physical Sciences matric results for these schools for the past five years had fluctuated, as shown in Table 4.2.

Table 4.2: Average passes (%) of selected schools in Physical Sciences

| School | 2006 | 2007 | 2008 | 2009 | 2010 |
|---------|------|------|------|------|------|
| Mukuza | 33 | 34 | 21 | 19 | 31 |
| Dima | 100 | 51 | 96 | 14 | 77 |
| Mango | 30 | 61 | 100 | 2 | 81 |
| Zimkhwa | 50 | 64 | 67 | 50 | 57 |
| Dlame | 23 | 35 | 26 | 0 | 38 |
| Motso | 35 | 41 | 37 | 33 | 41 |
| Mngoza | 29 | 28 | 44 | 0 | 0 |
| Mathe | 25 | 33 | 37 | 30 | 57 |

The primary concern of this study was not matric performance; however, Physical Sciences matric results are a useful indicator in illustrating the impact of teachers' experience in Physical Sciences. The DoE specifies a school that has obtained less than 50% pass rate in Physical Sciences as underperforming in that subject (DoE, 2003). It may be observed from the table that of the eight schools, four had an average pass of 44% or less in the five consecutive years. At Dlame and Mngoza high schools none of the learners passed Physical Sciences in 2009. The information in the table

indicates that 2009 was the worst-performing year. Only one school managed to obtain an average pass rate of 50%. The other schools showed a fair increase in the number of learners who passed Physical Sciences in 2010, but Mngoza high school showed no improvement.

The poor performance of Mngoza can be attributed to the fact that teacher H lacked experience in teaching Physical Sciences. Although she was appropriately qualified to teach Physical Sciences, she lacked appropriate pedagogic skills that would allow her to engage learners in practical activities. Here one is reminded of Cochran *et al.*'s (1993) argument that a lack of experience results in teachers experiencing difficulty in forming relationships between content matter and pedagogical ideas. A lower degree of PCK is attributed to the novice teacher; this probably applies to teacher H, and impacts negatively on learner performance.

The South African DoE introduced a new curriculum for Grades 10, 11 and 12 over three years, to begin in 2006 (DoE, 2003). The new curriculum of South Africa has placed many demands on science teachers (Mji & Makgato, 2006). This resonates with studies by Rogan and Grayson (2003), Loughran, Mulhall and Berry (2006) and Jita and Mokhele (2008) that indicate that the new topics of the new curriculum presented problems even to experienced teachers. Some of the demands required science teachers to integrate new instructional methodologies in their teaching of Physical Sciences (James *et al.*, 2008).

According to James *et al.* (2008), the greatest challenge facing some South African science teachers is the fact that the new science curriculum requires them to teach new content that they have not previously encountered before.

Most experienced educators in South Africa face various problems with regard to implementation of the new curriculum. Implementation problems are common in the historically disadvantaged and under-resourced schools (Rogan & Grayson, 2003; Jita & Mokhele, 2008). The findings of this study suggest that the multiple reviews of the Physical Sciences curriculum in South Africa and numerous changes to policy resulted in inconsistent pass rates in the matric examinations.

James *et al.* (2008) also state that Physical Sciences teachers in South Africa need not only to update their skills and knowledge, but also need to update their roles as teachers. This view is in accordance with Johnson *et al.* (2000, p. 181) when they state that “knowledge is a necessary condition for teachers to change their classroom practice, but it is not a sufficient one on its own”. Abell (2007) also stated that SMK is necessary, but not sufficient for effective teaching. James *et al.* (2008) argue that most South African teachers are the victims of their own previous education; they teach in the manner in which they were taught. This was evident in the remark made by teacher D that:

... they did not receive proper training on the use of science resources and they did not have laboratories.

Research reflects that over 60% of practising science teachers in South Africa had had no formal training in Physical Sciences (Rogan & Grayson, 2003). This accounts for the poor performance in some South African schools. (This is, however, different from the qualifications of the participants in this study, as shown in Tables 4.1 and 4.2.) The results of this study do not resonate with Rogan and Grayson’s (2003) assertion, since all of the teachers in this study

were qualified to teach Physical Sciences. However, the learners' results were poor in many cases.

Rogan and Grayson (2003, p. 1186) argue that "poor resources and conditions can limit the performance of even the best of teachers". Teacher D endorsed this view:

... but then there is no proper training that is done to the teachers as to how I use since some of the teachers they just went for training without actually going to the laboratories, so there are teachers who are still struggling.

In a study conducted by Jita and Mokhele (2008) it appeared that many schools in South Africa struggle to offer high-quality instruction in science. Jita and Mokhele (2008) argue that the ability to offer quality instruction in a specific subject is not determined only by the presence or absence of particular resources, but also by the construction and organization of the school's resources and their use. Apart from the lack of resources in some South African high schools, the numbers of learners in classes is also a great challenge, particularly in rural schools (Jita & Mokhele, 2008). James *et al.* (2008) state that the educator-to-learner ratio is so high that science teachers only conduct practical demonstrations in science, instead of engaging learners in hands-on activities and direct experience of practical work. This view resonates with the following statement from a participant:

I have a huge class and most of them did not really grasp the concept of interference or diffraction when you talk about but when you theorize it.

Many teachers deal with large classes by teaching more of the theory and engaging learners in minimal practical work. This disadvantages learners who struggle to grasp abstract concepts.

The role of the SRC as an outreach and teacher professional development unit aimed at addressing historical and systemic imbalances inherent in the South African education system through provision of sciences resources to poorly resourced schools cannot be ignored here.

Jita and Mokhele (2008) also state that the competence of teachers in content, pedagogy and assessment of their subject areas contributes to the teaching and learning of science in the school. This view is supported by the average performance of Dima High School, which showed a decrease in performance only once, in 2009 (a year when many schools underperformed). The teacher at Dima had more than a decade of experience in teaching Physical Sciences, and this experience was likely to have contributed to relatively superior pass rates among learners. This is proof of the implication that “the less qualified and/or experienced a teacher is, the more pronounced the struggle with content and pedagogical content knowledge (PCK) is likely to be” (Jita & Mokhele, 2008, p. 268).

4.3 The interview process

I had established a rapport with the eight teachers who participated in the study. They had attended physics and chemistry practical workshops at the SRC once a term during 2008 and 2009. After each workshop we sat together and enjoyed meals and conversed in a relaxed atmosphere about teaching in general. Connolly and Clandinin (2000) state that sharing experience through discussions is an important way of accessing teacher's knowledge about practice. Similarly, Loughran *et al.* (2006) point out that through conversations, workshops and observations more can be learned about teachers.

The teacher participants and I engaged with one another during my visits to the schools to offer support in the teaching and learning of Physical Sciences in order to fulfill one of the SRC's aims, of improving science in schools. We also engaged with one another when these teachers arranged to have their learners visit the Science Centre (where the SRC is situated) to enable them to learn in a "fun" environment. These interactions served to allow me to become more familiar with the teachers. This also heightened my awareness of their challenges when teaching Physical Sciences. Although teachers B and G taught in semi-rural schools while the other six teachers taught in deep rural schools, none of the schools had facilities and equipment to promote effective teaching and learning in science. They equally struggled with challenges such as teaching large classes, poor resources, lack of laboratories and inadequate financial support from school management because the school community was poor.

During the interviews an atmosphere of mutual respect prevailed. I was able to “embrace” the teachers according to Buher’s philosophy of listening (Gordon, 2011, p. 208). I was able to do this because I was aware of how they were different from myself, and I was eager to accept them for who they were (Gordon, 2011). I had no desire to influence the participants’ responses by presenting my own ideas (Lipari, 2004). I attempted to be sensitive to the participants because some of them had less experience in employing hands-on strategies to teach Physical Sciences. As an interviewer I was aware of the importance of being what Lipari (2004) refers to as ‘a responsible listener’. I did this by being attentive to what they were saying and receiving their ideas without judging them.

4.4 Analysis of results

My analysis of the data obtained from the teacher interviews is based on the two frameworks for representing science teachers’ PCK, namely, CoRes and PaP-eRs, as proposed by Mulhall *et al.* (2003). CoRes and PaP-eRs will be used as analytical frames to answer the following two questions:

1. How do Physical Sciences teachers use the Science Resource Centre?
2. Why do Physical Sciences teachers use the Science Resource Centre?

4.4.1 Construction of the CoRes

According to Loughran *et al.* (2008, p. 1305) CoRes represent “conceptualisations of the collective PCK of teachers around a specific science topic. CoRes include content ideas, known areas of confusion, and ways of framing ideas to support student learning”. According to Mulhall *et al.* (2003, p. 6), CoRes “attempt to portray holistic overviews of teachers’ PCK related to the teaching of a particular science topic to make a tacit nature of this expert PCK explicit to others”. Loughran *et al.* (2008) state that a CoRe is not intended to prescribe what to teach but offers a basis which can be added or changed as further insights are gained or clarified. In addition, different teachers may develop different CoRes for the same topic (Loughran *et al.*, 2008).

The CoRe represented in Table 4.3 focuses on ‘big ideas’ that were analysed from teacher interviews. It provides an overview of how the participants understood the use of science resources to teach about the wave phenomena, a topic in the Physical Sciences syllabus. It was developed by asking teachers what they considered to be the ‘big ideas’ associated with the use of resources in their chosen topic. These ‘big ideas’ formed the horizontal axis of the CoRe shown in Table 4.3. The ‘big ideas’ were then developed and asked through the prompts that are listed on the left-hand side vertical axis of the CoRe. The CoRe therefore represents each participant teacher’s PCK as it links the how, why and what of the use of resources with what they think is important in shaping learners’ learning and teachers’ teaching.

The manner in which I used and constructed the CoRe differs from Loughran *et al.*'s (2004) work, where a large number of experienced science teachers were studied to explore the main ideas surrounding individual topics. From their interaction, many big ideas were extracted. The CoRe shown in Table 4.3 reflects the responses of three teachers who coincidentally used the resources to teach the same topic on waves. I decided to arrange the responses alongside one another to enable the reader to draw a comparison between the three teachers more easily. Based on the idea stated by Loughran *et al.* (2006, p. 23) that "a CoRe contains only the amount of information and ideas proposed by those involved in its formation", the horizontal axis of a CoRe contains the 'big ideas' - which refers to each of the science ideas that the teachers see as crucial for the use of science resources in their chosen topic. I therefore decided to use the responses from the interview questions as well as from lesson plans (Appendix F) as 'big ideas', so that each teacher's PCK on the use of science resources can be articulated. In addition, this study was not based on the particular science content per se, but the focus was on *why* and *how* Physical Sciences teachers use the SRC. This provided insights into the decisions that teachers made around the issue of the use of science resources in science teaching.

Table 4.3: CoRe for three teachers on wave phenomena

| BIG IDEAS | Properties of waves and wave phenomena | | |
|--|---|---|--|
| QUESTIONS | Teacher A | Teacher B | Teacher F |
| 1. What do you intend the learners to learn about this idea? | Understanding of abstract concepts, such as <ul style="list-style-type: none"> • diffraction • interference • effects of slit width on diffraction | Key science concepts, such as <ul style="list-style-type: none"> • interference • diffraction • the effect of the size of the opening | Key science concepts, such as <ul style="list-style-type: none"> • diffraction of light • various colours associated with light diffraction |
| 2. Why do you think it is important for learners to know this? | <ul style="list-style-type: none"> • It facilitates understanding of abstract concepts • Learners enjoy theory being done practically | <ul style="list-style-type: none"> • It helps them to understand the concepts that were theorized | <ul style="list-style-type: none"> • They do not know the colours • Cannot differentiate between different colours of light |
| 3. What else do you know about this idea that you would not share with the learners yet? | <ul style="list-style-type: none"> • Diffraction and interference also occur in light and sound waves | <ul style="list-style-type: none"> • Diffraction and interference also occur in light and sound waves | <ul style="list-style-type: none"> • Diffraction and interference also occur in sound waves |
| 4. What are the difficulties associated with teaching this idea? | <ul style="list-style-type: none"> • The explanations of what is occurring are quite abstract • Manipulation of science equipment poses a challenge | <ul style="list-style-type: none"> • The class is large for individualization • Time constraints in the use of science equipment • Manipulation of science equipment poses a challenge | <ul style="list-style-type: none"> • One science kit did not allow for group work • Unavailability of transport to obtain the science kit • Manipulation of equipment poses a challenge |
| 5. What knowledge can | <ul style="list-style-type: none"> • Links with other ideas and | <ul style="list-style-type: none"> • They struggle with practical | <ul style="list-style-type: none"> • The kit created opportunity for |

| | | | |
|---|---|---|---|
| you share about learners' thinking that influences your teaching of this idea? | experiences that learners are making | investigations | learners to discuss among themselves their observations |
| 6. Are there any other factors that would influence your teaching of this idea? | <ul style="list-style-type: none"> • Less struggle in trying to explain abstract concepts • Teaching for understanding is the key objective | <ul style="list-style-type: none"> • Seek resources that could be used to introduce the topic | <ul style="list-style-type: none"> • Reading the booklet in the kit would assist with understanding of how the kit works |
| 7. What teaching procedures would you employ? | <ul style="list-style-type: none"> • Computerized apparatus • Smart boards | <ul style="list-style-type: none"> • Prior preparation of handouts • Prior setting up of apparatus • Making environment conducive for learning • Allocating time for practical work | <ul style="list-style-type: none"> • Making environment conducive for learning • Allocate time for practical work • Perform experiment prior to going to class |
| 8. Why would you use these procedures? | <ul style="list-style-type: none"> • Learners could do better in science • They assist with effective lesson delivery • They facilitate learner understanding of science concepts • Learners enjoy practical work | <ul style="list-style-type: none"> • Learners enjoy practical work • Science kits boost learner confidence in manipulation of apparatus | <ul style="list-style-type: none"> • They facilitate the understanding of science concepts • Some science kits can be used even if there is no electricity at school |
| 9. What strategies could you use to ascertain | <ul style="list-style-type: none"> • Learners would draw diagrams to demonstrate that they have mastered | <ul style="list-style-type: none"> • Always look for suitable kit that would assist to introduce the | <ul style="list-style-type: none"> • Use of practical work to explain abstract science concepts |

| | | | |
|---|-----------------------|------------|--|
| learners' conceptions/ misconceptions of this idea? | the concepts observed | topic/idea | |
|---|-----------------------|------------|--|

4.4.2 Discussion of the CoRes

The CoRe indicated similarities between the three teachers with regard to their teaching about wave phenomena. All three teachers highlighted the main objectives of using science resources as the facilitation of understanding of abstract science concepts of the wave phenomena. They also stated that the theory that was discussed earlier was easily clarified with the use of science resources. Responses from other teachers also reflect that all maintain that the use of resources enhanced learning. A point of concern common to all eight teachers was learner engagement in science lessons.

The teachers' responses to the prompts revealed that all confirmed that they experienced a sense of growth because they were able to realize that they need support in this regard. Responses to the prompts outlined fundamental things that educators needed to consider when planning to teach certain topics. Excerpts from teacher responses confirm this view. Teacher A remarked:

Indeed the resources do go a long way in our teaching in effective delivery; when we teach science we use practicals, they develop us as the teachers, they magnify our understanding.

The use of resources also impacted on the learners in the sense that:

- Their understanding of abstract science content improved, and there was enjoyment on the part of the learners as well.
- There was also excitement on the part of the learners.
- Learner confidence grew since other learners wanted to perform the experiments themselves, as commented on by teacher B (*“others were wanting to do it themselves...”*) and teacher H (*“Even the quiet learners who do not usually want to give answers in class, but with the kit they all wanted to try out the experiment for themselves”*).

They were all able to realise the positive impact that the use of resources had on science teaching. This was evidenced by the fact that the use of science resources assisted with the explanation of abstract science concepts.

Although teacher H's 'big ideas' were not reflected in this CoRe, her responses to interview questions revealed that her lack of experience in science teaching had an influence on her decision to use the resources. She is the only teacher among the eight teachers who did not involve learners in hands-on activities. She stated that she used DVDs to teach a chemistry lesson. This is an indication that her learners were not given the opportunity to gain the skills necessary to perform science experiments. In addition, she was not comfortable with the manipulation of equipment, as reflected in her comment:

Some of them I am afraid to use them, for instance the apparatus as such they use er the sulphuric acid, the dangerous acid; I fail to dilute it.

Teacher H also displayed challenges with conceptual understanding of the term 'practical work'. According to Millar (2004), practical work refers to any teaching and learning activity which involves observation or manipulation of real objects. In addition, Millar (2004) also argues that learning science involves seeing, handling and manipulating real objects and materials. Millar (2004, p. 7) further states that "through actions on the world, a view of what objects there are in the world, what they are made of, what can be made from them, what they can do and what can be done to them", constitutes practical work.

The role of practical work should help learners to make links between two domains of knowledge, namely the domain of objects and observable properties and events, on the one hand, and the domain of ideas on the other, as shown in Figure 1 below.

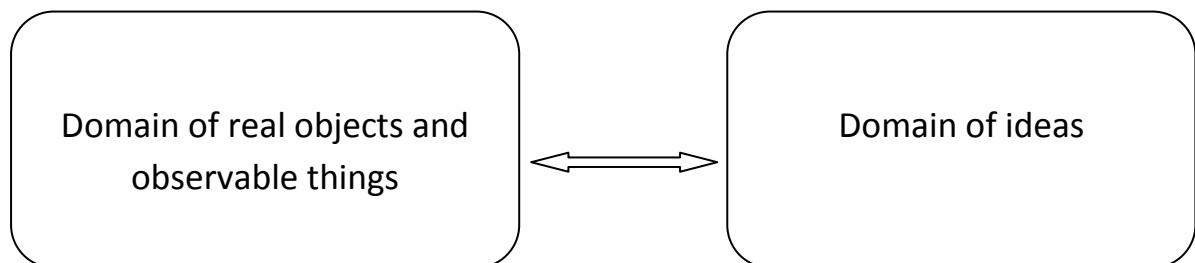


Figure 1: Practical work: Linking two domains of knowledge (adapted from Millar, 2004, p. 8)

The block on the left of Figure 1 implies that practical work activities should enable learners to observe objects, materials, events or phenomena, noting

some aspects of them so that they can recall these aspects later; these are the domain of ideas, represented by the block on the right. Millar (2004) argues that all practical work involves both domains, as represented by the arrow between the two blocks. Millar (2004) states that how this plays itself out in practice and the success of any given practical task depends on the intended learning objectives of the task.

Millar's linking of the two domains of knowledge can be used to suggest that if teacher H lacked conceptual understanding of practical work, then it would be difficult for her to select appropriate resources that would be useful in developing learners' understanding of scientific concepts and explanations. Teacher H therefore reflects an underdeveloped PCK on the use of science resources in science teaching.

Based on the above summaries, the next section represents a portrayal of PCK as it applies to PaP-eRs for the use of science resources for the eight teachers. The approach used is in accordance with the analysis identified by Loughran *et al.* (2004).

4.4.3 Construction of the PaP-eRs

According to Loughran *et al.* (2004; 2006) PaP-eRs help to illustrate the aspects of PCK in action, since they portray a particular teaching strategy in a particular context (Mulhall *et al.*, 2003). PaP-eRs therefore emerge from teachers' actual practice and are based on an understanding of what it is about the content that the teacher knows to purposefully shape the pedagogy

(Mulhall *et al.*, 2003). PaP-eRs are developed from detailed descriptions offered by individual teachers, and/or as a result of discussions about situations/ideas/issues pertaining to the CoRe, as well as classroom observations. They are the narrative accounts of the teachers' PCK for a particular piece of science content (Loughran *et al.*, 2004). PaP-eRs help to explain the decisions that support each science teacher's actions that are intended to help learners better understand the science content. According to Loughran *et al.* (2004), PaP-eRs should carry manageable information that would be useful for other teachers. Mulhall *et al.*, (2003) state that PaP-eRs are the methodological tools that portray each teacher's PCK in a particular content area. Mulhall, *et al.* (2003) affirm that concrete examples of PCK are difficult to find.

Van Driel, Verloop and de Vos (1998) argue that PaP-eRs do not necessarily apply to a particular teacher but are constructed by researchers using information obtained in discussions and classroom observations. In addition, Loughran *et al.* (2006) propose that PaP-eRs could be in various formats, such as interviews, journals, and other sources of data. In the light of this discussion it should therefore be noted that the PaP-eRs listed below are the synthesis of the research data from individual interviews with the science teachers who participated in this study. They reflect their thinking and actions about *why* they used these science resources and *how* they used them.

4.4.4 Discussion of the PaP-eRs

The PaP-eRs discussed focus on the teachers' practices before, during and after teaching.

4.4.4.1 Practices before teaching

Increasing capacity to teach

All eight teachers saw a need to increase their ability to offer quality instruction in Physical Sciences. This is evidenced by the fact that all of them mentioned that more science workshops should be conducted in order for them to improve their teaching skills, as teachers D and H state respectively:

...we need a lot of support in terms of workshops conducted, we need to have, if we can, a schedule for workshop for educators in a cluster... and

I need more support, Esh! Er... to get used to these, since now when you get these new things and then come to the class with confidence...

They also realized that using science resources would enhance their teaching; hence they made the necessary efforts to obtain resources necessary for concepts to be taught. Teacher F even used her own money to affiliate with the SRC:

I had to pay the affiliation fee, learners only pay R40 and the rest came from me, they were made to pay R2 per learner towards the affiliation fee...

According to Jita and Mokhele (2008, p. 255), these teachers “had *instructional capacity*, which involves identifying, mobilising and activating particular sets of resources to achieve the specific goals of teaching and learning in Physical Sciences”.

Lesson plans (Appendix F) also reflected ways in which teachers enhanced their capacity to teach. Past examination questions and handouts which were provided by the SRC were used. The teacher planned to use resources from the SRC (overhead projector and ripple tank with accessories). The lesson was planned according to the requirements stipulated in the NCS for Physical Sciences.

Dealing with time constraints

Six teachers made arrangements to ensure that the resources are used to teach a number of science concepts. Some borrowed periods from other teachers, while others used sports and break times and afternoon classes. As teacher B stated:

... the time allocated for the period is not enough, so I came early and I went to the lab and set up the apparatus and I made handouts, the sheets to fill in the hypothesis and stuff, then I during the period I go to class and fetch the learners, but then it would not be enough. So I made the break time available, that during break time those who want to come and do the practical themselves they can come. So during break time I was there and that day it was the sports day, so after 1 we usually go for sports but then I went to the lab and told them that if they

still want to come and observe they can still come, if they still want to come and do the practical again they can still come.

These teachers understood Loughran *et al.*'s (2006, p. 6) assertion that "recognising and responding appropriately to the issues associated with breaking set becomes important in coming to terms with the ongoing effort and commitment necessary to teach for understanding". Through previous experience these teachers understood the real challenge posed by time constraints. They were capable of making professional judgements about the programme for the school day, and of adapting by planning worksheets, using break time and sports times, and asking other teachers for their periods. What this reflects is pedagogical reasoning by the teacher which resulted in particular ways of planning to teach.

Preparing environment which is conducive to learning

Teacher F used her pedagogical knowledge and experience to ensure that the classroom was properly prepared for effective teaching, represented by the following statement:

I had to close the windows before the period starts, I had to make sure that the room is darker before they came in ...

Teacher B thought about teaching in advance of the lesson and prepared the learning environment. Teacher B assumed responsibility for making learners understand by engaging in practical work in a conducive environment.

4.4.4.2 Practices during teaching

Adhering to policy and implementing NCS, especially as they relate to Learning Outcome 1, and meeting CASS (Continuous Assessment) requirements

Teacher D understood Loughran's assertion (2006, p. 5) that "telling is not teaching and listening is not learning", and stated:

... they were investigating and trying to prepare some answers and thinking about the experiment so that when they come here they know exactly the apparatus. They can be able to speak and list the apparatus, the aim, the hypothesis, the variables and everything, so they were planning on their side so that when they come they were ready for the topic.

Teacher D believed that quality of learning Physical Sciences could be promoted if learners "master the skills of investigation". He also believed that "teacher telling" and "learner listening" are inadequate to facilitate conceptual understanding. Allowing learners to make observations in a practical lesson setting was, in teacher D's view, a more useful teaching strategy.

A problem-solving approach which was learner-centred was evident in the lesson planned (Appendix E), which was designed to achieve Learning Outcome 1. Facilitating conceptual understanding through independent investigation was encouraged in an unthreatening manner. Learners were required to design their investigation and submit their designs to the teacher, who would evaluate designs in a constructive manner.

Employing various pedagogical strategies

Teachers mentioned that they employ various teaching strategies such as teacher demonstration, group work, individual work and practical work to enhance learning. Millar (2004, p. 1) defines practical work as “teaching and learning which involves learners observing or manipulating real objects or materials”. Teachers were aware of the importance of practical work as per the requirements of the new science curriculum. Despite the fact that they did not have laboratories, they made efforts to obtain resources to use in their teaching.

According to Millar (2004, p. 2), “observation or manipulation of objects does not depend on the location in which this activity occurs”. In addition, teachers understood how learners learn, and on the basis of that understanding, they “choose and employ teaching procedures and approaches that would promote quality learning” (Loughran *et al.*, 2006, p. 6). Teacher A chose to teach differently after examining the relationship between what was to be taught and what was to be learned. This teacher did not merely want to “deliver” content in Physical Sciences, but wanted to “teach for understanding” (Loughran *et al.*, 2006, p. 1). According to Loughran *et al.* (2006, p. 7): “Teachers who teach for understanding develop professional knowledge about teaching and improve their practices.”

Teacher D used group work, and stated that:

learners were divided into groups and then because it was one experiment, one kit experiment, then one group had to prepare the experiment then other learners came with their groups to investigate

everything and bring a report and present their report to the entire class.

Teacher E added:

like for the group work they were also helping out one another, they were understanding.

Teacher H used an individual activity approach:

Each and every learner wanted to perform the experiment for themselves.

The need for support in teaching of science is not a solely South African phenomenon. Teachers in this study used the SRC for support in their quest to “pursue deeper levels of understanding of science with their students” (Loughran *et al.*, 2006, p. 2). Availability of the science kits was not a solution for these teachers. They required support related to manipulating apparatus in fully equipped laboratories. They also required knowledge about safety when using certain chemicals. Officials from the SRC provided some teachers with direct support by attending the lessons and clarifying concepts, and assisting the teachers in manipulating the resources (Appendix F). When teachers lack confidence in teaching then members from the SRC will work with these teachers as a team (team teaching).

The approaches highlighted above indicate that the teachers knew the specific practices that are associated with the current reforms initiated by the new curriculum of South Africa, and then decided to change from traditional teaching practices to new, innovative approaches (Jita & Mokhele, 2008). Jita

and Mokhele (2008, p. 268) assert that when “teachers are guided by provincial and national curriculum guidelines on what to teach; and how to approach each science concept, they appear to exercise some degree of autonomy with respect what to do, and how and when to do it in their own classrooms.”

4.4.4.3 Practices after teaching

Teacher reflections

Learner understanding through learner-centred approach: Enhancing learner understanding, increase in learner confidence, and increase in learner enjoyment and learner participation in a more learner-centred environment were reasons offered as to why they used resources in practical work. Teachers who taught large classes indicated that individual work was not possible, and opted for demonstrations. The greater part of the learning activities was mainly done by learners. The lesson plan (Appendix F) included a teacher reflection after teaching which revealed that learning was enhanced because learners enjoyed the activity. The teacher also reflected on how direct manipulation and observation of waves allowed learners to engage in active knowledge construction.

Facilitating more effective, meaningful and relevant teaching: All teachers realized that their skills and ability to manipulate resources were challenged; therefore, they all stated that they needed support in order for them to be able to offer effective and meaningful teaching. These teachers reflected on their

pedagogic development. They believed that their professional knowledge would improve through workshops on practical work. In addition, teacher E paid the affiliation fee herself. She did not have the support of the school because the school did not have adequate funds. Central to this teacher's endeavour is a real commitment to enabling learners to understand practical work, and this is evident in her willingness to spend her own money.

Through experience about teaching particular topics teacher D had developed the knowledge that a practical approach to introduce the topic would enhance the learners' understanding. This teacher understood that merely delivering theoretical constructs of the topic using the transmission mode was less effective in enabling learners to construct knowledge.

Enhancing teacher understanding of content and pedagogy: The above extracts indicate that teachers used teaching strategies that created meaningful opportunities for learners to engage in constructing and restructuring their own knowledge (Loughran *et al.*, 2006). Teacher G:

I used to perform the experiment at home before taking them to school to the kids, I used to do the experiment beforehand so that I easily identify mistakes and areas of concern and what needs to be emphasized to the learners.

Teacher F showed the ability to reflect on her own PCK, and believed that greater familiarity with skills associated with teaching practical work is vital. Although teacher F was a qualified teacher of Physical Sciences, she was aware of the importance of knowledge of pedagogy.

Teacher A stated that “*in every lesson, you [the teacher] always learn*”. Teacher A viewed himself as a lifelong learner. Continued use of apparatus allowed him to manipulate them more skilfully. He also learned about differences among varied pieces of equipment for the same investigation. Teacher A was happy to be teaching the same topic again. The repetition of the lesson (with another class) allowed the teacher to improve pedagogic strategies. The results of these improved pedagogic strategies became evident to this teacher, whose view was that learners “*really mastered the concept*”. In one instance the trigger for learner understanding was the engagement of learners in the practice of drawing diagrams. This teacher was able to combine knowledge of the content of the topic with pedagogic strategies which suited those learners in particular.

Due to lack of knowledge of the content, teacher H was unable to teach effectively. She also lacked knowledge of pedagogy because she did not develop the skills of handling apparatus in order to be able to use practical work for teaching and learning, as she confided her fear about safety when using chemicals.

The approaches reflect that teachers understood Loughran *et al.*'s assertion that “teaching is a problematic endeavour which requires a major shift in a teachers’ thinking and a subsequent practice” (2006, p.4). Loughran *et al.* (2006) further state that “teachers who teach for understanding develop professional knowledge about teaching and improve their practice through reflecting on their practice...”. Their limitations on the use of science resources offered new insights into their teaching, and created opportunities for professional development for them. The teachers in this study acted in

accordance with the view of Loughran *et al.* (2006, p. 6) that “professional learning was about learning from, and building on experiences and involved sustained reflection on practice, and a search to understand and construct new meaning by looking into situations from different perspectives”. Each of the teachers in this study reflected on his/her practice and revealed a willingness to engage in practical learning.

4.5 Summary

This study was analysed according to the frames of PCK. The CoRes were instrumental in allowing me to understand the nature of each teacher’s knowledge base with respect to the use of science resources. Although responses of only three teachers were used to formulate the CoRe, there were similarities among all eight participants.

Teachers’ understanding of the use of science resources impacted on the decisions they made in terms of the teaching process from planning to assessment, which ultimately improved their PCK. The five components discussed in Chapter 2 influence one another in an ongoing and contextually bound way (Soonhye & Oliver, 2007). According to Soonhye and Oliver (2007), teachers need to integrate the five components in order for effective teaching to occur and endorse them within a given context. In this study integration of the components was accomplished through the complementary and ongoing readjustment by reflection-to-action, reflection-in-action and reflection-on-action. If the coherence among the five components is strengthened through reflection on teaching, a stronger

PCK develops. The growth in PCK facilitates changes in teaching practice (Soonhye & Oliver, 2007).

CHAPTER 5

FINDINGS AND RECOMMENDATIONS

| TABLE OF CONTENTS | PAGE |
|---|-------------|
| 5.1 Introduction..... | 73 |
| 5.2 Overview of the study..... | 73 |
| 5.3 Discussions of the findings..... | 74 |
| 5.3.1 How do Physical Sciences teachers use the SRC?..... | 77 |
| 5.3.2 Why do Physical Sciences teachers use the SRC?..... | 79 |
| 5.4 Limitations of the study..... | 80 |
| 5.5 Recommendations..... | 80 |
| 5.6 Directions for future research..... | 81 |
| 5.7 Conclusion..... | 81 |

5.1 Introduction

This chapter begins with a brief overview of the research study and thereafter focuses on the critical reflection of the study, particularly on the methodology, and then proceeds to discuss findings. A summary of the findings regarding the research questions is elaborated upon, drawing conclusions where necessary. The limitations of the study with respect to relevant strengths and weaknesses are described. Finally, recommendations of the research are detailed and directions for future research close the chapter.

5.2 Overview of the study

The study attempted to determine how and why eight Physical Sciences teachers used the SRC to teach Physical Sciences. The study further determined how Physical Sciences teachers use science resources in their teaching of Physical Sciences. The participants' PCK was analysed in order to determine its impact on the use of science resources. The main findings are reflected in this chapter.

The study followed Loughran *et al.*'s (2004) methodology by capturing and documenting PCK through the use of CoRes and PaP-eRs. According to Loughran *et al.* (2004), a CoRe provides an overview of how teachers approach the teaching of a particular science topic and reasons for that approach. CoRes represent each science teacher's PCK because of the reasons they provide which link the how, why and what of the content to be taught (Mulhall *et al.*, 2003). PaP-eRs help to explain the decisions that

support each science teacher's actions that are intended to help learners better understand the science content (Mulhall *et al.*, 2003). This study was based on the content knowledge of eight science teachers and their related practice, particularly on the use of science resources.

The CoRe allowed me to form an outline of what a selection of teachers represented as aspects of PCK. The CoRe allowed for insights into important features of the use of resources and the PaP-eRs described the actual reasons specific to each teacher. They were helpful and complementary to the CoRe, and thus produced a more complete portrayal of each participant's PCK.

5.3 Discussion of the findings

Although the literature suggests a direct, positive influence of teacher qualification on learners' performances, these fluctuated although the learners were taught by qualified Physical Sciences teachers. This has implications for teacher training programmes at higher education institutions in South Africa.

A consistent feature of each school was that it lacked resources to teach Physical Sciences. Simply providing the resources to teach Physical Sciences was not a complete solution to this challenge; some teachers indicated that their undergraduate training did not enable them to use resources effectively. The value of the training to use resources which was offered at the SRC was highlighted by each participant.

Evidence of this was reflected in the responses by all eight teachers to the question that asked them whether they needed support in the use of science resources. All eight teachers indicated that they needed support in the form of workshops and training. This indicated that their PCK was not well-developed in that regard.

The frame of PaP-eRs as a means of analysis revealed several insights as they relate to teachers' professional growth which was enhanced through reflective practice. In this study these insights are examined as reflection-to-action (teachers' practices before they teach), reflection-in-action (teachers' practices during teaching) and reflection-on-action (teachers' practices after teaching).

Reflection-to-action

Teachers in this study were committed to increasing their capacity to teach. They believed that support in the form of workshops was vital, and viewed the Government as a source of funding for workshops. Teachers were willing to be trained at weekends to prevent disruption to learners' work during regular school days. Structured guides to using practical resources effectively were also viewed as a necessity for teaching practical work effectively.

The teachers in this study displayed altruistic traits because they were prepared to sacrifice their tea breaks and weekends to prepare to teach effectively. Teachers were able to recognise time constraints as a challenge when doing practical work, and were able to respond to these by planning more carefully. They revealed a conscious effort to succeed in the classroom.

Reflection-in-action

During the teaching activity several teachers were cognizant of the NCS requirements, especially as they related to the achievement of Learning Outcome 1. These teachers valued the engagement of learners in learning through practical activities, and they asserted that teacher talk cannot be equated to teaching, and learner listening cannot be equated to learning.

The NCS provided guidance about what was required in practical work. Teachers employed various pedagogical strategies; however, many strategies were contingent on the availability of resources and sizes of classes.

Reflection-on-action

Several teachers emphasized their aim to teach for understanding. Through constant reflection on their pedagogical practices they were able to adopt strategies which enabled a learner-centred approach. They also perceived every teaching activity as educative for the teacher because it enabled teachers to refine their skills, especially those related to practical work.

Findings of this study resonated with the findings from a pilot study conducted by Johnson *et al.* (2000) on teacher development and change in South Africa. In their study, Johnson *et al.* (2000) found that teachers in ex-Model C schools previously enjoyed good facilities and resources, were being well paid, and enjoyed comfortable housing, food, clothing and owned cars for easy travel to and from schools and training workshops. Their study reflected that teachers who taught under such circumstances were able to invest their personal time

and resources in professional development programmes (Johnson *et al.*, 2000).

However, teachers in rural schools where classes were overcrowded, with minimal furniture, books, and equipment and where science resources were non-existent; were paid low salaries, lived in uncomfortable homes with a short supply of food and clothing, and were dependant on public transport to attend teacher workshops and training seminars. They also viewed the idea of professional development as far-fetched. Teachers who experienced such challenging and unfavourable conditions were demotivated to attend any forms of professional development initiatives (Johnson *et al.*, 2000). Johnson *et al.* (2000) argue that “professionalism of teachers is not differentially distributed because of the inadequacies of individuals within the system; it is differentially distributed because of the variations within which the individuals work”.

Funding for teacher development programmes is seen as a barrier to effective professional development. This finding is in line with what Johnson *et al.* (2000, p.190) say when they propose that should money become available, “science teachers could be able to carry out the practical activities that would assist them to improve their teaching methods and improve their content knowledge while coping with the status quo”.

5.3.1 How do Physical Sciences teachers use the SRC?

The aim of the study was to explore the use of the SRC by Physical Sciences teachers in the teaching of Physical Sciences. The following findings are

presented in response to the first research question, which was ‘How do Physical Sciences teachers use the Science Resource Centre?’.

Each teacher taught in an underprivileged and under-resourced school that did not have facilities and equipment to promote effective teaching and learning of Physical Sciences. They therefore used the SRC to borrow equipment that they could use in their lessons. However, these teachers encountered challenges with the use of the SRC. One major challenge that was common among all of the teachers was the lack of knowledge and skills of handling apparatus in order to be able to do practical work for teaching and learning of science. Some teachers lacked knowledge of pedagogy, which caused them to resort to using DVDs for teaching practical work instead of using real equipment.

Other challenges included inadequate financial support from school management because of the poor school community. The SRC also had insufficient resources to cater for all teachers. One teacher reported that he wanted to divide his learners into five groups for a science practical, but had to compromise and make three groups due to the shortage of equipment he borrowed from the SRC. Another teacher also encountered the same problem when she discovered that the kit she wanted to borrow was being used by another school. The DoE supported teachers by conducting teacher workshops.

5.3.2 Why do Physical Sciences teachers use the SRC?

The following findings are presented in response to the second research question, which was 'Why do Physical Sciences teachers use the Science Resource Centre?'.

The role of practical work in science teaching is to “develop learners’ scientific knowledge and the knowledge about science” (Millar, 2004, p. 2). Teachers in this study used the SRC for support in their quest to “pursue deeper levels of understanding of science with their students” (Loughran *et al.*, 2006, p. 2). These teachers understood that in order for them to be able to offer quality teaching in science, they needed to use science resources. One way in which teachers’ PCK can be enhanced is by enabling them to link the “domain of real objects and observable things” to the “domain of ideas” (Millar, 2004, p. 8).

Almost all of the teachers exhibited an appropriate level of SMK. Their SMK was evident in their responses to the interview questions and showed a greater certainty and insight regarding the use of science resources in science teaching. Their ability to offer a wider range of reasons pertaining to the use of science resources in their lessons indicated strong awareness of knowledge of pedagogy, and therefore a grounded PCK. All teachers asked for support with the use of science resources, an indication of pedagogical growth and an increase in the level of PCK. The CoRe and PaP-eRs were crucial tools that enabled me to make PCK explicit rather than tacit.

5.4 Limitations of the study

The study used a qualitative case study methodology which examined the responses of eight Physical Sciences teachers whose schools were affiliated to the SRC. Since the sample was small, the tendency to make generalizations of the findings was therefore compromised to a certain extent.

5.5 Recommendations

The following recommendations arise from the findings of the study:

- The SRC should increase the quantity of the science kits to minimise shortages.
- The SRC should have a way to cater for schools that experience financial constraints which stops them from being able to affiliate to the SRC.
- Some means of transportation should be made available in order to assist the affiliated schools with obtaining resources from the SRC.
- The SRC and the education district should have skills training workshops to assist science teachers with handling of resources.
- Frequent opportunities should be created for teachers to interact with and support one another.
- Schools should have means of sourcing funds for affiliation to the SRC.

- Documented PCK should be made available to novice science teachers in order to effectively transform subject matter.

5.6 Directions for future research

South Africa is a developing country that requires a skilled workforce, which is largely dependent on the quality of instruction that the DoE is able to offer in the areas of mathematics and science. However, the lack of science resources in schools interrupts the learning process and fosters poor learner results in key areas. If the reason for poor learner performance is the lack of adequate science resources, then the role of subject matter knowledge of the teacher and the corresponding impact it has on learner performance needs to be more clearly defined.

5.7 Conclusion

This study reveals that the SRC is useful in assisting under-resourced schools with the provision of resources. However, as emerged from the findings of this study, the provision of resources alone was not a solution to the teachers' challenges. They also required support related to manipulating apparatus. One of the roles of the SRC was to offer programmes that address the effective use of science resources by science teachers. Excerpts from the teacher participants reflected that they required support with handling apparatus. This meant that the SRC was not doing enough in executing this function. Another finding which was of concern was the lack of support from school management in obtaining science resources. Interventions to support

schools should focus on removing the identified barriers for the improvement of science teaching in schools.

References

- Abell, S.K. (2007). Research on science teacher knowledge (Chapter 36). In S.K. Abell & N.G. Lederman (Eds.), *Research on Science Teacher Education* (pp. 1105 – 1149). New York: Routledge.
- Bassey, M. (1999). *Case Study Research in educational settings*. Buckingham: Open University Press.
- Beaton A.S., Mullis I.V.S., Martin, M.O., Gonzalez E.J., Kelly D.L. & Smith T.A. (1996). *Mathematics Achievement in the middle school years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College.
- Bucat, R. (2004a). Pedagogical content knowledge as a way forward: Applied research in Chemistry Education. *Chemistry Education Research and Practice*, 5(3), 215-228.
- Bucat, R. (2004b). *Pedagogical content knowledge: Applied Chemical Education Research – Bridging the Gap between 'Pure' Education Research and Teaching Practice*: Department of Chemistry, The University of Western Australia. Retrieved June 14, 2011 from <mhtml:file://E:\PEDAGOGICAL%20CONTENT%20KNOWLEDGE.mht>
- Bybee, R.W. & B. Fuchs.(2006). Preparing the 21st century workforce: A new reform in science and technology education. *Journal of Research in Science Teaching*, 43(4): 349-352.
- Cochran, K.F., DeRuterr, J.A. & King, R.A. (1993). Pedagogical Content Knowledge: an Integrative Model for Teacher Preparation. *Journal of Teacher Education*, 44, 263-272.
- Cohen, L., Manion, L. & Morrison, K. (2007). *Research Methods in Education*. (6th edn.). London & New York: Routledge.
- Connolly, F.M. & Clandinin, J. (2000). Narrative understandings of teacher knowledge. *Journal of Curriculum and Supervision*, 15, 315-331.
- De Miranda, M.A. (2008). Pedagogical Content Knowledge and Technology Teacher Education: Issues for thought. *Journal of the Japanese Society of Technology Education*, 50(1), 17-26.
- Denzin, N.K. & Lincoln, Y.S. (2000). *Strategies of Qualitative Enquiry*. London: Sage Publications.

- Department of Arts, Culture, Science and Technology. (1996). *White Paper on Science and Technology – preparing for the 21st Century*. Pretoria: Government Printer.
- Department of Basic Education. (2011a). *Final Physical Sciences CAPS document*. Pretoria: Government Printer.
- Department of Basic Education. (2011b). *National Education Infrastructure Management System (NEIMS)*. Retrieved November 23, 2011 from <http://www.education.gov.za/LinkClick.aspx>
- Department of Basic Education. (2011c). *Education Policy: School Fees*. Retrieved August 22, from <http://www.education.gov.za/LinkClick.aspx>
- Department of Education. (2001). *National Strategy for Mathematics, Science and Technology Education in General and Further Education and Training*. Pretoria: Government Printer.
- Department of Education. (2002). *Revised National Curriculum Statement Grades R - 9 (Schools) Policy: Overview*. Pretoria: Government Printer.
- Department of Education. (2003). *National Curriculum Statement – Grades 10 -12 Physical Sciences*. Pretoria: Government Printer.
- Department of Education (2009). *Analysis of Learner Performance. KwaZulu-Natal Provincial Report*. Pietermaritzburg: Government Printer.
- Du Toit, M. (2010). Can Science Centres Support and Improve Chemistry Education in South Africa? In V. Mudaly (Ed.), *Proceedings of the eighteenth annual meeting of the South African Association for Mathematics, Science and Technology* (pp. 311-317). Durban: University of KwaZulu-Natal/Cambridge University Press.
- Eisner, E. (1991). *The Enlightened Eye: Qualitative Inquiry and the Enhancement of Educational Practice*. New York: Macmillan.
- Forster, R. J. (2006). A theoretical Framework for Constructing a More Positive Self-Identity (How DSAP Might Work). Retrieved August 22, 2011 from <http://www.dependablestrengths.org/assets/documents/>
- Fraenkel, J.R. & Wallen, N.E. (1990). *How to Design and Evaluate Research in Education*. New York: McGraw-Hill.
- Frantz N.R., Friedenborg J.E., Gregson J.A. & Watter R.A. (1996). The rationale in support of the standards. *Journal of Industrial Teacher Education*, 34, 41-62.

- Gadebe, T. (2006, November 23). Free schooling for five million. *BuaNews*.
- Gardner, P.I. & Hill A.M. (1999). Technology Education in Ontario: Evolution, achievements, critiques and challenges – the context. *International Journal of Technology and Design Education*, 9, 103-136.
- Giroux, H. (1986). The politics of schooling and culture. *Orbit*, 17(4), 10-11.
- Gorard, S. & Taylor C. (2004). *Combining Methods in Educational and Social Research*. London: Open University Press.
- Gordon, M. (2011). Listening as Embracing the Other: Martin Buber's Philosophy of Dialogue. *Educational Theory*, 61(2), 207-219.
- Gray, A. (1997). *Constructivist Teaching and Learning*. SSTA Research Centre Report #97-07. Retrieved August 22, 2011 from saskschoolboards.ca/research/instruction/97-07.htm
- Hewson, P. W. (2007, January). *Teacher Professional development in science. A Case Study of the Primary Science Programme's CTI Course*. Paper presented at the Annual Meeting of the Southern African Association for Research, Science and Technology Education, Maputo.
- Howie S.J. (2003). Language and other background factors affecting secondary pupils' performance in Mathematics in South Africa. *African Journal of Research in Mathematics Science and Technology Education*, 7, 1-20.
- James, A., Naidoo, J. & Benson, H. (2008, September). *CASME's approach to the sustainability of science education in South Africa*. Unpublished dissertation paper presented at the XIII IOSTE Symposium, Turkey.
- Jita, L.C. & Mokhele, M. L. (2008). Capacity for (quality) instruction: a framework for understanding the use of resources to promote teaching and learning in schools, *Africa Education Review*, 5:2, 253 -273.
- Johnson, S., Hodges, M. & Monk, M. (2000). Teacher Development and Change in South Africa: A critique of the appropriateness of transfer of northern/western practice. *A Journal of Comparative and International Education*, 30(2), 179-192. <http://dx.doi.org/10.1080/713657456>
- Kelly, G.A. (1991). *The psychology of personal constructs: A theory of personality*. London: Routledge.
- Lester, N.B. & Onore, C.S. (1990). *Learning Change: One school district meets language across the curriculum*. Portsmouth, NH: Boynton/Cook Publishers.

- Lincoln, Y.S. & Guba, E.G. (1985). *Naturalistic Inquiry*. Newbury Park, CA: Sage Publications.
- Lipari, L. (2004). Listening for the other: Ethical implications of the Buber – Levinas Encounter. *Communication Theory*, 14(2), 122-141.
- Loughran, J., Mulhall, P. & Berry, A. (2004). In Search of Pedagogical Content Knowledge: Developing Ways of Articulating and Documenting Professional Practice. *Journal of Research in Science Teaching*, 41(4), 370-391.
- Loughran, J., Mulhall, P. & Berry, A. (2006). *Understanding and developing science teachers' pedagogical content knowledge*. Rotterdam: Sense Publishers.
- Loughran, J., Mulhall, P. & Berry, A. (2008). Exploring Pedagogical Content Knowledge in Science Teacher Education. *International Journal of Research in Science Education*, 30(10), 1301-1320.
- Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., & Chrostowski, S.J. (2004). *International Association for the Evaluation of Educational Achievement*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
- Mezirow, J. and Associates (1990). How critical reflection triggers transformative learning. A guide to transformative and emancipator learning (1-20). San Francisco: Jossey-Bass Publishers.
- Millar, R. (2004, June 3-4). *The role of practical work in the teaching and learning of science*. Paper prepared for the Meeting: High School Science Laboratories: Role and Vision, Washington, DC.
- Mji, A. & Makgato, M. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and physical science. *South African Journal of Education*, 26(2), 253 -266.
- Mulhall, P., Berry, A., & Loughran, J.J. (2003). *Frameworks for representing science teachers pedagogical content knowledge*. Asia Pacific Forum on Science Teaching and Learning. 4 (2), 1- 25. Retrieved August 24, 2011 from http://www.ied.edu.hk/apfslt/v4_issue2/mulhall/
- Padilla, K., Ponce-de-León, A. M., Rembado, F.M., & Garritz A. (2008). Undergraduate professors' Pedagogical Content Knowledge: The case of "amount of substance". *International Journal of Science Education*, 30(10), 1389-1404.
- Patton, M.Q. (1990). *Qualitative evaluation and research methods* (2nd edn.). Newbury Park, CA: Sage Publications.

- Pratzner, F.C. (1994). Time to create the future. *Journal of Industrial Teacher Education*, 31, 3-4.
- Ramsuran, A. (2005). Scientific literacy, ideology and the Natural Science Curriculum. *African Journal of Research in Mathematics, Science and Technology Education*, 9, 1-80.
- Rogan, J.M. & Grayson, D.J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education*, 25(10), 1171-1204.
- Sayed, Y. & Motala, S. (2009). *Finance, Fee-free Schools and Access to Education in South Africa*. Retrieved January 4, 2012 from <http://www.create-rpc.org>.
- Science Education Resource Center (SERC) (408) 924 - 4884. Retrieved March 23, 2012, from <http://www.science.sjsu.edu/serc/>
- Science, Technology, Engineering, and Mathematics (STEM) Education Coalition. Retrieved March 23, 2012, from <http://www.pbs.org/teachers/stem/>
- National Science Resources Center (NSRC). Retrieved March 23, 2012, from http://www.nsrconline.org/about_the_nsrc/mission_core_values.html
- Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.
- Shulman, L.S. (1987). Knowledge and teaching: foundations of new reform. *Harvard Educational Review*, 57(1), 1-23.
- Soonhye, P. & Oliver, J. (2007). Revisiting the Conceptualisation of Pedagogical Content Knowledge (PCK): PCK as a Conceptual Tool to Understand Teachers as Professionals. *Journal of Research in Science Education*, 38(3), 261 – 284.
- Strauss, A.L. & Corbin, J.M. (1990). *Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory* (2nd edn.). London: Sage.
- Twomey F.C. (1989). *Enquiring teachers, enquiring learners: A constructivist approach for teaching*. New York: Teachers College Press.
- Van Driel, J., Verloop, N. & de Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, 35, 673-695.

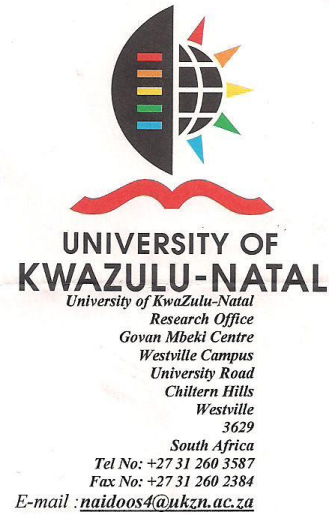
Wellington, J. & Ireson, G. (2008). *Science Learning, Science Teaching* (1st edn.). New York: Routledge.

World Science Forum. (2007). *Investing in knowledge, investing in the future*. Budapest: World Science Forum.

Yin, R. (2009). *Applications of case study research*. Thousand Oaks, CA: Sage.)

APPENDICES

APPENDIX A: ETHICAL CLEARANCE LETTER



19 September 2010

Mrs N P Xulu
P O Box 80548
RICHARDS BAY
3900

Dear Mrs Xulu

PROTOCOL: Exploring of the use of a Science Resource Centre by Physical Sciences Teachers

ETHICAL APPROVAL NUMBER: HSS/1083 /2010 M: Faculty of Education

In response to your application dated 10 September 2010, Student Number: **200292295** the Humanities & Social Sciences Ethics Committee has considered the abovementioned application and the protocol has been given **FULL APPROVAL**.

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully



**Professor Steve Collings (Chair)
HUMANITIES & SOCIAL SCIENCES ETHICS COMMITTEE**

SC/sn

cc: Dr. R Mudaly (Supervisor)
cc: Mr. N Memela

Ms NP Xulu

Postal Address: P.O. Box 80548
Richards Bay
3900
Telephone: 083 334 9993
E-mail: nokuthula@casmе.org.za

Dear Physical Sciences Educator

I work as a Science facilitator at the non-governmental organisation's Science Resource Centre in Richards Bay. Currently, I am a part-time student at the Edgewood campus of the University of KwaZulu-Natal. I am engaged in a research project entitled "The exploration of the use of a Science Resource Centre by Physical Sciences Teachers". The purpose of this project is to explore how Physical Sciences Teachers in selected schools use the Science Resource Centre in teaching Physical Sciences. I hope to use the findings of the project to make recommendations which are inclusive of the voices of Physical Sciences Teachers, to improve the Physical Sciences instructional strategies. I would like to collect data from your school by interviewing you, once, for 30 to 45 minutes, and by analysing one of your lesson preparations and one of your lesson plans for the lessons which involved the use of resources you borrowed from the Science Resource Centre. The interview will be recorded on the audio tape. Pseudonyms will be used to protect the identity/names of schools and participants.

The findings of this study will be used to design ways in which the Resource Centre serves teachers of Physical Sciences (like yourself), based on the needs of these teachers. It is envisaged that teachers will benefit from this study when their needs are addressed.

All the data will be treated with confidence and will be disposed off after a period of five years, by destroying audio cassettes.

In doing this, I agree to the following:

- 1. In no way will the research interfere with the teaching and running of the school.**
- 2. Should you find that you wish to withdraw your permission for the research, you may do so without any negative consequence.**

Thank you,

Yours faithfully

Mrs Nokuthula Xulu

For further information on this study, my contact details and my supervisor's details are listed below.

- My contact details are:
Nokuthula Pamela Xulu

Telephone number: 083 334 9993

Email: nokuthula@casmc.org.za
- My supervisor's contact details are:
Dr R Mudaly

University of KwaZulu -Natal

Telephone: +27(0)312603643

Email: mudalyr@ukzn.ac.za

-----Acknowledgement-Educator-----

I..... (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire, without any negative consequences.

SIGNATURE OF EDUCATOR

DATE

APPENDIX C: CONSENT LETTER - PRINCIPAL

Ms NP Xulu

Postal Address: P.O. Box 80548

Richards Bay

3900

Telephone: 083 334 9993

E-mail: nokuthula@casmе.org.za

Dear Principal

I work as a Science facilitator at the non-governmental organisation's Science Resource Centre in Richards Bay. Currently, I am a part-time student at the Edgewood campus of the University of KwaZulu-Natal. I am engaged in a research project entitled "The exploration of the use of a Science Resource Centre by Physical Sciences Teachers". The purpose of this project is to explore how Physical Sciences Teachers in selected schools use the Science Resource Centre in teaching Physical Sciences. I hope to use the findings of the project to make recommendations which are inclusive of the voices of Physical Sciences Teachers, to improve the Physical Sciences instructional strategies. I would like to collect data from your school by interviewing one of your Physical Sciences Teachers, once, for 30 to 45 minutes, and by analysing one of their lesson preparation and one lesson plan for the lesson which involved the use of resources borrowed from the Science Resource Centre. The interview will be recorded on the audio tape. Pseudonyms will be used to protect the identity/names of schools and participants.

The findings of this study will be used to design ways in which the Resource Centre serves teachers of Physical Sciences, based on the needs of these teachers. It is envisaged that teachers will benefit from this study when their needs are addressed.

All the data will be treated with confidence and will be disposed off after a period of five years, by destroying audio cassettes.

In doing this, I agree to the following:

- 1. In no way will the research interfere with the teaching and running of the school.**
- 2. Should teachers find that they wish to withdraw their permission for the research, they may do so without any negative consequence.**

Thank you,

Yours faithfully

Mrs Nokuthula Xulu

For further information on this study, my contact details and my supervisor's details are listed below.

- My contact details are:
Nokuthula Pamela Xulu

Telephone number: 083 334 9993

Email: nokuthula@casme.org.za
- My supervisor's contact details are:
Dr R Mudaly

University of KwaZulu -Natal

Telephone: +27(0)312603643

Email: mudalyr@ukzn.ac.za

-----Acknowledgement- Principal-----

I..... (full name of Principal) hereby confirm that I understand the contents of this document and the nature of the research project, and I grant consent for some of the data to be collected from my school.

I understand that teachers are at liberty to withdraw from the project at any time, should they so desire, without any negative consequences.

SIGNATURE OF PRINCIPAL

DATE

APPENDIX D: INTERVIEW SCHEDULE

Interview Schedule

SCHEDULE FOR FOLLOW-UP INTERVIEW WITH THE TEACHER AFTER S/HE HAS USED THE SCIENCE RESOURCES IN CLASS

Research questions

- 3 Why do Physical Sciences teachers use the Science Resource Centre?
- 4 How do Physical Sciences teachers use the Science Resource Centre?

A. Why do teachers use science resources in their teaching of Physical Sciences?

1. What kinds of science resources did you use in your lesson?
2. Where did you obtain these resources?
3. Did the resources help you cover the key science concepts in the topic? If so, can you tell me how?
4. What can you say about your pupils' response to the resources?

Checklist: Understanding
 Confusion
 Enjoyment
 Participation
 Boredom

5. Have you learnt anything new from using the resources in your class? Does the use of the resources affect your teaching? Can you please explain?
6. How do you feel about using these resources?
7. What other types of resources would you like to be made available to you?
8. Will you use these resources again? Can you please tell me why?

B. How are the resources used in different contexts?

9. Do you feel that you used the resources in the way that you intended?
10. Are these resources relevant to the context in which you teach? Can you please say why this is/ is not so?
11. What preparation did you have to do in order to use the resources?
12. In what ways can the resources help teachers to improve their teaching?

C. What support do teachers need to use the resources?

13. Did you receive any training in the use of science resources?
14. Do you need any support to use the science resources? If so, what support do you need?

APPENDIX E: LESSON PLAN (TEACHER D)

LESSON PLAN

PHYSICAL SCIENCE GRADE 12

PRACTICAL INVESTIGATION

LEARNING OUTCOME: Scientific inquiry and problem solving skills

Assessment Standard: Design, plan and conduct a scientific report inquiry to collect data systematically with regards to accuracy, reliability and the need to control variables.

Core knowledge: Chemical change

Content: Electrochemistry (indirect transfer of electrons)

Learner's activity

In a galvanic cell, chemical energy is converted to electric energy. Make use of the layout below to design, plan and conduct scientific investigation to verify this statement.

Planning

1. What is the investigative question for this investigation?
2. Write down the aim of the experiment.
3. Write down the hypothesis for this experiment
4. Write down one variable that you must control during this investigation.

Design

1. List all the suitable apparatus that you need for this investigation
2. Draw a galvanic cell using apparatus enlisted above
3. Describe, in not more than four lines, how the apparatus must be used to verify your hypothesis.
4. Submit your planning and design for approval before you start practical investigation.

Conduct investigation

1. Write down the voltmeter reading
2. Determine the direction of electric current
3. Observe the colour of the electrolytes
4. Check the mass of the electrodes

Conclusion

1. What can you conclude about conversion of energy in galvanic cell?
2. Write down net reaction for this investigation
3. Write down the cell notation for this galvanic cell.
4. What are standard conditions for this electrochemical cell?

Reinforcement

- After all groups of learners have presented, the educator will do one demonstration of the experiment and reinforce all necessary concepts.

APPENDIX F: LESSON PLAN (TEACHER A)

| TOPIC AND CONTENT | TR/LEARNER ACTIVITIES, ETC. | APPARATUS | SOURCE OF MATERIAL | FEED BACK EVALUATION |
|---|---|---|--|--|
| <p>11/05 <u>WAVES</u> Review on previous learnt content on wave phenomenon of wave front, transient and longitudinal waves. Differentiation of water waves. Importance of wave transport principle.</p> | <ul style="list-style-type: none"> • Learners to explore wave front. • Learners to show Huygens principle. • Tr and learner to describe differentiation of waves and perform experiment from the same. • Learners to sketch pattern on diffraction using single and double slit. • Learners to relate observations on phenomenon from the diffraction. • Tr to conduct the diffraction and associated experiment. | <p>Apparatus: The ripple tank and associated overhead projector.</p> | <ul style="list-style-type: none"> • Lab book for Physics/Science's practical from textbook (same). | <p>The lesson was carried out and the task to make arrangements to take wave type in the apparatus to demonstrate phenomenon on waves and diffraction. Learners enjoyed the use of the ripple tank and could observe result and understand pattern. The activities were achieved. Present during the lesson were the CPME official who gave support and father clarified the concepts and manipulation of apparatus.</p> |
| | | | <p>3°</p> | <p>4°</p> |

APPENDIX G: Turnitin Certificate (please turn over)

APPENDIX H: Editor's Certificate

L. Gething, M.Phil. (Science & Technology Journalism) (*cum laude*)

WHIZZ@WORDS

PO Box 1155, Milnerton 7435 Cape Town, South Africa; cell 072 212 5417

leverne@eject.co.za

26 January 2012

**DECLARATION OF EDITING M.Ed. DISSERTATION:
EXPLORATION OF USE OF THE SCIENCE RESOURCE CENTRE BY PHYSICAL
SCIENCES TEACHERS**

By Nokuthula Xulu

I hereby declare that I carried out language editing of the above paper by Ms Xulu.

I am a professional writer and editor with many years of experience (e.g. 5 years on *SA Medical Journal*, 10 years heading the corporate communication division at the SA Medical Research Council), who specialises in Science and Technology editing - but am adept at editing in many different subject areas. I am a full member of the South African Freelancers' Association as well as of the Professional Editors' Association.

Yours sincerely

LEVERNE GETHING

leverne@eject.co.za