ASSESSING THE TEACHING EFFICACY BELIEFS OF SCIENCE TEACHERS IN SECONDARY SCHOOLS IN THE FREE STATE PROVINCE

by

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DECLARATION

I declare that this research study:

ASSESSING THE TEACHING EFFICACY BELIEFS OF SCIENCE TEACHERS IN SECONDARY SCHOOLS IN THE FREE STATE PROVINCE

results from my own independent work and has not been offered previously for any degree.

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Signature of student

DEDICATION

This study is dedicated to my late dad, Lazarus Moshobane Modise, and my late grandfather, Lentswe John Modise who has instilled in me the value of education, hard work and dedication. Once again Papa and Outata - this one is for you Bakgwatlheng. I know that you are rejoicing spiritually.

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ABSTRACT

The purpose of this study was to assess the science teaching efficacy of the Physical Science teachers in the secondary schools of the Free State province of the Republic of South Africa. Quantitative and qualitative methods were employed to gather data for this study. It was aimed at determining the effect of the demographic factors and the teachers' level of preparedness regarding content knowledge and assessment skills on science teaching efficacy. The sample consisted of 190 Physical Science teachers. Two instruments were used to collect data: (1) A self-constructed questionnaire with the Science Teaching Efficacy Belief Instrument for in-service teachers (STEBI-A) modified for this study, and (2) Semi-structured interviews. Teachers' biographical data and level of preparedness to teach Science were assessed against the two sub-scales of Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Analysis of data was by basic statistics, descriptive statistics and inferential statistics using SPSS 20.0. Qualitative data were transcribed and categorised into emerging themes.

Analysis of the self-efficacy survey indicated highly positive self-efficacy beliefs expressed by most of the practising secondary school teachers in regards to Science teaching. Teachers believe in their own teaching abilities (Personal Science Teaching Efficacy beliefs) and they believe learners' learning can be influenced by effective teaching (Science Teaching Outcome Expectancy beliefs). In addition, analyses of data on the respondents' level of preparedness to teach Science indicated a high level of self-rated Science knowledge, with higher confidence levels in Physics than in Chemistry among in-service secondary teachers. MANOVA analysis indicated that teachers' gender, teaching experience, professional and academic qualifications, Chemistry and Physics content knowledge, frequency of practical work, and confidence in conducting experiments played a significant role in the collective dependent variables, while the grades teachers taught, their age and learner assessments did not. Analysis further indicated that secondary school teachers with a B.Sc (Ed) degree had significantly stronger STOE than teachers with any other professional qualifications.

There was a significant difference between males and females in the STOE sub-scale scores ($F=6.139$; $p=0.014$) with males scoring higher than females; but no significant difference between males and females in the PSTE sub-scale scores ($F=5.925$; $p=0.667$). Moreover, teachers with at most five years and at least 16 years of teaching experience had significantly higher PSTE scores than teachers with different years of teaching experience. Furthermore, analyses of the level of preparedness in conducting practical work indicated that respondents were more confident to conduct Physics experiments than Chemistry experiments. In-service secondary Science teachers believed that assessment is an important and integral aspect of teaching and learning, hence they utilised a variety of assessment modes in their classroom.

It is recommended that further study should include a test in content knowledge, so that teachers can be assessed to confirm their confidence in content knowledge, rather than allowing them to rate themselves without an actual test. Moreover, qualitative studies may be conducted to support teachers' self-report measures, such as classroom observations, in order to gain in-depth data about teachers' efficacy beliefs. If more research is conducted on the self-efficacy beliefs of in-service Science teachers at secondary school level, the curriculum of teacher training programmes could be developed and structured further, there could be more understanding on what pre-service teachers face - this will help to understand how to motivate teachers to teach Science.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Advanced Certificate in Education
CAPS	Curriculum Statement Policy Statements
CDE	Centre for Development and Enterprise
CPD	Continuous Professional Development
DBE	Department of Basic Education
DOE	Department of Education
FDE	Further Diploma in Education
FET	Further Education and Training
GTE	General Teaching Efficacy
HOD	Head of Department
HSRC	Human Sciences Research Council
ICT	Information and Communications Technology
INSET	In-service Training
INSITE	International Innovation and Technology Exhibition
IPET	Initial Professional Education of Teachers
MDG	Millennium Developmental Goals
MEC	Member of Executive Council
NCATE	National Council for Accreditation on Teacher Education
NCS	National Curriculum Statement
NSMSTE	National Strategy for Mathematics, Science and Technology Education
NPDE	National Professional Diploma in Education
NQF	National Qualification Framework
NSC	National Senior Certificate
NSELC	Nova Scotia Educational Leadership Consortium

OBE	Outcomes-Based Education
PCK	Pedagogical Content Knowledge
PGCE	Postgraduate Certificate in Education
PSTE	Personal Science Teaching Efficacy
PTE	Personal Teaching Efficacy
REQV	Relative Education Qualification Values
SAASTE	South African Association of Science and Technology Educators
SABC	South African Broadcasting Corporation
SCORE	Science Community Representing Education
STEBI	Science Teaching Efficacy Belief Instrument
STOE	Science Teaching Outcome Expectancy
TE	Teaching Efficacy
TES	Teaching Efficacy Scale
TIMMS	Third International Mathematics and Science Study
TLC	Teacher Locus of Control
YEAST	Year of Science and Technology

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CHAPTER 1

BACKGROUND TO THE STUDY

1.1 Introduction

Changes in education policies and curricula bring added challenges, demands and responsibilities for the teachers who are the implementers of change (Blignaut, 2008; Taole, 2013). Teacher training programmes have to respond to such changes by offering training programmes aimed at producing effective teachers who are able to meet the challenges of the day (Taole, 2013; Ono & Ferreira, 2010).

In the era of rapid technological advancements and increase in knowledge, there is a growing interest in the fields of school effectiveness and the quality of education. The prevailing multicultural education context worldwide, and in South Africa, in particular, demands that teachers assume more demanding roles and responsibilities. Although teaching is a practical activity, it is not a static element that can be applied from observed classroom context to all other contexts and situations (Lam & Fung, 2001). Teaching is a complex activity that requires teachers to develop the capacity to make intelligent decisions to handle ambiguous and challenging situations. Hence, teacher education is charged with the responsibility of fostering such capabilities through theoretical understanding and practical experience (Matoti & Junqueira, 2012).

This means that in-service teachers have to be empowered with the necessary and relevant skills to meet the challenges of the ever-changing developments in education (Clement & Vandenberge, 2000). One way towards assisting them is to assess their teaching efficacy in specific subject domains. Such assessment would help identify problems they encounter in teaching Science; strategies would then be devised to help them overcome these problems.

1.2 Background to the study

Teacher characteristics, such as qualification and experience, are factors relating to learner performance (Omolara, 2008). Hence, there is a need for quality teachers as they make a difference in learner achievement. Miles and Stapleton (1998) concur with Omolara (2008) when they argue that the major factor contributing towards academic success is dependent upon trained and capable teachers.

Teacher quality is an important topic of concern for the South African education system authorities, and the South African public at large, in ensuring quality education. There have been many changes in the South African education system since 1994. These changes were deemed necessary because of the nature of the South African education system, which was fragmented and segregated along racial and ethnic lines under the apartheid government. There was never a co-ordinated education system, and this led to different teacher training programmes, some of which were very basic in terms of content knowledge and pedagogy. While the government has been trying to redress the imbalances of the apartheid system in the field of education, and teacher education, in particular, the quality of teachers and teaching in the historically disadvantaged communities is still an area of concern (Department of Education, 2005).

Through the programmes, such as the National Professional Diploma in Education (NPDE) and the Further Diploma in Education (FDE), teachers who were categorised as under-qualified, according to the new qualifications framework, were retrained to bring them in line with the acceptable Relative Education Qualification Values (REQV) 13 qualification. Other qualifications, such as the Advanced Certificate in Education (ACE), were introduced as a way of reskilling teachers. The Norms and Standards (DoE, 2000) have shifted the minimum qualification requirements for all new teachers from REQV 13 to REQV 14. A Bachelor of Education, an Advanced Diploma in Education, or another appropriate degree and an Advanced Diploma in Education have been proposed as the basic Initial Professional Education of Teachers (IPET) qualifications (DoE, 2005).

Changes in the educational policies, curricula and teaching methodologies come with their own demands and challenges, which all come to bear on teachers. Changes in curricula, in particular, assume that teachers are equally trained and prepared to teach; yet research has shown otherwise. Research has shown that preparedness of both teachers and learners are related to self-efficacy. Self-efficacy has been identified as an important predictor of teacher effort and persistence (Emmer & Hickman, 1991); instructional effectiveness (Ashton & Webb, 1986); and efficient classroom organisation, planning and practices (Pajares, 2002). All these changes adversely impact on the same teachers who were historically disadvantaged. These changes appear to have widened the gap between the historically advantaged and well-resourced schools and the historically disadvantaged and resource-starved schools. How then do we ensure that the practising teachers are competent and confident enough to deal with the challenges of dealing with content knowledge and pedagogy/instruction, as well as the demands of classroom management?

Within the domain of science teaching and learning, some specific problems have been identified. These include teachers' low level of content knowledge in science subjects (De Laat & Watters, 1995; Wu & Chang, 2006), inability to perform science experiments and other practicals (Muwanga-Zake, 2001), and inability to use technology in presenting science subjects (Hakverdi, Gugum & Korkmaz, 2007). All these factors affect the confidence of Science teachers in presenting Science classes, and consequently, these impact negatively on the performance of learners (Onwu & Stoffels, 2005; Arends & Phurutsi, 2009). Thus, how do we assist the teachers to be successful in their classrooms?

One consistent measure of teachers' future success in the classroom is their self-efficacy, or belief in their capability to do the job. This issue is of the utmost importance in ensuring teacher quality, since the link between a teacher's perceived self-efficacy and his or her potential effectiveness in the classroom has been established by educational research (Gibson & Dembo, 1984; Riggs & Enochs, 1990, Rubeck & Enochs, 1991; Henson, 2001).

With the current state of affairs in South Africa regarding the Physical Science content subject knowledge of teachers, the introduction of the then new curriculum adds fuel to the fire. The general poor performance in the Grade 12 Physical Science results is alarming, and this continues to decline year in, year out. With specific reference to the Free State, the Physical Science pass percentages from 2006 to 2009 were 38.62%; 49.56%; 40.57%; and 21.71%, respectively (Free State Department of Education, EMIS 2009).

The table below shows the performance in Physical Science for 2009, 2010 and 2012 across the five districts of the Free State province:

Table 1.1: Physical Science pass percentages for the five districts of the Free State province for 2009, 2010 and 2012, respectively (Free State Department of Education, EMIS 2009, 2010, 2012)

District	2009 pass %	2010 pass %	2012 pass %
Xhariep	17.6%	23.5%	25.19%
Motheo	15.3%	23.6%	48.28%
Lejweleputswa	18.2%	25.8%	76.80%
Thabo Mofutsanyana	13.8%	18.8%	70.80%
Fezile Dabi	12.1%	19%	64.21%

It is evident from the results in Table 1.1 that the overall performance of Physical Science is in a poor state provincially. Even though there has been a slight improvement in the results for all the districts from 2009 to 2010, the situation remains bad as the pass percentages for all five districts of the Free State province are below 30%. It is not only the Free State province that experiences poor performance in Science and Mathematics; this is a national crisis, and the whole of South Africa is in a similar situation. However, the sudden drastic improvement from 2010 to 2012 is alarming and is reason for concern. It is worth noting that even though the performance seems to have improved nationally, the pass percentage is at 30%, far below the minimum requirement of 50% that qualifies entry into a university or university of technology for further studies in Physical Science-related fields. This is shown on the table below as represented by the 2012 National Senior Certificate (NSC) results:

Table 1.2: 2012 National Grade 12 Physical Science performances. (DBE, 2012)

Province	% achieved at 30% and above			% achieved at 40% and above		
	2010	2011	2012	2010	2011	2012
Free State	44.0	55.2	68.6	26.9	35	44.2
Northern Cape	45.6	44	60.1	27.9	27.6	38.1
North West	50.2	56.3	62.5	30.9	36	38.9
Limpopo	41.3	52.1	59.9	23.8	31	36.1
Mpumalanga	41.5	52.2	63.1	24.7	33.3	41.4
Western Cape	59.6	65.3	70.9	45.1	50.8	54.4
Eastern Cape	43.3	46.0	50.4	23.5	25.9	27.0
Gauteng	55.6	59.7	70.1	38.4	42.4	50.5
KwaZulu-Natal	50.4	51.9	58.3	30.3	30.8	35.2
National	47.8	53.4	61.3	29.7	33.8	39.1

It can be noted from the above results that even though there has been a slight increase in the Physical Science performance throughout the nine provinces of South Africa over a period of three years, the large proportion of passes are in the percentage achieved at 30% and above, but the numbers reduced as the percentage increased. This means that the majority of the learners who pass Physical Science in Grade 12 do not qualify to pursue Physical Science-related career paths because they do not meet the requirements for admission to institutions of higher learning. This shows the large number of passes of poor quality that are produced.

Makgato and Mji (2006) indicated that several studies (e.g. Howie, 2003, Reddy 2004, TIMMS 1995) have reported a number of shortcomings in Mathematics and Science teaching and learning in South Africa. For example, the Third International Mathematics and Science Study (TIMSS) conducted in 1995, in which South Africa participated together with 41 other countries, reported that South African Mathematics learners came last, with a mean score of 351. This mean score was significantly lower than the international benchmark of 513. According to Beaton (1996 in Mji and Makgato, 2006), less than two percent of these learners reached or exceeded the international mean score. The TIMSS-R, conducted in 1999, indicated that Grade 8 learners performed poorly again. Their mean score of 275 was significantly below the international mean of 487. Also, the South African mean of 275 was lower than that of Morocco, Tunisia, and other developing countries such as Chile, Indonesia, Malaysia, and the Philippines. Reddy (2004) in Mji and Makgato (2006), further highlighted that a later TIMSS-R, conducted in 2003, similarly indicated no improvement by South African Mathematics and Science learners (Mji & Makgato, 2006).

It is worth noting that South Africans' performance in the TIMSS carried out in 1995, 1999 and 2003 was very poor. In each of the three assessment periods, South Africa was in the last position. In the 2003 assessment period, South Africa was outperformed by every country, including all the African countries that participated in the assessment (Howie, 2003; TIMSS, 2003; Human Resources Research Council, 1998 in Reddy, 2006). The 2011 TIMMS was administered at Grade 9 level, instead of Grade 8 for South Africa, Botswana and Honduras. These three countries, according to the Human Sciences Research Council (HSRC), continued to demonstrate low performances at this level for both Mathematics and Science. Their national scores were among the bottom six countries at the Grade 8 level and below the low-performance benchmark (HSRC, 2011). This is a clear indication that the teaching and learning of Mathematics and Science in South Africa remains below standard.

1.3 Problem statement

Self-efficacy beliefs are believed to predict future behaviour (Hoy, 2004). If a teacher believes that he or she is capable of managing his or her classroom and conducting meaningful lessons, he or she will more likely do just that. In line with this thinking, schools of education in general, and teacher preparation programmes in particular, need to be aware of the factors associated with increased levels of self-efficacy, in order to produce the most capable, innovative, and dedicated teachers possible. The effective learning of Science by learners is directly influenced by teacher confidence and competence (Midgley, Feldlaufer & Eccless, 1989; Ashton & Webb, 1986 in Schriver, 1993; Taimalu & Oim, 2005). Science is a two-way subject comprising of the theoretical and practical aspects. It is important for the teacher to master the theoretical scientific concepts before he or she can apply them practically. If the teacher is deficient or lacks confidence in these concepts, it becomes impossible to conduct the practical activities (Muwanga-Zake, 2001). This leads to a gap between theory and practical, where learners end up considering Science as impossibly difficult.

1.4 Research aims

Given the history of disparities in teacher preparation in South Africa, and the plethora of changes in the curriculum and the Outcomes Based Education (OBE) approach, this study was deemed necessary to assess:

- the general teaching efficacy of the Science teachers in secondary schools in the Free State province;
- the effect of the demographic factors, such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels, on Science teaching efficacy, and
- the effect of the teachers' level of preparedness regarding content knowledge and assessment skills on teaching efficacy.

1.5 Research questions

The following are the research questions used to guide this study:

1. What is the general teaching efficacy level of Science teachers in secondary schools in the Free State province?
2. Are there differences in the teaching efficacy of Science teachers in terms of demographic characteristics, such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels?
3. To what extent does teachers' subject content knowledge affect their teaching efficacy?
4. To what extent does practical work knowledge affect their teaching efficacy?
5. To what extent do teachers' assessment skills affect their teaching efficacy?

1.6 Research hypotheses

The hypotheses for consideration in this study were:

1. Science teaching efficacy is affected negatively by teachers' demographic factors, such as location of the school and educational background.
2. There are differences in the teaching efficacy of Science teachers differentiated by age, gender, educational background, teaching experience, geographical location of the school, and grade levels.
3. Lack of proper subject content knowledge among teachers influences Science teaching efficacy negatively.
4. Lack of exposure/practical knowledge affects Science teachers' efficacy negatively.
5. Lack of proper assessment skills among teachers affect Science teaching efficacy negatively.

1.7 Theoretical framework

The study is grounded on the Social Cognitive Theory. The Social Cognitive Theory is the overarching theoretical framework of the self-efficacy construct (Bandura, 1986, 2000). Through the Social Cognitive Theory, Bandura advanced a view of human functioning that accords a central role to cognitive, vicarious, self-regulatory, and self-reflective processes in human adaptation and change (Pajares, 2002). People are viewed as self-organising, proactive, self-reflecting and self-regulating, rather than as reactive organisms shaped and shepherded by environmental forces or driven by concealed inner impulses. From this theoretical perspective, human functioning is viewed as the product of a dynamic interplay of personal, behavioural and environmental influences. Bandura (1986, 2000) calls this three-way interaction of behaviour, personal factors (in the form of cognition, affect and biological events), and environmental influences or situations the “triadic reciprocality”. Within the classroom setting, learners’ academic performance (behavioural factors) is influenced by how learners themselves are affected (cognitive factors) by instructional strategies (environmental factors), which in turn builds itself in a cyclical fashion.

The cognitive personal factor proposed by Bandura was self-efficacy and refers to beliefs in one’s capabilities to organize and execute the course of action required to produce given attainments. Bandura further emphasized that the environment can influence self-efficacy which in turn can influence behavior.

Children are not without ideas about the events and phenomena in the world around them. They have formed ideas in making sense of everyday experiences, but these ideas often conflict with the scientific view (Wellington, 1994). Children have to be treated as knowledgeable, as having ideas that need to be elicited and challenged (Traianou, 2006). Therefore, the role of the teacher is to develop approaches to encourage conceptual change. Thus, it is imperative that teachers are efficacious in teaching Science, as their competence directly affects the learners' learning of Science. This is emphasised by Ausubel's famous line, "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach them accordingly" (Ausubel, 1968). Knowledge of content and pedagogy is not sufficient on its own for the effective teaching of Science (Taimalu & Oim, 2005). Scientific understanding involves procedural capability; enabling links to be drawn between scientific knowledge and areas of experience (Traianou, 2006). The knowledge of learners and their characteristics is another vital aspect of the relationship. Thus, it is important to assess the level of understanding and the efficacy of teachers in order for the learners to be taught accordingly, and for meaningful learning to take place.

Pajares (2002) argues that of all the thoughts that affect human functioning, and standing at the core of the Social Cognitive Theory, is self-efficacy beliefs. Therefore, the next section examines self-efficacy.

1.8 What is efficacy?

1.8.1 Self-efficacy

Self-efficacy beliefs are defined as "people's judgements of their capabilities to organise and execute courses of action required to attain designated types of performances" (Bandura, 1986:391). Self-efficacy beliefs provide the foundation for human motivation, well-being, and personal accomplishment. It is also a critical determinant of self-regulation.

Almost a decade later, Bandura (1995:2) again defined self-efficacy – this time as "the belief in one's capabilities to organise and execute the courses of action required to manage prospective situations", while Pajares (2000) defined it as people's confidence in their ability to do the things that they try to do. The ideas that come through in these definitions are one's judgements, beliefs and confidence in one's abilities to perform a particular task. Bandura's (1997:2) key contention regarding the role of self-efficacy beliefs in human functioning is that "people's level of motivation, affective states and actions are based more on what they believe than on what is objectively true". How people behave can often be predicted by the beliefs they hold about their capabilities, rather than by what they are actually capable of accomplishing, as these self-efficacy perceptions help determine what individuals do with the knowledge and skills they have (Pajares, 2002).

1.8.2 Perceived self-efficacy

Bandura (1997, 2000) defines perceived self-efficacy as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves, and behave. Ross, Beath and Goodhue (1996) emphasise that individuals who feel that they will be successful on a given task are likely to be so because they adopt challenging goals, try harder to achieve them, persist despite setbacks, and develop coping mechanisms for managing their emotional states. All these diverse effects can be produced through four major processes: cognitive, motivational, selection and affective (Bandura, in Ramachaudran, 1998). Through cognitive processes, high self-efficacy contributes to the adoption of higher goals, increased commitment, and the expectation that goals will be achieved despite setbacks along the way. Through motivational processes, high self-efficacy subjects take responsibility for the outcomes of their actions, attributing success and failure to their own efforts rather than to factors beyond their control. Through affective processes, those with high self-efficacy develop coping strategies enabling them to turn off negative thoughts that lower performance. Through selection processes, self-efficacy shapes lives by influencing the selection of activities and environments (Bandura, 1993).

People form perceptions of their self-worth and their own capacity to accomplish goals and overcome obstacles. It is imperative for Science teachers to form optimistic self-efficacy perceptions because people with optimistic self-efficacy perceptions tend to become involved in challenging activities, to be more resolute in the pursuit of their goals, and will show both cognitive and affective resilience in the face of setbacks (Bandura in Steyn & Mynhardt, 2008). In contrast to this, those with low self-efficacy perceptions are characterised by traits that undermine performance (Steyn in Steyn & Mynhardt, 2008).

Perceived self-efficacy affects how successfully goals are accomplished by influencing the level of effort and persistence a person will demonstrate in the face of obstacles. That is, the stronger the perceived self-efficacy, the more active our efforts. Higher self-efficacy is also associated with more persistence, a trait that allows us to gain corrective experiences that reinforce our sense of self-efficacy.

1.8.3 Teacher efficacy

In the context of education and teaching, assessing and measuring teacher efficacy has been found to be useful. Gibson and Dembo (1984:573) refer to two aspects of efficacy, that is, teaching efficacy and personal teaching efficacy. In this regard, “efficacy is perceived as teachers’ belief or conviction that they can influence how well students learn, even those who may be considered difficult or unmotivated” (Guskey & Passaro, 1994:628). Research has pointed to the impact that self-efficacy has on desirable behaviours exhibited by teachers and on the effects that those behaviours have on learners. Gibson and Dembo (1984) found that teachers who are efficacious responded more positively to learners who gave incorrect answers to verbal questions; higher efficacy teachers also were more effective in leading learners to correct answers than teachers with lower self-efficacy. Woolfolk and Hoy (1990) found that pre-service teachers with high teaching efficacy scores, who were also high in personal efficacy, were more understanding in their approach to learner control.

Teacher efficacy is the form of self-efficacy that is referred to as teachers' beliefs in their ability to influence learners' outcomes (Ross, Cousins & Gadalla, 1996; Sridhar, Hamid & Badiei, 2008). Even though the terms have previously been used interchangeably, Bobbet, Olivier and Ellett (in Eren, 2009) showed in 2008 that teachers' efficacy beliefs and teachers' self-efficacy beliefs are distinctly different constructs. Teacher efficacy or teachers' sense of efficacy refers to teachers' beliefs in their abilities to affect student performance, whereas teachers' self-efficacy beliefs refer to teachers' beliefs in their capabilities to perform specific teaching tasks at a specified level of quality in a specified situation. The definition of teacher efficacy is derived from the construct Personal Teaching Efficacy (PTE). It can be distinguished from other constructs in the same domain, such as General Teaching Efficacy (GTE), teachers' outcome expectancies and teachers' locus of control. GTE is a form of Teaching Efficacy (TE) that refers to the belief that the teacher population is able to bring about student change, despite out-of-school constraints.

Teachers' outcome expectancies refer to beliefs that particular teaching actions will lead to student success. It differs from PTE in that the teacher holding the belief does not necessarily believe that he or she is able to perform the actions thought to be productive. GTE can be viewed as the sum of the teacher's outcome expectancies; many researchers treat GTE and the teacher's outcome expectancies as equivalent. Teachers' locus of control refers to teachers' willingness to attribute learner outcomes to their own performance. It differs from PTE in that taking responsibility for outcomes does not mean that one anticipates that the outcomes will be positive (Ross *et al*., 1996). For teachers, PTE involves belief in their own effectiveness in using methods competently to foster learning among learners. PTE relates specifically to an individual's beliefs in his own ability to bring about desired results (Tabbodi & Prahallada, 2009).

Savran and Cakiroglu (2003) supported Bandura's postulate that efficacy beliefs were powerful predictors of behaviour because ultimately they were self-referent in nature and directed toward perceived abilities given a specific task. Such beliefs influence the course of action people choose to pursue, how much effort they will expend in given endeavours, and how long they will persist despite obstacles and failures.

Sridhar and Badiei (2008) look at teacher efficacy as centred around two categories of teachers - teachers with substantial confidence in their efficacy are described with terms such as confidence, a positive sense of teacher efficacy, or more efficacious; those with moderate or low levels of efficacy are labeled as having less confidence, doubting their efficacy, having a low sense of teacher efficacy, or less efficacious. High efficacious teachers believe that they can influence learners' outcomes; the less efficacious teachers believe that there is little that can be done to affect learners' outcomes, or that they personally lack the skill to do so.

In the next section, Science teaching efficacy will be discussed.

1.8.4 Science Teaching Efficacy

The ineffective teaching of Science has been attributed to a number of factors - a lack of a strong background in science content, poor preparation in science content, inadequate facilities and equipment, poor instructional leadership, and teacher attitude (De Laat & Watters, 1995). Teachers' overall attitudes towards science influence their efficacy in teaching the subject.

In a study conducted on experienced teachers in the United States using the Science Teaching Efficacy Belief (STEBI), Ramey-Gassert (1996) identified a range of factors that contributed to high Science teaching self-efficacy beliefs. They were recollections of positive, enjoyable science-related antecedent experiences from which they developed a lasting interest in science, and a positive desire to assist both their learners and to improve their Science teaching (De Laat & Watters, 1995).

Shulman (1991) argues that it is only with a sound grasp of science content that teachers can develop pedagogical knowledge, which he characterised as building "bridges between their own understanding of the subject matter and the understanding that grows and is constructed in the minds of students". Whilst content knowledge is a key factor in the effective teaching and learning of Science, pedagogical knowledge is of equal importance. Key aspects of pedagogy include planning, classroom management and organisation, questioning and assessment.

What the teacher already knows affects his/her own teaching. The teacher's own image or view of what science is has implications for the way that he or she presents and teaches Science in the classroom, both on content and process (Wellington, 1994:34). This is further emphasised by Shuell (1987 in Wellington,1994:34), who says: "The conceptions and assumptions we hold about the nature of knowledge, the way knowledge is acquired determines what we study in science education, what we teach in science classrooms and the way in which the teaching of science is carried out".

A review of the literature shows that there is a need to explore the concept of self-efficacy that is attributed to positive changes. In general, researchers have established that self-efficacy beliefs and behaviour changes and outcomes are highly correlated and that self-efficacy is an excellent predictor of behaviour. It also shows that it is not simply a matter of how capable one is, but of how capable one believes oneself to be.

1.9 Research methodology

In this section, the research design, research instruments and research sampling techniques used in this study are explained.

1.9.1 Research design

A mixed method approach that is QUANTI-quali was appropriate for this study since a relationship was established between the respondents' biographical data, their level of preparedness in Science in terms of content knowledge, practical and assessment skills as independent variables, and their Science teaching efficacy as a dependent variable. The analytical procedure used in this study was to explain results by conducting a quantitative survey to identify how two or more groups compare on a variable. This was then followed up with qualitative semi-structured interviews to explore the reasons why these differences were found.

1.9.2 Research instruments

Two research instruments were used in this study, namely a questionnaire and semi-structured interviews. A questionnaire was used as the main data gathering instrument. The questionnaire comprised of the Science Teachers' Efficacy Belief Scale (STEBI-A), which was designed by Enochs and Riggs in 1990 and was tested for reliability, and a self-constructed questionnaire that required information on teachers' biographical data and their level of preparedness and confidence in teaching Physical Science. The study determined if all the independent variables influenced teachers' perceptions of their teaching efficacy, as measured by the STEBI-A.

Semi-structured interviews were conducted with a conveniently selected number of teachers. Initially, lowest scoring and highest scoring teachers on the STEBI-A were to be considered, but teachers had to be interviewed based on their availability since not everybody selected was willing to participate.

1.9.3 Research sample

This study involved 190 Physical Science teachers from secondary schools in the Free State province.

1.10 Significance of the study

The significance of this study cannot be over-emphasised, as Physical Science (like all academic subjects) can contribute to learners being informed decision-makers of the future. Secondary school Science programmes are integral to this process of development as they prepare learners for university entry. Thus, it is important that secondary school Science teachers are well-trained and competent in order to offer quality Science to their learners.

This study will shed light on the teaching efficacy of Science teachers in the Free State province. Bandura (1986, 2006) argues that self-efficacy is a situational and domain specific construct whereby confidence varies depending upon the skill required or the situation faced (Bandura, 2006). In line with this argument, the study will make departmental officials and principals aware of the context specific, as well as subject specific, problems that teachers encounter in their schools and offer possible solutions to the problems.

1.11 Scope of the study

This study will focus on secondary school Science teachers in the Free State province of the Republic of South Africa.

1.12 Methodological limitations of the study

The following limitations of the study are highlighted for future research:

- The size of the sample may make it impossible for generalisation of the results to be made to the greater Republic of South Africa.
- The use of self-rating on content knowledge may not be a true reflection of the teachers' level of confidence in content knowledge.

1.13 Definition of concepts

Teaching Efficacy

Teaching Efficacy is "perceived as teachers' belief or conviction that they can influence how well students learn, even those who may be considered difficult or unmotivated" (Guskey & Passaro, 1994:628). Tshannen-Moran and Woolfolk Hoy (2001) defined teacher efficacy as teachers' perceptions of their resources and strategies for bringing about student behavioural and instructional outcomes.

Science Teaching Efficacy

This refers to a combination of a teacher's comprehensive Science knowledge, understanding of the links between the content knowledge and the teaching and learning process, sound understanding of pedagogy, and the ability to apply successfully his/her understandings and skills practically (Ginns & Watters, 1999).

Since this study involves the assessment of teaching efficacy beliefs, thus self-efficacy, teaching efficacy and science teaching efficacy will somehow be used interchangeably.

Preparedness

Preparedness, as used in teacher preparedness, includes “the state or condition of being prepared; readiness; and emphasises the attitudinal aspect of being prepared to do something” (Gill & Dalgarno, 2008).

Confidence

Confidence is defined as “a feeling of self-assurance arising from an appreciation of one’s own abilities” (South African Oxford Dictionary, 2002).

A secondary school

It refers to an educational institution that operates to provide formal secondary education to school age learners. According to the World Bank (2002), secondary education completes the provision of basic education and aims at laying the foundations for lifelong learning and human development by offering more subjects or skill-oriented instruction using more specialised teachers. In the South African context, there are different types of secondary schools - independent, public, and farm schools. They are also referred to as schools in the Senior Phase and Further Education and Training (FET) bands of the National Qualification Framework (NQF) and constitute Grade 8 to Grade 12 classes. For the purpose of this study, secondary schools refer to schools in the FET band, and are also independent, public and farm schools as they constitute the research sites of the researcher.

The teacher

This refers to the person who must educate, teach and manage. The teacher plans, organises, leads and controls the events in the classroom (Kruger & Van Schalkwyk, 1997).

Physical Science

Department of Basic Education (DBE), 2011 Curriculum Assessment Policy Statement for Physical Science refers to Physical Science as the study that investigates physical and chemical phenomena. This is done through scientific inquiry, application of scientific models, theories and laws in order to explain and predict events in the physical environment. In some instances of this study, Physical Science will be presented as Science.

1.14 Chapter outline

Chapter 1

This chapter provides the context and the background to the study, the statement of the problem, the aims of the study, the research questions, and a brief overview on the research design followed in the study. It also presents the significance of the study, its limitations, the definitions of concepts, and the outline of the thesis.

Chapter 2

This chapter presents the literature review of the study. It focuses on the problems facing the teaching and learning of Science and how these problems hamper the teaching and learning of Science. It covers the problems facing the teaching and learning of Science, the general school factors that have a negative influence on the learning environment, and factors outside the school setting affecting the teaching and learning of Science.

Chapter 3

Through the literature study in Chapter 2, the theoretical framework was adapted to be relevant for the purpose of the study. Relevant literature on Bandura's Social Cognitive Theory is reviewed, including self-efficacy and Science teaching efficacy.

Chapter 4

This chapter presents the research methodology for this study which deals with the research design, procedures and techniques (which include aspects of qualitative and quantitative research methods) and data collection.

Chapter 5

This chapter deals with data presentation and analysis of the quantitative data. The findings, interpretation and discussion thereof are covered in this chapter.

Chapter 6

This chapter provides the data presentation and analysis of the qualitative data. The findings, interpretation and discussion thereof are covered in this chapter.

Chapter 7

This chapter provides a summary of the study, conclusions and recommendations based on the research findings.

1.15 Conclusion

This introductory chapter provided an overview and the background of this study. The aims and objectives of the study were outlined, as well as questions relating to the study. This chapter also highlighted the theoretical framework underpinning the study. In addition, the key concepts were defined.

The next chapter focuses on the literature review pertinent to this study.

CHAPTER 2

LITERATURE REVIEW: PROBLEMS RELATED TO SCIENCE TEACHING

2.1 Introduction

This chapter presents the literature pertinent to the study. It covers the following sections: (1) problems facing the teaching and learning of Science, (2) general school factors that have a negative influence on the teaching and learning environment, and (3) factors outside the school setting affecting the teaching and learning of Science. With reference to Bandura's (1997) triadic reciprocality causation model, that relates personal factors, behaviour and external environment, it is important to start the literature review on problems affecting the teaching and learning of Science, since the external factors influence one's belief in bringing about a desired outcome. By changing the environmental conditions to more favourable situations can promote positive changes in behaviour and increase positive personal experiences (Taylor, 2006). This chapter will also focus on problems facing the teaching and learning of Science and how they hamper the teaching and learning of this subject. This will lead to the review of related literature on teaching efficacy, which will be explored more in the next chapter.

2.2 Problems facing the teaching and learning of Science

The teaching and learning of Science has always been, and continues to be, clouded by problems that impede the effective delivery of the subject to learners. These factors will be divided into the following sections: (i) teacher-related factors that hamper the teaching and learning of Science, (ii) general school factors that have a negative influence on the learning environment, and (iii) factors outside the school setting affecting the teaching and learning of Science. These factors will be discussed in terms of the global context, approaching them from the international through to the national, and lastly, to the local perspective, where appropriate.

2.2.1 Teacher-related factors that hamper the teaching and learning of Science

Teacher-related factors are referred to as endogenous variables, according to Pell and Elvis (2009 in Wee-Loon, 2011). These variables, including teachers' characteristics, are within the influence of the school process and are, therefore, open to changes that can improve attitudes (Wee-Loon, 2011). A number of factors, which make the teaching of Science ineffective in classrooms, have been identified. These include lack of a strong background in Science content, poor preparation in Science content, poor instructional leadership, inadequate facilities and equipment, and the teacher's attitude (De Laat & Watters*,* 1995, Halim & Meerah, 2002). These factors that make the teaching of Science ineffective in classrooms are discussed further in the following sections.

2.2.1.1 Lack of strong background in Science content

Subject knowledge has come to be seen as a major component of teacher expertise, one that underpins the ways in which teachers help children to develop understanding of the content of Science, as well as their ability to inquire (Traianou, 2006). A lack of background knowledge in Science often reduces the capacity to exercise judgment in handling the unexpected behaviours of children when using hands-on materials (Spickler & Hernandez-Azarraga, 1997; Udeani & Ejikeme, 2011). It seems clear that discomfort with Science content can lead to discomfort with inquiry teaching and lack of confidence in teaching the subject (Udeani & Ejikeme, 2011).

Where teachers do not have strong subject knowledge resources, they tend to see successive curricula as rejecting their antecedents, and, as a result, teachers may discontinue using valuable practices and materials from previous curricula. With respect to the Curriculum Assessment Policy Statements (CAPS), in the absence of strong subject knowledge on the part of teachers, there is the danger that the strategies set out in the policy documents may be mistaken for the outcomes of learning, and may even obscure the knowledge capacities they aim to promote. However, no matter how clearly written any curriculum might be, it always involves interpretation on the part of the teacher (Taylor, 2012).

The role of a teacher is to impart knowledge to the learners so that they acquire desirable skills, abilities, knowledge and other competencies, which would help them in their later life. To achieve this, the teachers should be well-versed in their teaching subjects and be ready to teach within the level of their learners (Abuseji, 2007). It is the responsibility of teachers to ensure that they equip learners with the appropriate knowledge. For them to be able to do so, they must be knowledgeable in their subject fields.

It is not only about possessing the knowledge in the classroom, its application is also critical. The importance of pedagogical knowledge should also be addressed, equally to subject knowledge. Harlen and Holroyd (1995 in Clark, 2009:6) found that "about a third of the teachers identified their own lack of background knowledge as a source of problems". They also listed three levels of understanding of background knowledge, based on the depth of teachers' awareness of the "big ideas" within the areas they teach at school. These levels are: (i) ideas commonly understood by teachers, (ii) ideas less commonly understood, but where understanding is readily developed, and (iii) ideas not commonly understood and where understanding is difficult or time-consuming to develop. They found teachers vary widely between the levels, with many misunderstanding the ideas they were trying to develop in their pupils. This can frustrate teachers in the classroom when expected results do not occur or equipment breaks down, negatively affecting self-efficacy. A lack of background knowledge can also affect how teachers organise, implement and deliver tasks (Clark, 2009).

Teachers need a rich and deep understanding of their subject in order to respond to all aspects of learners' needs. However, teachers often reported that they felt least qualified to teach Science. Primary school teachers cited an inadequate Science background as one of the reasons for not wanting to teach the subject (Abuseji, 2007).

Lack of knowledge of Science can lead to problems in practice. According to Volkmann (2005 in Clark, 2009), a problem that may arise is the tendency for many teachers to teach as they themselves were taught, which often leads to simply regurgitating the facts of Science with little thought to the conceptual or procedural aspects of the sessions. A lack of knowledge often affects good practice when it limits a teacher's ability to anticipate the direction in which learners' scientific learning might proceed and be able to offer advice or extension activities (Clark, 2009).

Subject matter knowledge is structured into substantive and syntactic areas, where substantive content knowledge refers to the concepts, principles, laws and models in a particular content area of Science. Syntactic content knowledge of a discipline is the set of ways in which truth or falsehood, validity or invalidity is established (Schwab 1978, in Shulman, 1986). A teacher with both syntactic and substantive knowledge will not only be capable of defining for learners the acceptable truths in a domain, but will also be able to explain why it is worth knowing and how it relates to other propositions, both within the discipline and without, both in theory and in practice. Both kinds of subject matter knowledge are needed for educators' development of Pedagogical Content Knowledge (PCK) (Ibeawuchi, 2010).

2.2.1.2 Preparation and qualifications in Science

The Science teacher preparation programme's main goal must be to prepare Science teachers so that they are able to respond in a variety of ways to the instructional decisions they may face in the process of transforming and representing subject matter so that it is comprehensible to the learners (Gess-Newsome, 2002). Teacher training education has to develop competent and confident teachers. Pre-service teachers may lack a sense of efficacy due to a lack of teaching experience; therefore their programmes need to be structured in a way that promotes mastery of the subject content knowledge and pedagogical knowledge.

Regardless of where preparation occurs, the Science teacher education programme has a responsibility to demonstrate that candidates are prepared in relation to the standards and to content recommendations (Udeani & Ejikeme, 2011). Many pre-service teachers entered their student teaching semester with limited conceptual understanding of scientific ideas, regardless of how many previous Science classes they had attended. Even if they possess high school and university Science qualifications, Science teachers often lack a fundamental understanding of many concepts found in science standards and elementary science texts, such as seasons, night and day, heat and temperature, the water cycle, etc. (Rice, 2005). Qualified teachers are among the most valuable resources of schools.

Research indicates that teacher preparation/knowledge of teaching and learning, subject matter knowledge, experience, and the combined set of qualifications measured by teacher licensure are all leading factors in teacher effectiveness. According to the National Council for Accreditation on Teacher Education (NCATE), a professional teacher preparation accrediting body that aims to establish high quality teacher education, most of the research findings on pre-service teacher preparation are consistent with common sense and the experience of those in the classroom. Not only does the lack of content knowledge and pedagogical content knowledge inhibit conceptual change, create an over-reliance on didactic and rote learning, and restrict curriculum choices, it also causes teachers to lack confidence in their ability (Lanier, 2009; NCATE, 2005:2). Thorough research was done on the role of teacher preparation as a key to teacher effectiveness. The key findings from the existing research on teacher preparation are:

- Teacher preparation helps candidates develop the knowledge and skills they need in the classroom;

- Well-prepared teachers are more likely to remain in teaching;
- Well-prepared teachers produce higher student achievement; and
- Leading industrialised nations invest heavily in pre-service teacher preparation (NCATE, 2005:3).

Two components are critically important in teacher preparation: teacher knowledge of the subject to be taught, and knowledge and skill in how to teach that subject. Research tells us that subject matter knowledge is necessary for effective teaching. But, there is a second part of the equation: knowledge and skill in how to teach is also imperative. Effective teachers understand and are able to apply strategies to help learners increase their achievement. They understand and apply knowledge of child and adolescent development to motivate and engage learners. They are able to diagnose individual learning needs. They also know how to develop a positive climate in the classroom in order to make it a stimulating learning environment (NCATE 2005:4).

While content knowledge is important and necessary, it alone cannot determine whether the teacher is able to teach so that learners learn. That is why NCATE requires the parallel development of teaching knowledge, that is specific to the content being taught, as well as general pedagogical knowledge and knowledge of child and adolescent development as applied to teaching.

To follow are some key converging findings from research on teacher preparation. This represents the collective knowledge based on teacher preparation today:

1. High Quality Teacher Preparation Helps Candidates Develop Essential Knowledge and Teaching Skill.
2. Teacher Preparation Increases Beginning Teacher Retention.
3. High Quality Teacher Preparation Makes a Difference in Student Achievement.
4. High Standards for Teacher Preparation in Leading Industrialised Nations Lead to High Student Achievement (NCATE 2005:12).

The Center for the Study of Teaching and Policy, in collaboration with Michigan State University, released a report titled "Teacher Preparation Research: Current Knowledge, Gaps, and Recommendations" in which it provides five key questions to be considered about what it means for teachers to be well-qualified and what it takes to prepare teachers well:

1. What kinds of subject matter preparation, and how much of it, do prospective teachers need?
2. What kinds of pedagogical preparation, and how much of it, do prospective teachers need?
3. What kinds, timing, and amount of clinical training ("student teaching") best equip prospective teachers for classroom practice?
4. What policies and strategies have been used successfully by states, universities, school districts, and other organisations to improve and sustain the quality of pre-service teacher education?
5. What are the components and characteristics of high quality alternative certification programmes? (Wilson, Floden & Ferrini-Mundy, 2001:4-5)

These are the types of questions that each and every accredited institution of learning, which offers qualifications in teacher education and training, should take into consideration. These questions must be embedded in the curriculum; hence, helping to produce well-trained and well-prepared teachers for the future.

Fulp (2002, in Lanier, 2009) reported that elementary teachers often go through each year teaching less Science and engaging in even fewer professional development activities to improve their ability because they feel unqualified to teach Science. When teachers feel unprepared, they often rely on textbook publishers to determine the curriculum, rarely deviating beyond their personal comfort zone. Furthermore, when teachers feel unprepared, even when resources are available to teach Science, they often do not know how to incorporate these resources effectively into Science lessons (Lanier, 2009).

Findings from a number of studies were outlined in Abuseji (2007) to show the relationship between teachers' qualifications and learners' performance. Greenwald, Hedges and Laine (1996) indicate a significant positive relationship between learners' performance and teachers' qualifications. Friedman (2000) supports the idea that achievement in Science is low. He attributes this to, among other factors, the teaching of Chemistry by teachers with neither a major, nor a minor in the subject. Ingersoll (1999) found in a study that 63 percent of Chemistry, Physics, and earth and space Science instructors did not have certification in the subjects and this resulted in the poor performance of learners (Abuseji, 2007)

The preparation of Science teachers is crucial to the successful implementation of government policy on Science education. This is because teachers are the final arbiters of curricular programmes (Udeani & Ejikeme, 2011).

The next section looks into instructional leadership.

2.2.1.3 Instructional leadership

Instructional leadership involves developing a common vision of good instruction, building relationships, and empowering staff to innovate in instruction, offer one another feedback, and share best practices (Jones, 2010). It ensures that all learners have ongoing access to high quality teaching and learning to achieve curriculum outcomes.

Instructional leadership, according to Gümüşeli (2005), is unique to the field of education and it differs from other types of leaderships because it is related to learners, teachers, curricula and learning-teaching processes. The critical role of "being an instructional leader" played by the principals affects teaching and student achievement (Education, 2005). The principal as an instructional leader is expected to assist teachers in planning effectively, emphasising effective teaching strategies, and serving as an instructional coach, ensuring that the vision of the school is achieved and the goals are met (Moak, 2010).

Instructional leaders demonstrate instructional leadership when they:

- focus on improving the effectiveness of instruction to increase the achievement of all learners;
- know when, how, and why to initiate and sustain instructional change;
- create a school-wide inclusive culture of high expectations for achievement and for rigor, relevance, and respect in the classroom;
- ensure instructional practices are appropriate to the context and grounded in research and the authentic assessment of student learning;
- close the knowing-doing gap by moving successfully from sound theory to effective practices; and
- are knowledgeable about and deeply involved in the implementation of the instructional programme of the school (Nova Scotia Educational Leadership Consortium, 2013:1).

Research (Coladarci, 1992; Coladarci & Breton, 1997; Fresko, Kfir & Nasser, 1997, 2010) has shown that greater teaching commitment was related to job satisfaction and the level of continuous training. Teaching commitment tended to be expressed by those teachers who were higher in both general and personal efficacy; who taught in schools with fewer learners per teacher; and who worked under a principal regarded positively in the areas of instructional leadership, school advocacy, decision making, and relations with learners and staff (Coaldarci, 1992; Coladarci & Breton, 1997; Fresko, Kfir & Nasser, 1997; Bentea & Anghelache, 2012).

Ryan (2007) examined the relationship between teacher efficacy and teachers' perceptions of their principals' leadership behaviours. According to the outcomes of the study, total respondent data indicates a generally positive relationship between these two variables. Teachers with strong efficacy reported strategies that foster teacher efficacy, make teachers feel good about teaching, and promote the development of teacher efficacy (Ryan, 2007).

According to Hallinger (2005), instructional leadership has three dimensions: defining a school's mission; managing the school's instructional programme; and promoting a positive school climate where learning is optimised. These dimensions and their ten leadership functions are illustrated in the figure below:

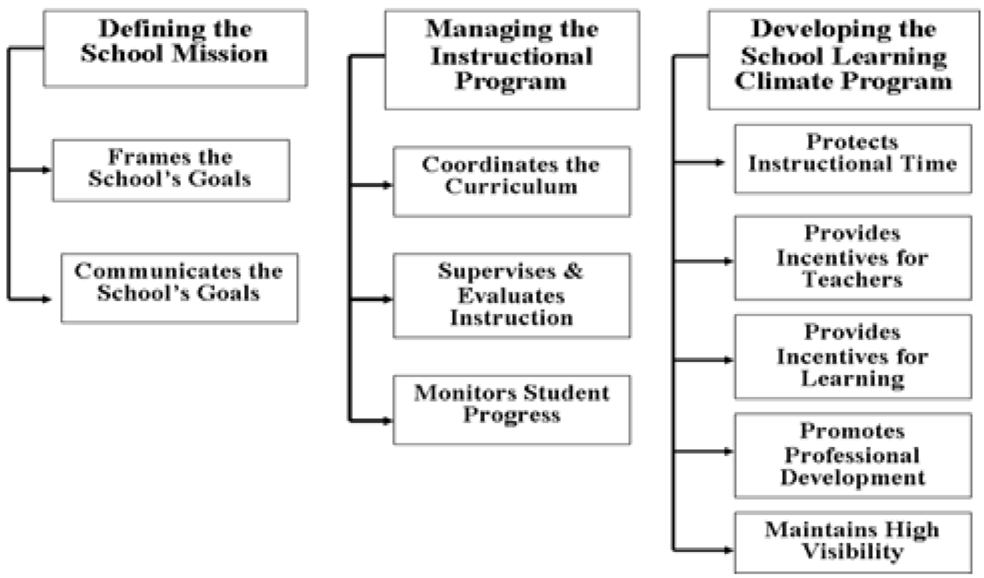


Figure 2.1: Dimensions of instructional leadership
Source: Instructional Management Framework (Hallinger & Murphy, 1985)

Good instructional leadership in schools is characterised by coherent planning and coordination, effective language policies and programmes, good time management, procurement and deployment of books, promoting high levels of writing, using assessment to improve teaching and learning, and fostering professional development among teachers. Provincial and district offices provide support services to schools with respect to these practices (Taylor, 2012).

2.2.1.4 Teacher attitudes

Teacher attitudes and beliefs are important considerations in understanding classroom practices and conducting teacher education programmes that are designed to help prospective and in-service teachers towards developing their thinking skills and classroom practices (Voltaire, 2007). A teacher's enthusiastic nature and positive attitude towards Science makes Science highly memorable for pre-service teachers when considering their secondary school Science experiences (Hudson, Usak, Fancovicova, Erdogan & Prokop, 2010)

Koballa and Crawley (1985 in Sarikaya, 2004) emphasised that the attitude toward Science should not be confused with scientific attitude, which may be aptly labeled scientific attributes (e.g., suspended judgement and critical thinking). "I like Science", "I hate Science" and "Science is horrible!" are considered to be expressions of attitudes toward Science because they denote a general positive or negative feeling toward the formal study of Science or Science as an area of research (Sarikaya, 2004).

Being aware of teachers' attitude toward Science is one of the major influences on learners' attitude toward Science. A study by Shrigley (in Sarikaya, 2004) investigated the status of the attitude of pre-service elementary teachers toward Science. The variables tested in this study were: (1) the effect of sex difference, (2) the effect of male elementary teachers, (3) the effect of organised and incidental elementary Science programmes, and (4) the effect the number of high school Science courses had on the Science attitude of pre-service teachers. The population for this study was 207 third-year elementary education majors at Pennsylvania State University. The Science attitude scale was administered by the investigator during the first week of their enrolment in a Science education course. Results of this study indicated that: (1) There is no sex difference in Science attitude of pre-service teachers, (2) Sex difference would not have a more positive effect on the Science attitude of their learners, (3) An organised elementary Science programme affects the Science attitude of pre-service teachers positively, (4) Either the student who enrolls in four or more high school Science courses is the one with a more positive attitude toward Science or the enrolment in more Science courses affects the attitude positively (Sarikaya, 2004). Many teachers recognise the importance of engaging learners in Science; yet there are others who do not enjoy teaching Science, therefore they lack the commitment needed to teach in reform-minded ways.

Problems with Science and Technology education in Turkey, as established by Özden (2007) in a study to determine attitudes towards a Science and Technology education programme and the reasons for low achievement in Science education, were identified as follows:

- an insufficient number of Science and Technology teachers take an active role in the preparation of the programmes,
- insufficient in-service training of the Science teacher in the transition state of a new programme,
- the large number of learners in a class,
- the informal education orienting learners towards only examination achievement, and
- the broken link with other lessons (e.g. a Mathematics programme), and the insufficient physical conditions of schools.

Teachers' negative attitudes and low confidence in the teaching of Science could be detrimental as they prevent new teachers from exploring better ways of instilling Science knowledge and making the subject a fun one to learn (Wee-Loon, 2011). Teachers end up relying more on textbooks than encouraging conceptual understanding of Science. This reliance on textbooks during Science lessons is undesirable as it emphasises the learning of answers, more than the exploration of questions, and memory at the expense of critical thoughts (Wee-Loon, 2011). According to Munck (2007), the attitudes and beliefs of elementary Science teachers about the teaching and learning of Science are often manifested in their actions. They often mask their unfavourable disposition by teaching as little Science as possible, teaching within their comfort zone, and over-utilising expository teaching methods (Munck, 2007).

These above-mentioned factors make the teaching of Science ineffective in classrooms, thus influencing teachers' competence and the quality of teachers. Learners' learning is influenced by among others, school organisation resources and the climate which involves teacher skills, curriculum structure, and content. Teachers' characteristics, such as qualifications and experience, are factors which relate to learners' performance; it also affects their learning (Omolara, 2008). Hence, there is a need for quality teachers as they influence learner achievement positively. Learner achievement increases when there are competent teachers. The major factor contributing to academic success is dependent upon trained and capable teachers (Miles & Stapleton, 1998). The most prominent of the teacher-related factors are teacher competence and the quality of teachers (Taimalu & Oim, 2005), which will be dealt with in the following paragraphs.

2.2.2.1 Teacher competence

Teacher competence, according to Medley (1982 in José Passos, 2009), refers to the knowledge, abilities, and beliefs a teacher possesses and brings to the teaching situation. These attributes constitute a stable characteristic of the teacher that does not change appreciably when the teacher moves from one situation to another (José Passos, 2009). Teacher competence is a combination of academic knowledge and methodology - academic skills are not enough to have a positive influence on the learners' results, and a broader teaching competence is also necessary (DoE, 2005).

The ultimate measure of a Science teacher's effectiveness is in the ability to transform the content into a form accessible to the learners. The teacher must be able to transform what they know to teaching strategies that make that knowledge accessible to the learners. This is referred to as Pedagogical Content Knowledge (PCK), according to Shulman (Gess-Newsome, 2002). If PCK involves knowing the kinds of strategies which are effective in teaching certain subject topics, classroom competence is the practical ability to deploy these strategies with learners so as to affect learning. A good teacher is one who engages learners' cognitive attention through a set of activities and interactions with text and other materials. This teacher knows the subject well, and understands the level at which to pitch it for the grade and the steps required to build each concept. A good teacher is experienced in presenting the forms of knowledge representation which the learners find most illuminating, and has an intuitive feel for the pacing of activities which stretch his or her charges to their capacity (Taylor, 2012).

The teacher is one of the three content variables identified within factors that influence learners' attitude towards Science. The other two variables are the learner and the learning environment (Wee-Loon, 2011). The problem of teacher competence is not related only to the level of teacher instruction, but also to the level and quality of training. Both the academic level achieved and the quality of the professional training received, contribute to the competence of a teacher (José Passos, 2009).

Concerns regarding teacher competence date back to 1970, when the National Council Accreditation of Teacher Education (NCATE) in the United State began to revise the accreditation standards. In Australia, the University of Sydney has developed an elaborate set of generic competencies for beginning teachers. Hence, determining competence is both the concern of the accreditation party and the teacher education institute. Though teachers are certified, beginning teachers rarely attain the competence of effective teachers. Teachers should continue to develop their competence throughout their professional lives (So, Cheng & Tsang, 1996).

Effective Science teachers know how to best design and guide learning experiences, under particular conditions and constraints, and to assist diverse groups of learners develop scientific knowledge and an understanding of the scientific enterprise. PCK is integral to effective Science teaching. An understanding of PCK and its influence on teachers' practice is necessary to foster the improvement of Science teaching and Science teacher education (Gess-Newsome, 2002).

Research findings on teacher competence

According to Loucks-Horsely, Love, Stiles, Mundry and Hewson (2003 in Cripe, 2009), Science teachers need enhanced knowledge, skills and experiences so that they feel comfortable and have the confidence needed to help their learners succeed in learning (Cripe, 2009). However, although teachers may feel confident, this does not necessarily imply competence (Lardy & Mason, 2011).

The identification and determination of teacher efficacy are crucial in teacher education and development. Firstly, teacher certification groups are using competence as an indicator. Secondly, teacher education institutes are planning their programmes, which aim to maximise teacher competence, and thirdly, teacher educators are using teacher competence to reflect various stages of teacher development (So, Cheng & Tsang, 1996). This is an indication that teacher competence is key in the training and development of teachers.

Research by Lumpe, Haney and Czerniak (2000) and Posnanski (2002 in Cripe, 2009) has shown large numbers of Science teachers who, for various reasons, such as the lack of a Science content background, do not feel prepared to implement the Science standards in order for their learners to succeed in Science (Cripe, 2009).

Strategies used to improve teacher competence

Teacher competence is usually linked to an academic and professional qualification and years of regular in-service training (Gopal & Stears, 2007). With the changes taking place in the South African curriculum system, teachers' morale has been greatly affected as they felt that the training they received towards the implementation of the then new system was not sufficient. Research has shown that teacher confidence is one attribute that influences a teacher's ability to adopt and teach the new curriculum. Research conducted on agricultural teachers showed that those who possess a high level of self-perceived knowledge and ability to teach biotechnology skills, issues and content may be more willing to adopt the new curriculum (Wilson & Flowers, 2002).

Rennie, Goodrum and Hackling (2001) emphasise that the most important factor in improving learning is the teacher. Efforts to close the gap must focus on helping teachers to recognise the gap between learners' real needs in Science and what is offered in the actual curriculum. Teachers also need support to develop the understanding and skills needed to make the changes possible. Leadership in schools and systems are also important, but it should be balanced by teacher input. Research has shown that imposed change without teacher engagement and ownership of the change brings little effective improvement in the longer term. The power for improvement lies in the collegial efforts of teachers and their profession (Rennie, Goodrum & Hackling, 2001). Thus, the more engaged the teachers are in the changes involving their teaching, the more improved is their competence.

Teacher factors limiting the teaching of Science include inadequate time for the preparation needed for teaching Science, lack of background knowledge to teach Science, lack of Science professional development, or poor access to Science professional development in primary teachers. For secondary teachers, the following reasons were common: teachers had inadequate time for preparation, reflection and collaboration, teachers lacked the knowledge and skill to teach Science or there was a lack of professional development, there was inadequate time for teaching Science and or too much content to cover in the available time. The education systems are experiencing constant change, reflecting changes in society; most teachers are open to changes that they believe will benefit the learners. However, many teachers lack the time, resources and professional development opportunities for change to imply positive personal growth; rather it becomes a time of stress and feelings of inadequacy. Teachers need support to maintain an ongoing commitment to personal professional development (Rennie, Goodrum & Hackling, 2001).

Learners' prior knowledge

Science teachers' concerns relate to assisting learners to understand Science concepts, the availability of materials that can help them understand better what learners already know (learners' prior knowledge) and what might be difficult for them to understand, as well as how best to evaluate them. These concerns are central to describing the knowledge that distinguishes a teacher from a subject matter specialist (Gess-Newsome, 2002).

PCK is central to understanding effective Science teaching. It draws attention to a special kind of teachers' knowledge that is specific to teaching and integrates the subject matter knowledge and knowledge of pedagogy. It also refers to teachers' interpretation of subject matter knowledge in the context of facilitating learners' learning. "Pedagogical content knowledge is therefore the amalgam of content and pedagogy that is the province of educators" (Shulman, 1987). In other words, it is the type of knowledge that is unique to teachers and is based on the manner in which teachers relate their subject matter knowledge (what they know about what they teach) to their pedagogical knowledge (what they know about teaching) (Shulman, 1987). Since PCK is specific to teaching and context specific, it therefore differentiates expert teachers in a subject area (Science/Mathematics teachers) from subject area experts (scientists/mathematicians). For instance, Science/Mathematics teachers differ from scientists/mathematicians, not necessarily in quantity or quality of subject matter knowledge, but in how that knowledge is organised and used (Ibeawuchi, 2010). Thus, it is imperative to integrate the subject matter/content knowledge with pedagogic knowledge to ensure that the teaching strategies are utilised accordingly for effective Science teaching.

Research (Viri, 2003; Halim & Meerah, 2002) indicates that teachers' knowledge, especially teachers' pedagogical content knowledge, influences learners' achievement in Mathematics. The studies show that the extent to which an educator possesses each component of pedagogical content knowledge determines the quality of instruction, and subsequently affects what learners learn.

While many Australian secondary teachers have a good grasp of traditional discipline knowledge, it seems that they often cannot make meaningful links between discipline knowledge and its application in the world outside the classroom (Rennie, Goodrum & Hackling, 2001). Many need to refine their pedagogical skills and knowledge so that they are more effective in facilitating inquiry-oriented, student-centred learning activities and formative assessment. Some teachers also lack a contemporary understanding of how learners learn and how best to enhance a developmental, outcomes-focused approach to learning (Rennie, Goodrum & Hackling, 2001).

Lack of confidence towards Science is a major factor in the avoidance of teaching Science in elementary school. In a survey conducted on 28 Australian pre-service elementary Science teachers to determine the factors they believed contributed to their confidence towards Science and the teaching of Science, teacher practicum, teacher educator, Pedagogical Content Knowledge, the learning environment, assessment and reflection were identified (Howitt, 2005). If these factors can be addressed, teachers' confidence towards Science will be improved; thus, the quality of teachers will be of a high standard.

2.2.2.2 Quality of teachers

A teacher's qualities include preparation and training, the use of a particular instructional approach, and experience in teaching. The quality of education hinges on the quality of teaching that happens in the classroom, reinforcing the idea that quality teachers make up for the deficiencies in the curriculum and in educational resources. A good teacher can correct and adjust the curriculum and the syllabi to a specific context, and to their pupils' interests and motivation in order to achieve the goals defined by the Ministry of Education (José Passos, 2009).

Shulman (1986) argues that quality teachers have adequate knowledge of the subject matter content and that of pedagogical skills, which is termed Pedagogical Content Knowledge. Therefore quality teachers, according to Shulman (1986), would possess:

- Content knowledge, which is the teacher's content background in the subject they teach.
- General pedagogical knowledge, which embraces the principles and strategies of classroom management and organisation.
- Curriculum knowledge, which is the knowledge of curriculum materials and resources that are relevant for the teaching of a particular topic.
- Pedagogical content knowledge, which is the combination of content and pedagogy.
- Knowledge of the learners and their characteristics, which comprises the knowledge of learners' developmental levels and prior knowledge, and how teachers motivate learners' learning.
- Knowledge of educational contexts, which encompasses teachers' understanding of the school environment including the classroom and the knowledge of the school communities.
- Knowledge of education ends, purpose and values and their philosophical and historical grounds; this knowledge helps teachers to put their own goals into a larger perspective.

An effective teacher is described as a teacher who is able to successfully perform the tasks expected of him/her. Okpala and Ellis' definition of teacher effectiveness ranges from what a teacher knows and does in the classroom, to how knowledge is attained (Okpala & Ellis, 2005). Küçükahmet (1999 in Ali, 2011) points out that teachers have the potential to influence learners, both positively and negatively, through their qualifications and personality traits. According to Ingersoll (1999 in Ali, 2011), the quality of a teacher is determined by his/her personality traits, teaching applications, and level of academic development. This emphasises the importance of personality traits in determining the success or failure of teachers, and sees success as a product of their level of academic development. Yet, teachers influence learners not only through the content they teach, but also through their personality traits and the communication of these traits through behaviour.

Effective Science teaching is the gateway to attainment of scientific and technological greatness. Science and Chemistry teaching can only be effective when teachers make use of appropriate methods and resources in teaching the learners (Abuseji, 2007). Darling-Hammond (2000 in Abuseji, 2007) found that teacher quality characteristics, such as certification status and a degree in the subject to be taught, were significant and positively correlated with subject outcomes in Science and Mathematics.

According to a German report of a national quality development programme on increasing the efficiency of Science and Mathematics instruction, it appears that not only the way Science and Mathematics are taught is responsible for the deficiencies as revealed by the Trends in Mathematics and Science Study (TIMMS), but also the image of these subjects in the broader public. The learning of Science and Mathematics is not highly valued; there is a common belief that the ability to learn these subjects is a matter of being gifted. Another reason for limited efficiency is that German teachers are not well prepared to improve the quality of instruction, as co-operation among teachers and reflection about instruction are not well developed and are insufficiently supported by teacher training programmes (Prenzel & Duit, 2000).

A Taiwanese study by Wu and Chang (2006) indicated that elementary teacher education faced the dilemma of preparing prospective teachers to be generalists or specialists for certain subject areas. The study further emphasised that teacher preparation programmes are characterised by a lack of coherence and articulation across the general education, Science education and professional education curriculum strands. Since education is a compulsory subject for all learners training to become teachers, very few choose majors in Science and Mathematics. This led to few teachers being qualified to teach Science subjects, and consequently inadequate preparation, and insufficient content knowledge and conceptual understanding of, and efficacy towards Mathematics and Science (Wan, 2010).

In a study conducted in Nigeria to determine teachers' adequate knowledge of the Science content of the curriculum and how often they carry out the practical activities specified in the curriculum, the findings show that a significant number of these teachers experienced difficulties in teaching many of the topics of the Science curriculum. Further findings were based on the qualifications, gender and experiences of the teachers (Ogunleye, 2008). Moreover, teachers seemed not to be coping with their teaching responsibilities because of the challenges that they faced. This was also why many Australian Science teachers felt undervalued, under-resourced and overloaded with non-teaching duties (Rennie, Goodrum & Hackling, 2001). The question arises how this relates to the situation in South Africa?

The South African context

The National Strategy for Mathematics, Science and Technology Education (NSMSTE), presented to the Portfolio Committee on Education on 13 February 2004, states that South Africa is not on par with countries such as Chile, Cuba and Brazil in the output of Science and Engineering graduates. South Africa has inherited a legacy of an undersupply of qualified Mathematics and Science teachers because graduates and top performers in these fields are attracted to better paying professions, especially in the private sector. Negative views about teaching are prevalent among learners, making it difficult to inspire them to want to become teachers. Miles and Stapleton (1998) believe it is imperative to influence learners to pursue a career in education in their adolescent years. What then are the problems that South Africa is facing with regards to the teaching of Science?

Muwanga-Zake (2001) identified the following problems in Science teaching in South Africa:

- *Teaching profession absorbs poor passes*:

Most learners choose teaching as a profession as a last option because they have been rejected somewhere else, e.g. in Engineering where the entry requirements are higher than in Education. The entry requirements to study teaching should be revisited to ensure that the intake is of a high quality. If the teaching profession is absorbing the poor passes, it leads to a generation of teachers who lack confidence in teaching Science because they did not perform that well in the subject during their school years.

- *A poor quality of teachers*:

If the teaching profession is absorbing poor passes, how can teachers then be of a high quality? This will obviously lead to a shortage of competent and confident Science teachers. This leads to a deficiency in practical skills and conceptual understanding due to a lack of confidence towards the subject.

- *Teaching Science is unpopular*:

Science teachers have low morale due to low salaries, if compared to scientists in industry. Teaching Science at school requires more input than other subjects; it involves teaching both theory and practical and managing the Science laboratory. Overcrowding creates more work for the teacher as every learner in the classroom deserves his or her undivided attention to ensure adequate understanding of concepts, as well as ensuring safety in the laboratory, as it can be a hazardous place if it is not properly managed. There are no promotion opportunities; hence, there are no Science educators in senior positions. Consequently, non-scientists manage Science projects in the Department of Education. Is this due to the scarcity of Science educators or is it because they are unsuitable to perform the administration work that goes with management? In line with this situation, policy decisions are made without the professional input of Science educators.

From a research report entitled "From Laggard to World Class, Reforming Maths and Science Education in South Africa's Schools" (November 2004) carried out by the Centre for Development and Enterprise (CDE), there are three key factors that emerged as major determinants in senior certificate Mathematics and Science. The first factor is educator knowledge, which involves the educator's educational qualification. It is stated that in 2001, only 14 percent of schools reported having Mathematics and Science educators with what the government considered the minimum level of qualification. The second factor is the language competence required for instruction and examination purposes. There is a correlation between the marks achieved in the language of instruction and the marks achieved in Mathematics and Science. Most concepts in Science are not clearly understood because of the language barrier. Fish (1994), Solomon (1994), Moje (1995) and Atwater (1996) (in Muwanga-Zake, 2001) agree that Science is not culture-neutral based on the language (Muwanga-Zake, 2001). Research shows that most South African schools use either English or Afrikaans as the medium of instruction, whilst these two languages are second languages to most South African citizens, especially those from the previously disadvantaged communities. Vygotsky (1978) argues that concepts cannot be acquired in conscious form without language and a child cannot have a conscious understanding of concepts before they are explained in a related context using language. This was later supported by the findings of amongst others, Cassels and Johnstone (1983, 1985), Pollnick and Rutherford (1993), Bird and Welford (1995), and Johnstone and Selepeng (2001). The third factor is the school and classroom environment; the nature and characteristics of the school determine its success.

Quality teaching is the use of pedagogical techniques to produce learning outcomes for learners. It involves several dimensions, including the effective design of curriculum and course content, a variety of learning contexts (including guided independent study, project-based learning, collaborative learning, experimentation, etc.), soliciting and using feedback, and effective assessment of learning outcomes. It also involves well-adapted learning environments and student support services (Hernard & Roseveare, 2012).

2.2.3 General school factors that have a negative influence on the learning environment

Research has shown that there are a number of factors that have a negative influence on the learning environment. These include learners' lack of motivation to learn and their ability to concentrate in class; language skills; self-discipline and punctuality; poor infrastructure; classroom overcrowding and teacher-to-pupil ratio (Smith & Schalekamp in Letlhoko, Heystek & Maree, 2001). It is further stated by Smith and Schalekamp that there is a lack of professionalism among teachers and principals, and a lack of preparation for lessons by under-qualified teachers.

The National Commission on Teaching and America's Future, conducted in 2003, reported an increase in teacher retirements and the number of teachers leaving the profession. If this becomes the situation in South Africa, schools will be understaffed and learners will be taught by novice, less experienced teachers who do not have experienced teachers as mentors.

The South African Broadcasting Corporation (SABC) in its news programme Morning Live on SABC 2 on 11 October 2011 provided the reasons that led to the poor Grade 12 results of the worst performing province, the Eastern Cape. This province has been achieving the lowest Grade 12 results out of the nine provinces for a number of years. The three main reasons were: (1) the power struggle between national and provincial departments; (2) the late delivery of books and stationery; and (3) ongoing problems with temporary teachers and learner transport. These problems could be avoided by: (1) allowing each office to perform its duties accordingly; (2) delivering books and stationery towards the end of the year for use in the following year; and (3) creating more stability and providing reassurance to the teachers by employing them on a permanent basis, and monitoring learner transport by ensuring that it is reliable and that the people responsible for transporting learners take full responsibility and are committed to the process.

MacDonald and Rogan (1988 in Muwanga-Zake, 2000) argue that some school environments de-motivate learning. School environments that could be de-motivating include poor physical structures, such as dilapidated buildings, environments devoid of examples of “school” Science, and a lack of facilities, such as science equipment, laboratories and libraries, particularly in rural schools.

Inadequate facilities and equipment

Well-equipped laboratories enhance the teaching and learning of Science subjects. The provision of laboratories and laboratory equipment needs to be carefully planned and executed so as to effectively support the teaching of Science. Ajileye (2006) argues that insufficient resources for the teaching and learning of Science constitute a major cause of student underachievement. The insufficient resources include laboratories, Science equipment, and specimens to be used as teaching aids (Ajileye, 2006).

Rennie, Goodrum & Hackling (2001) investigated the quality of teaching and learning of Science in Australian schools. They found that the factors most frequently mentioned by primary school teachers were lack of resources, inadequate time for preparing to teach Science lessons, teachers’ lack of Science background knowledge, and the overloaded school curriculum which limits the time available for teaching Science. The factors most frequently mentioned by secondary school teachers were inadequate resources and budget, insufficient time for preparation, collaboration and reflection, and large class sizes (Rennie, Goodrum & Hackling, 2001). Factors common in both primary and secondary schools are resource limitations and curriculum resources, outlined in the next paragraphs.

Resource limitations, such as the availability of teachers with specialist knowledge of Science, teaching space, Science consumables, Science equipment, curriculum resources and information technology are a significant constraint on the quality of teaching and learning (Rennie, Goodrum & Hackling, 2001).

Many of the curriculum resources limit Science teaching in the sense that curriculum resources provide materials and dictate approaches for implementing syllabuses and curriculum frameworks. Whilst there are modern and innovative curriculum frameworks, many of the curriculum resources are limiting Science teaching. Limited equipment, access to a suitable Science teaching space, lack of support staff to assist with organising and storing materials, an inadequate Science budget, poor access to laboratories, and inadequate equipment are the common limiting factors cited by teachers (Rennie, Goodrum & Hackling, 2001).

Onwu (1999) reports on research conducted in selected schools in the then Northern Province (now known as the Limpopo Province). It was found that in all ten schools there were great variations in the resources and facilities available for the teaching and learning of Science at Grade 12 level. Although all the schools in the study, with the exception of one, were public schools which depended on the provincial government for the bulk of their funding, the five poorly/low performing schools were so impoverished that some did not have the basic necessities, such as sufficient desks per class, classroom space to sit and move around, sufficient textbooks and exercise books, not to mention facilities like laboratories, Science equipment, libraries, teaching aids (audio-visual teaching equipment), storage space, chemicals and other consumables (Onwu, 1999). Later in 2005, after the implementation of the Outcomes-based Curriculum, Onwu and Stoffels argued that teacher competence in teaching reform-based Science in large classes remained one of the challenges in the continuing reform of South Africa’s education system. Most teachers had little experience, meagre training and operated in large and poorly resourced Science classrooms (Onwu & Stoffels, 2005).

The availability and quality of the resources varied according to the schools’ performance categories, from good/adequate in high performing schools to fair/poor/inadequate in low performing schools. Teaching aids, textbooks and exercise books, for example, were sufficient or fairly adequate in schools with a matriculation pass rate ranging between 60 and 100 percent, but insufficient in others, particularly the two schools with a pass rate of between five and 20 percent. The four high performing schools (40%) had libraries and Science laboratories, and the rest - one high, and five low performing schools - had none of these facilities. Interestingly enough the location of these schools were typical of their status categories, with most of the low performing schools being in more rural settings than the high performing schools (Onwu, 1999).

Muwanga-Zake emphasizes that a well-equipped laboratory stimulates learners' interest and promotes practical tuition in Science. Not so for Eastern Cape learners, where according to Jennings and Everett (1996) in Muwanga-Zake , only 23 percent of Black schools had laboratories. The authors also found that only six of the 21 schools had laboratories, and these were high schools. Junior schools, the level at which interest in Science should be inculcated, often did not have laboratories and were overcrowded. Thus, the learners' construction of knowledge was likely to be limited to textbook information (Muwanga-Zake, 2001) since they did not have facilities to conduct practical work. It is thus important to note that learning in schools is influenced by, among others, school organisation resources and the climate, which involves teacher skills, curriculum structure and content.

2.2.4 Factors outside the school setting affecting the teaching and learning of Science

The teaching and learning of Science is affected by a variety of contextual factors. It is a common norm and practice to mostly consider what happens inside the schools and classrooms, such as lack of resources and facilities, teacher qualifications, time devoted to Science, and learners' attitude to Science as factors affecting Science education. However, it is also important to explore the factors outside the school setting that influence the teaching and learning of Science.

Exogenous variables encompass student gender and socio-economic status; they are located outside the institution of the school and are not under the direct influence of the school process (Wee-Loon, 2011). It is imperative to take note of the fact that learners are products of communities, and out of school factors, such as home background, language and cultural differences play a critical role towards the learning of Science. Science is not only a school issue; science is the study of life, how we live it and how we understand the world around us. Therefore, it is important to take Science back home. In his address at the International Innovation and Technology Exhibition (INSITE) media briefing on 28 August 2006, the Minister of Science and Technology, Mr Mosubudi Mangena said: "Being illiterate in Maths and Science in this century is as big a handicap as the inability to read and write". People need an awareness of Science and Technology; the stereotype attached to Science that it is perceived as a difficult subject has to be removed. But, the main problem is ignorance and lack of knowledge. Most parents are not part of their children's efforts to learn Science, as this is not their area of expertise and they are not eager to become involved.

It is easy to access books, encyclopedia and magazines on Human Sciences and Economic and Management Sciences in most households, but why are Science materials so inaccessible? If we consider the media coverage of the SABC, one of the most easily accessible mediums, there are always news reports on what is happening around the globe, politically and economically, but not much is said about Science. The only time the media are vocal about science is when there is a new invention, and during National Science Week. It takes us back to 1998 when the first Year of Science and Technology (YEAST) was declared – close to two decades later it is a largely ignored topic.

If parents are involved in their children's learning (such as attending Science expos, visiting museums and zoos, assisting with homework and projects), is the language used at home to explain phenomena to their children scientific enough, or does it lead to misconceptions? The differences in cultural beliefs about natural phenomena affect children's understanding of science, for example lightning and a rainbow are attached to witchcraft in most South African communities. Race, ethnicity, language, culture, gender and socioeconomic status are among the factors that influence the knowledge and experience children bring from home to the classroom. Teachers are also members of these communities; therefore all these contextual factors have a bearing on the teachers and affect how they teach.

Factors concerning the Department of Basic Education include the lack of funding to rebuild schools, renovate buildings and supply teaching aids and materials. School environments have poor physical structures, such as dilapidated buildings and the lack of facilities such as Science equipment, laboratories and libraries. Insufficient facilities and resources hamper effective teaching and learning. The image of the school in most instances might reflect on the productivity of the school. *Sunday Times* reported on 11 October 2009 on the 100 top achieving schools in South Africa, indicating that at the top of the list was mostly former model C and private schools. It begs the question - what about government schools in previously disadvantaged communities? There are only a few exceptions, such as Mbilwi Secondary School in Limpopo. This school does not have impressive facilities, but the dedication and commitment of the teachers contributed towards the improvement of their competence and this was transferred to their learners. If teachers in all schools could be like the teachers of this school, then education will shape better communities, and the country at large. A noteworthy finding from the *Sunday Times* survey was that single gender schools outperformed those that had girl and boy learners, with girls-only schools outperforming boys-only schools (*Sunday Times*, 2009). Single gender schools are not common in townships. In line with this finding, it was not explored further to determine the gender of the teachers involved in the single gender schools; hence, gender is another factor that is under investigation in this study in regards to teacher efficacy.

Other factors in schools, such as lack of discipline, respect for teachers, poor infrastructure and overcrowded classrooms which lead to high teacher-learner ratios, affect teaching and learning (Muwanga-Zake, 2000). Hence, the teaching profession ends up not recruiting the cream of the crop.

2.3 Infusing technology into teaching

The act of integrating Information and Communications Technology (ICT) into teaching and learning is a complex process and one that may encounter a number of difficulties (Khalid, 2009). What influences teachers' preparedness to use ICT in the classroom?

Barriers to teacher use of ICT

Schoepp (2005 in Khalid, 2009) defines a barrier as any condition that makes it difficult to make progress or to achieve an objective, which in this case is successful ICT integration in Science education. In addition to lack of time, resources and training, human factors including the lack of confidence in using ICTs, a resistance to change and negative attitudes to ICT, and a lack of perceived benefits (the need for extensive support) are barriers to teacher use of ICT.

Groves and Zemel (2000 in Capobianco & Lehman, 2006) believe that training and support in technology can help education faculties to effectively integrate technology into classes for future teachers. In their study, Capobianco and Lehman (2006) categorised factors that contributed to the success of the Science teacher's work as internal and external motivation. Internal motivation has the following factors: the teacher's own beliefs, interest and commitment to improving both teaching and the learners' understanding of teaching. Under external motivation there are three main factors that influence the Science teachers' use of technology in own teaching, namely, administrative support, equipment access and faculty professional development, and informal technical assistance. Teachers need to be encouraged to use technology in their teaching and this can be embedded in teacher training programmes.

The most difficult barrier to successful technology integration is the mindset of the teachers and their deeply held beliefs about the nature of teaching, learning and technology (Sandholtz, Ringstaff and Dwyer 1997 in Lundeberg and Levin, 2003). Thus, it is important that preliminary information sessions are held with teachers to discuss the problems they encounter in their Science classrooms before computers are introduced.

The positive aspects of teaching need to be revisited. The goal of Science is to create scientifically-literate individuals who can function in a contemporary technological society, and ultimately prepare more learners for Science-related careers. The South African government, through the Department of Education, has embarked on the Laptops for Teachers Programme which aims at providing teachers with an allowance or subsidy of R1500 every five years towards buying a laptop (*Mail & Guardian*, May 2009). This is an initiative and commitment that encourages South African teachers to use computers.

Hakverdi, Gucum and Korkmaz (2007) highlighted the factors influencing teachers' use of computers as computer self-efficacy, computer experience, computer access, age and gender. Compeau and Higgins (1995 in Hakverdi *et al*., 2007), in their study to examine factors affecting an individual’s use of technology, found that participants with higher self-efficacy beliefs used computers more often and experienced less computer-related anxiety.

Science education courses should challenge teachers to analyse their teaching experience for pedagogical conundrums, the concepts that are inherently difficult to present to learners and/or difficult for learners to understand. Once identified, the pedagogical task is to select appropriate teaching strategies and representations of content to address these topics. Digital technologies are an important category of options for approaching these conundrums. For example, a familiar but abstract Science concept taught in secondary Physical Science classes is the Doppler Effect which is commonly defined as the change in frequency and pitch of a sound due to the motion of either the sound source or the observer. While the phenomenon is part of learners' everyday experiences, its explanation is neither easily visualised nor commonly understood. This difficulty stems from the invisible nature of sound waves and the fact that traditional representations are limited to static figures of the phenomenon, which by definition involves movement. Computer simulations are able to get past these limitations by simulating the sound waves emitted by moving objects (Flick & Bell, 2000).

2.4 Conclusion

The kind of teacher envisaged by CAPS, as a follow-up on the National Curriculum Statement (NCS), is that all teachers and other educators are key contributors to the transformation of education in South Africa. CAPS is an attempt to guide and shape activities in the school, and particularly the classroom, so as to provide opportunities for learners to acquire subject knowledge in a structured manner. It is the third such attempt in South Africa since 1994. Starting in 1998, Curriculum 2005 (C2005) formulated the outcomes of learning in the broadest terms, allowing space for teachers to customise teaching and learning activities to suit each class. The realisation that most teachers did not have the knowledge resources required to design specific curricula in the way envisaged in C2005, prompted a review of the curriculum and the formulation of the National Curriculum Statements (NCS) in 2002, which set out to specify the knowledge components of the curriculum in more explicit detail. Then, from 2011, CAPS took a third approach, recommending particular sets of strategies to sequence and pace the knowledge in each subject at each grade level (Taylor, 2012).

The National Curriculum Statement Grades 10 - 12 (General) visualises teachers who are qualified, competent, dedicated and caring. They will be able to fulfill the various roles outlined in the Norms and Standards for Educators. These include being (i) mediators of learning, (ii) interpreters and designers of learning programmes and materials, (iii) leaders, administrators and managers, (iv) scholars, researchers and lifelong learners, (v) community members, citizens and pastors, (vi) assessors, and (vii) subject specialists.

The Manifesto on Values, Education and Democracy (Department of Education, 2001:9-10) states the following about education and values:

> Values and morality give meaning to our individual and social relationships. They are the common currencies that help make life more meaningful than might otherwise have been. An education system does not exist to simply serve a market, important as that may be for economic growth and material prosperity. Its primary purpose must be to enrich the individual and, by extension, the broader society.

Are we preparing learners to pass the examination for certification, or are we preparing the critical thinkers, as envisaged by the NCS? Learners emerging from the Further Education and Training band, as stated in the NCS (2005), must:

- have access to, and succeed in, lifelong education and training of good quality;
- demonstrate an ability to think logically and analytically, as well as holistically and laterally; and
- be able to transfer skills from familiar to unfamiliar situations.

Successive curricula in South Africa over the last two decades should not be seen as being in opposition to one another, but as complementary perspectives on the subject knowledge to be acquired by learners. One would expect that the successful implementation of any specific curriculum is greatly enhanced when teachers and school leaders understand the relevant subject knowledge, and that the best teachers are able to implement a wide variety of curricula with equal success (Taylor, 2012).

The kind of learner who is envisaged is one who will be imbued with the values and act in the interests of a society based on respect for democracy, equality, human dignity and social justice, as promoted in the Constitution. To fulfill this national mandate, we need to ensure that teachers are ready and equipped to produce the envisaged learner; otherwise, this is going to be a recurring problem passed on from one generation to the next.

2.5 Summary

Table 2.1 below gives a summary of the problems associated with the teaching and learning of Science.

Table 2.1: Summary of problems associated with Science teaching

Problems associated with Science teaching		
Teacher (personal) factors • Science background • Preparation and qualifications • Teacher attitudes • Teacher competence (mastery) **Learner factors** • Negative attitudes • Learner preparedness **Facilitation** • Infusing technology into teaching	**School factors** • Availability/lack of facilities • Insufficient teaching time • Large classes **Instructional leadership** • Principal leadership behavior • Lack/incoherent in-service training workshops	**Outside school factors** • Government policies • Social factors • Language and cultural practices • Perceived difficulty of Science • Lack of parental involvement

The next chapter offers a review of related literature on teaching efficacy.

CHAPTER 3

LITERATURE REVIEW: SELF-EFFICACY AND TEACHING

3.1 Introduction

This chapter offers an in-depth review of related literature on Science teaching efficacy as a follow-up on the introduction in Chapter 1. As stated in Section 1.7, through the Social Cognitive Theory, Bandura advanced a view of human functioning that accords a central role to cognitive, vicarious, self-regulatory, and self-reflective processes in human adaptation and change (Pajares, 2002). People are viewed as self-organising, proactive, self-reflecting and self-regulating, rather than as reactive organisms shaped and shepherded by environmental forces or driven by concealed inner impulses. From this theoretical perspective, human functioning is viewed as the product of a dynamic interplay of personal, behavioural and environmental influences. Bandura (1986, 2000) calls this three-way interaction of behaviour, personal factors (in the form of cognition, affect and biological events), and environmental influences or situations the "triadic reciprocality". This relationship is shown in the figure below:

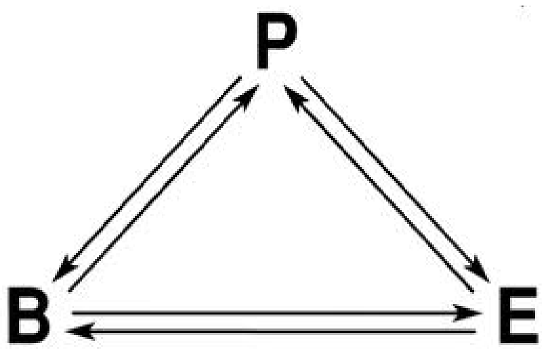


Figure 3.1: Overview of social cognitive theory

Sources and measurements of efficacy, as well as factors influencing teacher efficacy, are explored in this chapter.

3.2 Sources of teacher efficacy

Teacher efficacy is the form of self-efficacy that is referred to as teachers' belief about their ability to influence learners' outcomes (Ross, Cousins & Gadalla, 1996; Sridhar & Badiei, 2008). Bobbet, Olivier and Ellett (2008 in Eren, 2009) define teacher efficacy or teachers' sense of efficacy as teachers' belief in their abilities to affect student performance, whereas teachers' self-efficacy beliefs refer to teachers' beliefs in their capabilities to perform specific teaching tasks at a specified level of quality in a specified situation.

Four sources of information relevant to the forming or altering of self-efficacy perceptions are mastery experience, vicarious experience, verbal persuasion at motivational discussions or social persuasion, and physiological and emotional states (Bandura 1997, in Hoy & Spero, 2005; Steyn & Mynhardt, 2008). In mastering experience, one's direct experiences help in the successful performance of tasks which reinforces optimistic self-efficacy perceptions. Mastery experiences are the most powerful source of efficacy information, according to Tschannen-Moran, Woolfolk Hoy and Hoy (1998). The perception that a performance has been successful can raise efficacy beliefs and provide the source for the belief that future performances in a similar vein will also be successful (Cantrell & Young, 2003). Vicarious experience involves self-efficacy when people are observed performing challenging tasks. The observation of successful behaviour increases the observers' perception of their own skill at producing similar behaviour. The opposite is also a possibility when observation of an unsuccessful behaviour affects self-efficacy negatively. The approach and technique that a person uses to overcome this challenging vicarious experience allows the development of optimistic perceptions. Thus, modeling serves another tool for promoting self-efficacy. The more closely the observer identifies with the model, the stronger the impact on efficacy. Observing others perform tasks successfully raises expectations of personal success on the same task (Bandura, 1997).

Verbal persuasions at motivational discussions involve skilful persuaders who focus on an individual’s skills, counteracting doubt and obsession with personal shortcomings and weaknesses. Social persuasion can provide information about the nature of teaching, give encouragement and strategies for overcoming obstacles, and provide specific feedback on a teacher’s performance. Bandura (1997) suggests that the social framing of verbal persuasion is a critical factor that can influence efficacy. Evaluation that highlights personal capabilities may raise efficacy beliefs, whereas evaluation that focuses on shortcomings brings deficiencies into the spotlight and efficacy beliefs may be deflated (Cantrell & Young, 2003). These motivational discussions convince people to focus more on their skills that will assist them to be successful (Bandura, Maddux, Resnick & Wood in Steyn & Mynhardt, 2008). In physiological and emotional states, peoples’ mood, stress and pain have effects on their self-efficacy beliefs. The level of physiological and emotional arousal that a teacher experiences with a successful performance can also enhance efficacy beliefs (Cantrell & Young, 2003). Generally, positive emotions increase self-efficacy beliefs, while negative ones weaken them. Teachers’ sources of efficacy are influenced by these integration rules.

According to Bandura (1977), the information from all these sources of efficacy influence one another and are integrated when self-efficacy perceptions are formed. The four possible integration rules are summation rule, a relative weighting rule, a multiplication rule, and a configuration rule. When individuals operate according to the summation rule, the information from two sources has a greater influence than one. The relative weighting rule provides for the fact that sometimes a greater weight is assigned to certain types of information than to others. When information is integrated in terms of the multiplication rule, the fact that the effect of various sources of information amount to more than the sum, is accepted. In the configuration rule, the value of information depends on the type of accompanying information that is available, and different weights are assigned to specific factors, depending on the availability of other sources of self-efficacy information (Steyn & Mynhardt, 2008).

The main aim of the study conducted by Liaw (2009) was to investigate the effect that exposure to various sources of teacher efficacy had on pre-service teachers in Taiwan. The results showed some influences of classroom experience and group discussions on the teaching efficacy of a group of pre-service teachers. Pre-service teachers demonstrated a higher level of personal teaching efficacy after the classroom experience and group discussions (Liaw, 2009). In this regard, it shows that pre-service teachers' vicarious experience was enhanced when they observed their mentor teachers, or even when they experienced the classroom by conducting classes themselves.

A Taiwanese study by Lin and Gorrell (in Liaw, 2009) suggests that pre-service teachers' efficacy beliefs are influenced by cultural and/or social background, respective programmes, the context of their studies, and by their increasing experience. It also indicates that Taiwanese pre-service teachers are not confident about their abilities to overcome the influence of children's home environments, or to reach difficult children (Liaw, 2009). This is because pre-service teachers do not have experience of external factors in teaching and lack exposure to various tasks entailed in teaching.

Liaw (2009) emphasises that pre-service teachers have a high level of teacher efficacy before and during the teacher preparation programme, but it drops significantly after they start teaching. This can be understood as a shift from the teachers' early beliefs of taking responsibility for their learners' learning to a belief that learners had the responsibility for learning with the support of the teacher and parents (Liu, Jack & Houn-Lin, 2007).

3.3 The measurement of teacher efficacy

Tschannen-Moran, Woolfolk Hoy & Hoy (1998) identified two strands of research in terms of the construct and measurement of teacher efficacy. The first is grounded on

Rotter's (1966) Social Learning Theory of internal versus external control. The second strand is based on Bandura's (1977) Social Cognitive Theory, on which this study is grounded.

3.3.1 Measurement of Teacher Efficacy Based on Rotter's Theory and the RAND Studies

The RAND (1976) organisation was the first to conduct research on teacher efficacy and developed two items to measure a teacher's locus of control, namely the General Teaching Efficacy (GTE) and the Personal Teaching Efficacy (PTE). Both were based on Rotter's Social Learning Theory (1966), which seeks to examine the extent to which teachers believe that their ability to influence and control learning lies within their own control (internal) or outside their control (external), and is dictated by environmental factors (Wan, 2010). GTE emphasises that many other factors are out of the teacher's realm of control. These factors include the home environment, the learning environment, peer pressure, social values and beliefs, and physiological, emotional and cognitive needs, which have a real effect on learning. PTE is more representative of a teacher's personal conviction or beliefs and not about what a teacher can do generally or specifically. Locus of control is a type of outcome expectancy; however, it is a generalised expectancy about the link between behaviours and outcomes. Self-efficacy is not a generalised expectancy, but task and situation specific (Rotter 1966 in Dellinger, Bobbett, Olivier & Ellet, 2008).

In these studies, teachers were asked to respond to two five-point Likert-type items, ranging from strongly agree to strongly disagree. The two items used to measure teacher efficacy were: (a) "When it comes right down to it, a teacher really cannot do much because most of a learner's motivation and performance depends on his or her home environment," and (b) "If I really try hard, I can get through to even the most difficult or unmotivated learners". These items were designed to measure the degree to which teachers consider environmental factors as overwhelming any power that they can exert in schools (external) or accept personal responsibility for what happens to them (internal), respectively (Guskey & Passaro, 1994 in Yeşim Çapa, 2005).

Although these measures provide important implications for teacher efficacy research, several researchers tried to expand the construct of teacher efficacy, and to develop longer and more comprehensive measures because of reliability problems encountered with the two items. After these studies, three instruments with more items were developed. They are the Responsibility for Student Achievement, Teacher Locus of Control, and The Webb Scale (Yeşim Çapa, 2005).

3.3.2 Measurement of Teacher Efficacy Based on Bandura's Theory

The second theoretical framework for studying the teacher efficacy construct is credited to the work of Bandura's Social Cognitive Theory (1977) that views teacher efficacy as a tenet of self-efficacy (Wan, 2010).

Ashton and Webb (1982, 1986) developed a multidimensional model of teacher efficacy for assessing two dimensions of teacher efficacy by using two items that were developed by the RAND studies by using Bandura's Social Cognitive Theory, in which he made a distinction between "outcome expectations" and "efficacy expectations" (Ashton & Webb, 1986). Bandura (1997) defined the outcome expectation as "a judgment of the likely consequence such performances will occur," and the efficacy expectation as the "conviction that one can successfully execute the behaviour required to produce the outcome". Ashton and Webb (1986) stated that outcome expectations reflected perceptions of the consequences of teaching in general. This dimension was labeled as "teaching efficacy", and they believed that it was assessed in the first RAND item. In contrast, efficacy expectations reflect teachers' perceptions of their personal ability to bring about desired outcomes. They labeled this dimension as "personal teaching efficacy", and assumed it to be measured by the second RAND item. The following instruments: Gibson and Dembo's Teacher Efficacy Scale (TES), Bandura's

Teacher Efficacy Scale, and Teachers' Sense of Efficacy Scale (TSES) (presented below), are based on these dimensions (Wan, 2010).

The first instrument, the Teacher Efficacy Scale, was developed by Gibson and Dembo (1984). It is a 30-item six-point Likert scale, ranging from strongly disagree to strongly agree. Through factor analysis of 208 elementary teachers' 26 responses, they reported a two factor model that accounted for 28.8% of the total variance. Factor 1 represents a teacher's sense of personal teaching efficacy, and corresponds to Bandura's self-efficacy dimension. The second dimension stands for a teacher's sense of teaching efficacy, and corresponds to Bandura's outcome expectancy dimension. Gibson and Dembo called these dimensions "personal teaching efficacy" and "general teaching efficacy", respectively. They presented internal consistency reliability alpha coefficients of .78 for personal teaching efficacy, .75 for general teaching efficacy, and .79 for the total 16 items. They recommended the use of the revised scale of 16 to 20 items for further research. Woolfolk and Hoy (1990) emphasise that there is a discrepancy between Bandura's conceptualisation and the Ashton and Webb model of teacher efficacy. They observe that teaching efficacy is not an outcome expectation, but an efficacy expectation. They used the 16-item version of Gibson and Dembo, added four items that refer to a teacher preparation programme, and included two items of the RAND study. Woolfolk and Hoy interpreted their results as having three factors - one for teaching efficacy and two for personal efficacy. The two personal factors reflect a teacher's sense of personal responsibility for positive student outcomes and responsibility for negative outcomes (Yeşim Çapa, 2005).

There are other instruments adapted based on Gibson and Dembo's measure for specific subjects-matter. One of them, used in this study, is the Science Teaching Efficacy Belief Instrument (STEBI), developed by Riggs and Enochs (1990). Results of factor analysis yielded two uncorrelated factors, Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Gibson and Dembo (1984) followed a 30-item Likert type of Teacher Efficacy Scale (TES) to measure two dimensions of teacher efficacy, PTE, assumed to reflect self-efficacy, and GTE, assumed to capture outcome expectancy. Riggs and Enochs (1990) developed an instrument to measure the efficacy of teaching Science to reinforce Bandura's definition of self-efficacy as a situation-specific construct. The Science Teaching Efficacy Belief Instrument (STEBI) had two versions, STEBI-A and STEBI-B, for in-service teachers and pre-service teachers, respectively. The two dimensions, Personal Science Teaching Efficacy (PSTE), reflects on teachers' confidence in their ability to teach Science, and the Science Teaching Outcome Expectancy (STOE) scale, reflects on teachers' beliefs that student learning can be influenced by giving effective instruction (Savran & Cakiroglu, 2003).

Bandura developed his own teacher efficacy scale called Bandura's Teacher Self-efficacy Scale, which is a 30-item instrument. Bandura suggested that teacher efficacy should comprise seven sub-scales: efficacy to influence decision making, efficacy to influence the acquisition of school resources, instructional efficacy, efficacy in disciplinary matters, efficacy to enlist parental involvement, efficacy to enlist community involvement, and efficacy to create a positive school climate. Each item is measured on a nine-point scale anchored by the following: "nothing, very little, some influence, quite a bit, a great deal" (Bandura, 2001).

The Teachers' Sense of Efficacy Scale (TSES), previously called the Ohio State Teacher Efficacy Scale, was developed in a seminar on self-efficacy in teaching and learning at Ohio State University. The participants of the seminar searched for an instrument which included the types of tasks representative of frequent teaching activities. Taking the Bandura Teacher Efficacy Scale as a base, they developed and added new items. They decided to use a nine-point scale, as in the Bandura scale. The resulting instrument was investigated in different studies by Tschannen-Moran and her colleagues. The initial study of the instrument, with 52 items, was administered to a sample of 224 participants (both pre-service and in-service teachers). Thirty-two of the items were selected as a result of principal-axis factoring with varimax rotation

(Tschannen-Moran & Woolfolk Hoy, 2001). In the second study, the 32-item version of TSES was investigated with a sample of 70 pre-service and 147 in-service teachers. Tschannen-Moran and Woolfolk Hoy (2001) used principal axis factor extraction again. The rule of an eigen-value greater than one yielded an eight-factor solution, while the screen test suggested a possible two- or three-factor solution. After examining both two- and three-factor solutions, the authors decided to go with the three-factor solution, which better represents the tasks of teaching (Yeşim Çapa, 2005).

The instrument was later reduced to 18 items by removing redundant items and items with low factor loadings. The factor analysis with varimax rotation produced three factors accounting for 51% of the variance. These factors were called efficacy for student engagement (eight items with an alpha reliability of .82), efficacy for instructional strategies (seven items with an alpha reliability of .81), and efficacy for classroom management (three items with an alpha reliability of .72). A further analysis, using collapsing samples from study 1 and study 2, generated one strong factor with factor loadings ranging from .74 to .84. Tschannen-Moran and Woolfolk Hoy (2001) argued that TSES could be used for assessment of either three domains of efficacy, or one generalised efficacy factor (Yeşim Çapa, 2005).

3.4 Factors influencing teacher efficacy

Teacher efficacy is one significant factor that affects teacher quality. Thus, it is important to establish factors that affect teaching efficacy for these factors to be explored and taken into consideration in teacher preparation programmes in order to improve the quality of teaching. Chang and Wu conducted a study in 2007 to examine beginning teachers' sense of efficacy in elementary schools, as well as its influential factors. Beginning teachers, whose background was and was not in Mathematics and Science, were compared to explore the differences of their teacher efficacy. According to research findings, all efforts should be devoted to establish a positive and effective learning organisation in order to promote beginning teachers' efficacy internally, externally, and promptly, starting from the beginning year (Chang & Wu, 2007).

According to the qualitative findings of Chang and Wu's exploratory study of elementary beginning Mathematics teacher efficacy, two categories of factors that influenced the change of their teacher efficacy were found. The first category is teacher's teaching belief and practical instruction (internal factor), which includes background knowledge and previous experience, instructional belief and action, and student-teacher interaction. The second category is peer interaction and administration support (external factor) that involves peer interaction, administrative support and teaching resources (Chang & Wu, 2007).

The findings of Chang and Wu's study indicated that beginning Mathematics teachers had inadequate mathematical background knowledge and practical experience before they entered the classroom. This inadequacy led to several obstacles, such as difficulty in preparing their lessons, making mistakes in the teaching process, and low teacher efficacy. Secondly, the beginning Mathematics teachers who had low efficacy tended to have insufficient instructional strategies and bad teacher-student interaction. They usually did not know how to propose questions and guide the classroom discussion. Consequently, they mostly "lectured" in the classroom. Even if they had a discussion, it always was ineffective. This situation not only decreased teachers' efficacy, but also reduced learners' learning interests and motivation. There was also less teacher-student interaction (Chang & Wu, 2007).

There are a number of elements that are used to predict teacher efficacy: gender, experience, educational qualification, grade levels taught, classroom characteristics, learner behaviour, and job satisfaction. These variables address both dimensions of GTE and PTE. Even though self-efficacy can be generalised to other behaviours that require similar skills, Pajares (1997) suggested that measures of self-efficacy should be context specific (Sridhar & Badiei, 2008). For the purpose of this study, teachers' sense of efficacy is grounded on Riggs and Enochs' (1990) Science Teaching Efficacy.

In a study conducted by Cantrell, Young and Moore to determine factors affecting the Science teaching efficacy of pre-service teachers, they explored the relationships between the levels of efficacy beliefs and various factors such as gender, prior Science experience, and Science teaching time (Cantrell, Young & Moore, 2003). Their findings revealed that the males in their sample were more interested in Science in high school, as demonstrated by them taking more courses and participating more in extracurricular Science activities. The greatest effects for gender occurred when males took more courses, while at the same time reported they had participated in extracurricular Science activities. This information could be useful in the recruitment process for elementary teacher education. Prospective learners who report taking extra Science courses, as well as participating in extracurricular Science activities in high school, may be more likely to develop higher Science teaching efficacy beliefs over the course of their teacher preparation coursework; thus, they may be more likely to have a positive impact on their future elementary learners in Science (Cantrell, Young & Moore, 2003).

Cantrell *et al.* (2003) also found that the amount of time actually spent in teaching Science to children in an elementary classroom was another factor that seemed to give rise to large effect sizes on Personal Science Teaching Efficacy (PSTE). Although the pre-service teachers had been in the classroom since early in their college experience, the methods semester was the first time they had prepared and taught a lesson to children. The largest increase in PSTE was for students in the methods group who were able to teach Science to children for more than three hours across the span of their three-week practicum. This suggests that there may be a significant increase in PSTE with the first successful Science teaching experiences, which is supported by Bandura's (1997) suggestion that mastery experiences help to increase efficacy beliefs. Going through the process of preparing Science lessons with children in mind, and then spending more than one hour per week teaching Science lessons to children seems to have a positive effect on PSTE (Cantrell, Young & Moore, 2003).

The findings of Cantrell *et al*. (2003) indicated that the Science teaching efficacy beliefs of the student teacher group in their sample did not differ significantly from those in the methods group. They opined that it might be that when student teachers were placed in schools for a longer period, the school climate and other factors might begin to impact efficacy experiences more than college classroom experiences, so the methods courses seemed to be the most appropriate time to provide Science teaching experiences in order to develop efficacy beliefs. Ashton and Webb (1986) postulated that teacher efficacy beliefs only increased over time and within the context of the multifaceted social and organisational structure of school life.

The only significant effect found by Cantrell *et al.* (2003) for Science Teaching Outcome Efficacy (STOE) occurred in the student teaching group when students apply their knowledge and skills to the practice of teaching Science to children. The students who had taken more than the required number of college Science content courses had higher STOE beliefs than those who took only the required number of courses. It may be that the practice of teaching Science caused the student teachers to draw upon their content knowledge and training most recently completed at college level, rather than at high school level, and by doing so, their outcome efficacy beliefs were positively impacted. However, this result may also be an anomaly since few researchers have found that prior Science courses impact Science teaching efficacy beliefs (Tarik, 2000). One possible explanation for the result could be that 75 percent of the students in the student teacher group reported taking more than the required amount of Science courses at college level, compared to only 32 percent of the seminar group, and 27 percent of the methods group (Cantrell, Young & Moore, 2003).

In a study conducted by Yeşim Çapa (2005) into what might account for the variation among levels of first-year teachers' sense of efficacy, it was found that support within the organisation (the principal, colleagues and a mentor), characteristics of the teaching assignment, and the quality of the teacher preparation programme (coursework, the education faculty, and field experience) were some of the factors which played an important role. These factors will be elaborated on in the next section**.**

3.5 Teacher efficacy

3.5.1 Teacher efficacy and classroom behavior

Teacher efficacy has been found to relate to learner outcomes, such as achievement, motivation and the learners' own sense of efficacy. Learner outcomes is one of the important variables related to positive teaching behaviour in the classroom. This is emphasised by Ashton and Webb (1986 in Kurz & Knight, 2004), when they state that teachers with higher self-efficacy are likely to have a positive classroom environment, support learners' ideas, and meet the needs of all learners. Deemer (2004, in Eren, 2009) highlights that teachers with high levels of efficacy are more likely to seek out resources and develop challenging lessons, persist with learners who are struggling, and teach in a multitude of ways that promote learner understanding.

Teachers' sense of efficacy can affect the tasks of managing and motivating learners. Thus, teachers with low self-efficacy might avoid planning activities that they believe exceed their capabilities, might not persist with learners who are experiencing difficulties, might expend little effort to find materials, might not re-teach content in ways which help learners to better understand, and display little variety in their teaching approaches (Cakiroglu, Cakiroglu & Boone, 2005; Eren, 2009). Teachers with high self-efficacy are likely to develop challenging activities, help learners succeed, persevere with learners who have trouble learning, and adopt more student-centred approaches than teacher-centred approaches in educational settings such as the classroom (Tschannen-Moran & Woolfolk Hoy, 2001; Ross, 2003; Cakiroglu *et al*., 2005; Eren, 2009). It is important for a teacher to reflect after a lesson, look at what worked well and what did not, and explore possibilities for expanded opportunities to assist all the learners to succeed in their learning. Teachers with high self-efficacy have a tendency to adopt humanistic orientation for classroom management (Aydin & Boz, 2010).

Teaching efficacy consistently correlates with learner acquisition of school-approved values and attitudes. High teacher efficacy is associated with enhanced learner motivation, increased self-esteem, improved self-direction, and more positive attitudes toward school. This has an impact on collective teacher efficacy; which relates to how well a school functions as a social system is heavily dependent on the belief system of the staff of that school. All the investigations and interventions to enhance efficacy should also address the social and organisational structures of schools (Bandura 1997 in Kurz & Knight, 2004). Even though learner achievement is associated with a teacher's success in the classroom, schools are at the centre of contributing to a teacher's sense of collective efficacy.

In Chang and Wu's study (2007), it was found that beginning Mathematics teachers with low efficacy were likely to spend a great deal of time in managing the classroom order. They often felt powerless and pressured, which led to unsuccessful teaching. Providing information on classroom management could complement the instructional strategies and teacher-learner interaction, thus enhancing teaching and learning quality (Chang & Wu, 2007).

Studies conducted in the United States by Emmer *et al.* (1997) and in the United Kingdom by Wragg (1997) on teachers' classroom and behaviour management have consistently found that the way a classroom is managed is important to avoid misbehaviour. Student misbehaviour is most likely to occur during the start of the lesson, at the end of the lesson, during downtime (which should be limited as much as possible), and during transitions. In all four cases it is important to establish clear procedures for student behaviour. More generally, spending some time on establishing clear rules and procedures at the beginning of the year can save teachers a lot of time later in the year. However, the teacher should limit the number of rules and procedures used, and rules should be rigorously enforced otherwise they will soon be ignored by learners. The reasons for enforcing particular rules needs to be explained to learners, and learners should be engaged in the process of making rules. Working at a fast pace will prevent learners from becoming disengaged and bored, thus minimising learner misbehaviour (Muijs & Reynolds, 2002).

The findings by DiFabio and Palazzeschi (2006 in Furner, 2007) indicate a significant positive relationship between teacher efficacy and emotional intelligence. These findings suggest that emotional intelligence is linked to teacher self-efficacy in managing classroom behaviour, engaging learners, and implementing useful teaching interventions (Furner, 2007).

Low self-efficacy has the potential to impede the ability of teachers to function optimally in the classroom and in educational settings. Pintrich and Schunk (1996 in Furner, 2007) suggest that a teacher's belief that he or she is unable to manage classroom behaviours is likely to lead to avoiding classroom management techniques. The teacher will often "give in" to unruly learners because the task of managing the class is seen as exceeding their competence, thus perpetuating further lack of efficacy in classroom management. It is conceivable that this cycle is applicable to various other aspects of teaching, including working with low functioning learners, communicating with teachers and parents, and lesson plan development and delivery (Furner, 2007).

Strong, Silver and Perini (2001 in Furner, 2007) argue that teachers can incorporate rigour, thought, diversity and authenticity in the classroom as a way to increase learner achievement. Mulholland and Wallace (2001 in Yeşim Çapa 2005) also emphasised the significance of learners' attitudes for novice teachers. For example, learners' enthusiasm in participating in the activities was an incentive for teaching, whereas their disruptive behaviour in class provided discouraging information about the novice teacher's ability to teach Science (Yeşim Çapa, 2005).

Teachers' efficacy beliefs related to their teaching affect their actions in class (Aydin & Boz, 2010). Effective classroom management leads to increased learner achievement. Learners tend to focus more in a well-organised and managed classroom where a conducive learning environment is encouraged. However, a teacher also needs to be flexible to meet the learning needs of the learners.

3.5.2 Teacher efficacy and teaching experience

Range of teaching experience, such as years and subjects taught, and available support have a significant impact on pre-service teachers' teaching efficacy (Liaw, 2009). The results of a study by Liu, Jack and Chiu (2006) advocate the position that the years of general teaching experience of elementary Science teachers in Taiwan have a significantly greater impact upon their personal Science teaching efficacy and Science teaching outcome expectations, than years of teaching Science (Liu, Jack & Houn-Lin, 2007). Huang, Lui, and Shiomi (2007) found a significant positive correlation between teacher efficacy and self-esteem. The data suggested that as teachers acquire experience, teacher self-efficacy and teacher self-esteem increase (Furner, 2007: Aydin & Boz, 2010).

A study by Liu, Jack and Houn-Lin (2007) indicated that Taiwan in-service elementary teachers who have 11 or more years of teaching experience had a higher score on the Personal Science Teaching scale and the Science Teaching Outcome Expectations Efficacy scale than teachers who have one to ten years of Science teaching experience. This shows that the teaching efficacy one obtains through the years of general teaching can affect a domain specific area, such as Science or Mathematics.

A study on changes in teacher efficacy during the early years of teaching, by Hoy and Spero (2005), contradicts Liu *et al*.'s findings. A comparison of four measures revealed that teaching efficacy went down with teaching experience for novice teachers. This is because the study was based on pre-service teachers and their teaching practice. Hoy and Spero (2005) emphasised that student induction and an induction year provided opportunities to gather information about one's personal capabilities for teaching. Prospective and novice teachers often underestimate the complexity of the teaching task and their ability to manage many agendas simultaneously. New teachers may either interact too much with their learners as peers, find their classes out of control, or they may grow overly harsh and end up not liking their "teacher-self". They become disappointed with the gap between the standards they have set for themselves and their own performance. Novice teachers sometimes engage in self-protective strategies, lowering their standards in order to reduce the gap between the requirements of excellent teaching and their self-perceptions of teaching competence, suggesting that the optimism of young teachers in some situations may be somewhat tarnished when confronted with the realities and complexities of the teaching task (Hoy & Spero, 2005).

Bandura's Theory of Self-efficacy suggests that efficacy may be malleable early in the learning phase, thus the first years of teaching could be critical to the long-term development of teacher efficacy. Bringing it back to the context of teacher training institutions, it is imperative to make sure that student placements for teaching practice are done accordingly, as student's first experience in the teaching environment can tarnish their teaching efficacy if conditions are not favourable. School placement was shown to be the most positive factor to influence pre-service teachers' confidence towards Science and teaching Science (Howitt, 2007). This was also confirmed by novice teachers who were interviewed by Cahill and Skamp (2003 in Howitt, 2007), who believed that pre-service school placement experiences had a positive influence on their confidence levels (Howitt, 2007). Once established, efficacy beliefs of teachers seem resistant to change (Hoy & Spero, 2005).

In a study conducted by Desouza (2004) among elementary and middle school teachers in urban schools in India, using the STEBI-A, it was found that although the number of years of teaching Science was important, they do not necessarily help teachers feel confident about teaching the subject. The main reason was that Indian teachers of Grades 1 - 5 were unable to become Science subject experts. Besides Science, the Indian elementary teachers also taught other core subjects. Thus, Desouza concluded that the number of years of Science teaching experience was not synonymous with being an efficacious teacher. Teacher efficacy is context and subject matter specific. Therefore, teachers who are subject experts have a higher sense of teacher efficacy. The study also found that Tschannen-Moran's view of teacher efficacy, as both context and subject matter specific, may not accurately reflect what influences Taiwanese teachers' Science teaching efficacy at the elementary level (Liu, Jack & Houn-Lin, 2007).

3.5.3 Teacher efficacy, support and leadership

Schools can enhance the beneficial effects of strong initial preparation with strong induction and mentoring in the first years of teaching. A number of studies have found that well-designed mentoring programmes raise retention rates for new teachers by improving their attitudes, feelings of efficacy, and instructional skills (Darling-Hammond, 2003).

Studies on pre-service teachers' teaching efficacy rate the external dimensions of teacher efficacy, such as learners' environmental influence or parental support, significantly lower than that of experienced teachers. The opportunities to work with learners in the classroom and the practical knowledge acquired from performing tasks, such as meeting parents or achieving administrative requirements, help increase teachers' level of confidence and improve skills in managing different issues within different contexts. A supportive community that provides encouragement and solutions during times of frustration and confusion is a place where pre-service teachers are nurtured with practical tips that they can never learn from lectures in teacher preparation programmes (Liaw, 2009).

Many teachers find learner discipline a reason for low morale. Teachers who have difficulty in handling discipline issues arising in the classroom, or teachers who receive little support from their administration while handling discipline issues may have low morale and may even leave the profession (Tye & O'Brien, 2002 in Rowland, 2008). It is important for principals to make their teachers feel they are supported in order to keep quality teachers in the profession and maintain morale in the demanding field of education (Rowland, 2008).

Principals have the power to influence many factors at a school. They have a myriad of roles included in their job description. One of the most important and influential roles is the effect the principal has on the teachers of the school. However, a good teacher will be successful in spite of a poor principal. This good teacher knows how to handle the pressures of the profession and ignores the incompetence of the principal. This teacher is interested primarily in what is good for the individual learners in the classroom. For the others - the teachers who need some support, a little guidance, or an occasional pat on the back - the principal plays a vital role in their morale. Blase and Blase (1994 in Rowland, 2008) state that praise by the principal provides teachers with increased efficacy, self-esteem, and creates greater motivation.

The time spent during teaching practice and the first year of real teaching are critical as they can either make or break a teacher's teaching efficacy, depending on the support the novice teachers gets. The sources of support, as pointed out by Hoy and Spero (2005), include the quality of teaching resources provided, support from colleagues, support from administrators, support from parents, and support from the community. Confident new teachers gave higher ratings to the adequacy of support they had received than those teachers who ended their year with a shakier sense of their own competence. Efficacy beliefs of new teachers are related to stress and commitment to teaching, as well as satisfaction with support and preparation. Contextual influences on efficacy include criticism from colleagues, isolation, work overload, lack of recognition or reward, and inappropriate initial teacher training as sources of stress and threats to efficacy (Hoy & Spero, 2005).

The influence of the Science teacher educator, as a component in the Science teacher education programme, was investigated by Howitt in 2007. The interaction between the Science teacher educator and the pre-service teacher has been found to play a vital role in increasing pre-service teachers' confidence in their Science teaching abilities and Science teaching skills. The most powerful influence on increasing the learners' confidence was found to be the modeling that the teacher used, which included effective Science teaching strategies, behaviours that contributed to a positive learning environment, and enthusiasm for Science and Science teaching. The Science teacher educator has the role of establishing an effective learning environment in order to improve attitudes to Science. These learning environments need to be positive and supportive to minimise anxiety and encourage freedom to experiment and verbalise opinions. This should include a variety of experiences that make connections with prior knowledge, which are supported by constant feedback to allow for the development of Science and pedagogy, and increased beliefs and attitudes to Science and self (Howitt, 2007).

In a study with first-year Agriculture teachers, Knobloch and Whittington (2002) investigated the variation in teacher efficacy in the tenth week of the school year, predicted by various variables such as perceived support (utilising a mentor, principal support), collective efficacy, teacher preparation quality, and student teaching experiences. In their study, neither the mentor nor the principal had a significant influence on teacher efficacy. The authors suggested that teachers may not perceive those variables as important during the first weeks of their teaching. In addition, mentor support was measured by one item. They suggested that further studies should be conducted to investigate the effect of the mentoring relationship on novice teachers' sense of efficacy with longer, thus more reliable measures (Yeşim Çapa, 2005).

3.5.4 Teacher efficacy and teacher preparation/education

Research on pre-service teachers' teacher efficacy indicates that factors such as self-perceptions of teaching competence, personal characteristics, emotional and pedagogical support from fellow pre-service teachers, as well as the preparation programme contribute to teaching efficacy (Liaw, 2009).

Pre-service teachers' level of efficacy can be increased by the school-university collaboration where prospective teachers can experience hands-on experience of real life teaching. School-university collaborations and discussions among student teachers when performing a task in a group setting provide both vicarious experience and verbal persuasions as resources to enhance their level of efficacy. The observation of other pre-service teachers during the task, or of experienced teachers in a real classroom, creates a model for success that further increases their confidence that they will be able to perform similar tasks in the future (Liaw, 2009).

Darling-Hammond, Chung and Frelow (2002) reported on the importance of being well prepared in the teacher preparation programme. They found a significant relationship between teachers' ratings of their overall preparedness and their belief in their ability to reach all learners, handle problems in classrooms, and make a difference in learners' lives. Teachers' sense of efficacy was also higher for those working at the elementary level, those teaching within their area of certification, and for minority teachers. Efficacious teachers seemed more satisfied with the teaching profession and were more likely to stay in the profession (Yeşim Çapa, 2005).

Yeşim Çapa (2005) suggests that further studies are required, which examine the impact of beginning teachers' preparation programmes and their current teaching context on their sense of efficacy. The findings would be helpful in better preparing teachers and maintaining a supportive setting for them in which they can grow professionally, stay in the teaching field, and contribute to student achievement (Yeşim Çapa, 2005).

The national concern for quality teacher education in the United States has been fostered by the *No Child Left Behind* Elementary and Secondary Education Act (ESEA), adopted in January 2002. ESEA required that states take action to ensure that all teachers were highly qualified by the end of the 2005/2006 school year (U.S. Department of Education, 2002). Quality education and quality teacher education are considered as significant factors affecting the future of society. In traditional four year teacher preparation programmes, there are three primary components: liberal arts education, professional study, and practical experience. The first component includes coursework in a single content area, in which the secondary teacher candidate will be licensed. Elementary teacher candidates often major in elementary education or educational psychology. The second component includes coursework in the study of education, including introduction to education, educational psychology, and teaching methods. The last component includes a variety of field experiences, in which teacher candidates are expected to make initial observations and then, near the end of the programme, do student teaching in elementary or secondary schools under the supervision of a cooperating teacher and a faculty member from the teacher preparation programme (Darling-Hammond & Cobb, 1996). Student teaching has been considered as the most beneficial component of the teacher preparation programmes by teachers, teacher education students, and teacher educators (Yeşim Çapa, 2005).

The situation is no different in South Africa. In a story published on News24 on 3 May 2010, the Democratic Alliance (DA) in the Western Cape said that more than 1 700 South African Science teachers were not qualified to teach the subject. This meant that at least 50 000 learners were not receiving teaching from qualified educators. Wilmot James, the party spokesperson on higher education and training, said that Science education in South African high schools was generally in a very poor state. He further indicated that the 2009 matriculation results had 60 percent of all learners who wrote the Physical Science examination receiving a mark of less than 40 percent, failing therefore by any decent standard of assessment. The province was considering means to improve the quality of Science tuition by conducting school inspections and directly assessing teacher performance in the classroom.

3.5.5 Teacher efficacy and teaching practice/placement

Most educational researchers concur that most elementary teachers have some problems in teaching some subjects. Concerning Science, both pre-service and in-service teachers perceive it as a difficult subject and feel themselves inadequately prepared to teach Science in elementary schools (Yilmaz & Cavas, 2008). Research studies by Booth (1993), Karmos and Jacko (1977) in Yeşim Çapa, 2005) indicated that mentor teachers were perceived as the most significant person in the student teaching experiences. Although the university supervisor plays a role in supervision, the mentor teacher during teaching practice plays the most vital role in familiarising the student-teacher with the real teaching and learning environment. There is evidence to suggest that student teachers often move closer to the attitudes and behaviours of their mentor teachers by the end of the student teaching experience. For example, a poorly chosen placement can have negative consequences for the student teacher, including feelings of inadequacy, low self-confidence, and a negative attitude toward teaching (Yeşim Çapa, 2005).

Mulholland and Wallace (2001, in Yeşim Çapa, 2005) carried out a longitudinal case study in which an elementary Science teacher wrote a reflective journal, describing her experiences while passing from pre-service to in-service teaching. In addition, interviews and observations were conducted for two years. They found that, in addition to the importance of support from supervisors in the early years of teaching, mastery experiences were also sources of information for building efficacy. Particularly when the experiences were successful, they appeared to be effective in enhancing efficacy. During both pre-service and in-service teaching years, previous experience with an instructional activity, knowing learners' characteristics, and preference of manageable activities helped the teacher (Yeşim Çapa, 2005).

A number of studies (Wingfield 2000, Meyer 1999, Woolfolk Hoy and Kolter Hoy 2006) in Clark (2009) showed that teaching practice play a critical role in pre-service teachers' science teaching efficacy. Wingfield (2000) found that suitable site-based Science teaching enhanced the feelings of self-efficacy of trainee teachers; which has implications for teacher training programmes. Meyer (1998) also noted that after their first year, the quality of the Science information new teachers gained had increased, which led to higher confidence levels and better teaching methodology within their classrooms. However, they did not report an increase in the breadth of Science knowledge, rather an increase in the depth within certain areas of the subject (Clark, 2009). They also highlighted the fact that trainee teachers learnt a great deal through observing good Science teaching practice, using them as frames of reference when they begin practice. Woolfolk Hoy and Kolter Hoy (2006) found that prospective teachers tended to increase in their personal sense of efficacy as a result of completing student teaching. Wenglinsky and Silverstein (2006:26) further added in Clark (2009) that "Many studies show a close correlation between student achievement in Science and teacher preparation in Science. Of the many steps needed to improve Science education, none is more important than improving teacher training" (Clark, 2009). However, a paired-samples t-test conducted by Yilmaz and Cavas to evaluate the impact of teaching practice on self-efficacy and classroom management beliefs of pre-service elementary teachers revealed no statistically significant difference between pre-test (before teaching practice) and post-test (after teaching practice) means on the PSTE and STOE sub-scales (Yilmaz & Cavas, 2008).

3.5.6 Teacher efficacy and instruction

Teaching is a career in which teachers have significant influences on pupils' thoughts, behaviours and academic performance; thus, it is important for teachers to find ways to increase their professionalism (Mutahar, Xiang & Abudhim, 2007).

The relation between the contextual variables and self-efficacy beliefs were investigated in a study conducted by Tschannen-Moran and Woolfolk Hoy (2007). The study revealed that experienced teachers' efficacy beliefs for instructional strategy and efficacy in classroom management were higher than those for novice teachers. The researchers indicated that the difference between them might be explained by the difference in the amount of mastery experience they had. Moreover, experienced teachers indicated that they had more teaching resources and support from administrators (Aydin & Boz, 2010).

Gaith and Yaghi (1997) conducted a study to investigate the relationships among teacher experiences and attitude toward the implementation of instructional innovation. The results revealed that experience was negatively correlated, personal teaching efficacy positively correlated, and general teaching efficacy not correlated with teachers' attitudes toward implementing new instructional practices (Gaith & Yaghi, 1997).

Countries worldwide have ongoing curriculum reforms aimed at revising the traditional approach of Science learning as a mastery of factual knowledge and procedures to an inquiry approach of learning where learners are expected to be engaged in methodological learning by discovering scientific concepts and developing the processes of problem-solving. In order to bring about such important reform in Science education requires that teachers possess certain beliefs about themselves, Science learning, and Science teaching that depart significantly from the realities of current school Science practices. One possible reason why some teachers are not able to change their traditional models, while others accept reform practice and change the environment of their Science classroom, is that these teachers have different beliefs about teaching and learning. That is, they have different teaching efficacy beliefs which can be considered an integral and essential aspect of the teaching process (Hassan & Tairab, 2012). Thus, it is imperative for every educational system to be considerate of the reforms that need to be implemented and how they influence the efficacy of teachers, who are also the bearers of change.

3.5.7 Teacher efficacy and gender

Research has shown that since females constitute the majority of elementary teachers in many countries, the impact of pre-service teachers' gender on their attitudes toward Mathematics and Science is suggested as another reason for the negative attitude of elementary teachers towards teaching these subjects. It has been reported that male elementary teachers express higher self-efficacy for teaching Mathematics and Science than female teachers in both in-service and pre-service situations (Cantrell & Young, 2003).

Riggs (1991) conducted research on gender differences in elementary Science teacher self-efficacy. She reported higher scores for males on self-efficacy for Science teaching in both the in-service and pre-service samples. There were no significant differences obtained for outcome expectancy scores. Riggs (1991) questioned the cause of these gender differences. Could this be explained by the female teachers' lack of a background in Science? She offered a reason for the different experiences males and females encounter within the same classroom. Riggs (1991) proposed that the difference may lie within the self-efficacy ratings of the male teachers; that the higher Science self-efficacy ratings are due to the higher expectations put upon male teachers by those around them. The male teachers are often thrust into the role of Science coordinator for the school. This practice, as Riggs (1991) opines, could have led to a self-fulfilling prophecy in that the male teachers end up viewing themselves as Science teaching experts.

By examining the background and experiences of Southern Australian female leaders in primary Science, who had developed the confidence and competence to teach Science, Paige (1994) found that there were many interrelated factors that contributed to their expertise in teaching primary Science. Five factors stood out:

- influence and support from key people such as teachers, family, focus teachers, coordinators and university lecturers;
- their own natural curiosity, personal interest, inquiring mind, and enjoyment of challenges and problem-solving;
- participation in long-term, whole school training and development programmes;
- interest in and experience with the environment; and
- the joy of children discovering and learning in Science (Wee-Loon, 2011).

There have been many studies comparing the self-efficacy of male and female teachers, many of which are conflicting. From all the results of the studies, there was no clarity about whether self-efficacy differs according to gender; the difference in the results of the studies may result from cultural differences (Wee-Loon, 2011).

3.5.8 Teacher efficacy and subject knowledge

According to Shulman (1986), there are two forms of knowledge that teachers need to master. The first is subject matter knowledge (SMK) and the second is pedagogical content knowledge (PCK). Shulman (1986) opined that through the process of planning and teaching specific content, teachers would develop more powerful forms of subject matter knowledge. The growth of knowledge of how to teach their subject matter is a crucial aspect of teachers' knowledge development in their early years. Pedagogical knowledge, the second kind of content knowledge, goes beyond knowledge of the subject matter to the dimension of subject matter for teaching (Wee-Loon, 2011).

According to Hollon, Roth & Anderson (1991, in Wee-Loon, 2011), it is the role of teachers to constantly acquire adequate knowledge of the topic to be taught. With greater Science content knowledge, they are better at identifying key points, developing instructional representations and analysing student thinking, and helping learners to explain observed phenomenon accurately (Wee-Loon, 2011).

Newton & Newton (2001, in Wee-Loon, 2011) indicated that if teachers possess deficiencies in content knowledge for topics to be taught, it can cause a whole range of problems. These teachers were seen to interact less, and ask fewer questions overall, and about causes in particular (Wee-Loon, 2011). New teachers with strong Science content knowledge have higher self-efficacy about teaching Science, but on the other hand, teachers who have taken the minimum required number of Science courses feel that their content knowledge is lacking (Cantrell, Young & Moore, 2003). These teachers tend to avoid teaching topics that they do not know well for fear that their learners will ask questions that they cannot answer (Rice & Roychoudhury, 2003 in Wee-Loon, 2011). Consequently, this contributes to their hesitancy, and possibly, their inability to provide effective Science instruction in their classrooms (Wee-Loon, 2011).

Fewer studies have examined the effects of Physical Science teachers' content knowledge on their self-efficacy beliefs, especially those of in-service teachers of secondary schools. Most of the studies on the efficacy beliefs of Science teachers are either on primary school teachers or pre-service teachers.

Studies by Goldhaber and Brewer (1997) and Aaronson, Barrow and Sander (2007) examined the relationship between content knowledge and effectiveness, particularly in teaching Mathematics (Rockoff, Jacob, Kane & Staiger, 2008). Although the evidence on this issue is mixed, these studies used proxies for content knowledge, such as the number of courses taken in a subject, or a college/university major. Some math educators and researchers argue that it is not simply mathematical knowledge *per se*, but the ability to express mathematical concepts in the context of classroom teaching, which is critical. Mathematical knowledge for teaching involves the ability to explain difficult mathematical concepts in multiple ways, and to describe the intuition behind mathematical reasoning instead of focusing exclusively on algorithms and procedures (Schulman 1986, 1987; Wilson, Shulman and Richert, 1987, in (Rockoff, Jacob, Kane & Staiger, 2008). The situation is no different in the teaching of Physical Science.

The quality of education that teachers provide to learners is highly dependent upon what teachers do in the classroom (Furner, 2007). Thus, in preparing the learners of today to become successful individuals of tomorrow, Science and Mathematics teachers need to ensure that their teaching is effective. Teachers should have the knowledge of how learners learn Science and Mathematics, and how best to teach (Furner, 2007). Proper training in teaching Mathematics and Science does not only entail content, but teachers also need to be trained in Educational Psychology to help them understand how learners learn.

A study conducted in the United States by Korn (2000, in McDonnough, McKelvey, Baski & Lewis, 2004) showed that most teachers had minimal training in the Physical Sciences, but they are expected to teach Science to their learners so that they can pass standardised examinations. To do this effectively, pre-service and in-service teachers should be exposed to educational experiences that build their content knowledge of Physical Science in the context of sound instructional practices (McDonnough, McKelvey, Baski & Lewis, 2004).

Tepner and Dollny (2012) found that Chemistry teachers' content knowledge varies according to the type of school in which they teach. For the purpose of this study, teachers' content knowledge was investigated against the teachers' demographic data on their qualifications and the major subjects taken during their training**.**

Hill, Rowan and Ball (2005 in Rockoff *et al*., 2008) found that there is evidence of a positive relationship between content knowledge and student achievement gains in first and third grade. Hoy and Woolfolk (1993) found that the educational level of teachers was the only personal variable that predicted personal teaching efficacy uniquely. Similarly, Friedman (2003) found that the educational background of teachers had significant effects on their efficacy. The quality and quantity of Science taught to learners is strongly influenced by their teachers' confidence, attitude and knowledge level (Taimalu & Oim, 2005).

The Physical Science content in the South African context

3.5.8.1 Physical Science knowledge areas

In some instances of this study Physical Science will be presented as Science. In relation to CAPS, Physical Science investigates physical and chemical phenomena. This is done through scientific inquiry and the application of scientific models, theories and laws in order to explain and predict events in the physical environment. The subject also deals with society's need to understand how the physical environment works in order to benefit from it and responsibly care for it. All scientific and technological knowledge, including Indigenous Knowledge Systems (IKS), is used to address challenges facing society.

The purpose of Physical Science is to make learners aware of their environment and to equip learners with investigating skills relating to physical and chemical phenomena, for example, lightning and solubility. Examples of some of the skills that are relevant for the study of Physical Sciences are classifying, communicating, measuring, designing an investigation, drawing and evaluating conclusions, formulating models, hypothesising, identifying and controlling variables, inferring, observing and comparing, interpreting, predicting, and problem-solving and reflective skills.

Physical Science promotes 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. Six main knowledge areas inform the subject Physical Science. These are:

1. Matter and Materials
2. Chemical Systems
3. Chemical Change
4. Mechanics
5. Waves, Sound and Light
6. Electricity and Magnetism (DBE, 2011).

Mechanics, waves, sound and light, and electricity and magnetism are Physics concepts; chemical changes and chemical systems are Chemistry concepts; whereas matter and materials are shared between the two components.

3.6 Research done on teaching efficacy

3.6.1 Research on Mathematics teaching efficacy

The quality of education that teachers provide to student is highly dependent upon what teachers do in the classroom. Thus, in preparing the learners of today to become successful individuals of tomorrow, Science and Mathematics teachers need to ensure that their teaching is effective. Teachers should have the knowledge of how learners learn Science and Mathematics and how best to teach them (Furner, 2007).

Teacher efficacy influences how teachers plan and organise their instruction and how teachers manage their classrooms. Studies by Alamri (2003) conducted in Yemen showed that middle school teachers' performance was poor; also that Mathematics teachers used traditional methods in the teaching process (Mutahar, Xiang & Abudhim, 2007).

A study by Mji and Makgato (2006) in Tshwane North, South Africa, indicated two influences, direct and indirect, associated with high school learners' poor performance in Mathematics and Physical Science. The direct influences have five areas related to teaching strategies, content knowledge and understanding, motivation and interest, laboratory usage, and non-completion of the syllabus. In teaching strategies, learners complained of teachers working too fast or being impatient, while teachers considered learners as unwilling to learn and not being serious about their studies. For content knowledge, learners were dissatisfied about the application of their prior knowledge to aspects they were being taught in their current grades because they memorised without understanding and it made learning difficult; even teachers confessed to having difficulty with some of the concepts in Mathematics and Science. Under motivation and interest, learners appeared to put all the blame on the teachers and lack of resources that demoralised them; whereas teachers were concerned about the learners' behaviour, arriving late for class, and lack of concentration in class. In regards to laboratory use, learners and teachers complained about the lack of practical equipment to enhance their teaching and learning of Science. According to the learners, non-completion of the syllabus had to do with teachers wasting time on concepts they had mastered and neglecting other concepts, and teachers not being punctual for classes. On the other hand, teachers identified activities such as sport and breaks in teaching as time-consuming (Mji & Makgato, 2006).

The second factor, associated with indirect influences, was attributed to the role played by parents in their children's education, and general language usage, together with understanding in the two subjects (Mji & Makgato, 2006). The focus for this study will be based more on the first factor, which has a direct bearing on the teaching efficacy of teachers as associated with the direct influences outlined above.

Education reports (DoE, 2001) indicate that outdated teaching practices and the lack of basic content knowledge have resulted in poor teaching standards. These poor standards have been exacerbated by a large number of under-qualified or unqualified teachers who teach in overcrowded and non-equipped classrooms. These reports show that 50 percent of Mathematics and 68 percent of Physical Science teachers have had no formal subject training. Mji and Makgato (2006) also highlighted that the Education for All 2000 assessment (2005) found that, in spite of approximately 85 percent of Mathematics teachers being professionally qualified, only 50 percent specialised in Mathematics in their training; similarly, with 84 percent of Science teachers professionally qualified, but only 42 percent qualified to teach Science. Therefore, an estimated 8 000 Mathematics and 8 200 Science teachers needed in-service training to address the shortcomings in these subjects. Another problem was that very few learners, who graduated with good Mathematics and Physical Science marks, chose teaching as a career. This led to an under-supply of teachers; thus, schools did not offer Mathematics and Physical Science as subjects. The schools that offered these subjects were not fully equipped to promote effective teaching and learning (Mji & Makgato, 2006). This affected teachers' morale and had a negative influence on their teaching efficacy in regards to these subjects.

Teachers consider Mathematics ability as the underlying reason for the difficulty that learners face with Mathematics (Dowker, 2004). However, perceptions of competence and non-competence might account for the lack of motivation to engage in mathematical activities and for persistence in the face of difficult problems, thus resulting in avoidance of the subject matter and low performance. Failure might also result from anxiety due to low efficacy beliefs. Therefore, at classroom level, teachers need to recognise the importance of learners' perceptions of their capabilities and try to identify sources of low efficacy in order to alter them (Michaelides, 2008).

Research by Pietsch, Walter and Chapman found that self-efficacy items are related to competency components of self-concept, but not to affective ones, and that self-efficacy is more highly related to Mathematics than to self-concept (Michaelides, 2008). The low efficacy beliefs in mathematical competence may account partly for the avoidance of

Mathematics-related courses and careers. According to Zelden and Pajares (2000), women who were successful in Science, Mathematics and Technology had verbal persuasions and vicarious experiences as critical sources of their self-efficacy beliefs. While women relied on relational episodes to persist in male-dominated disciplines, men constructed their self-efficacy beliefs primarily through interpretations of their achievement and successes in those fields (Michaelides, 2008).

3.6.2 Research on Science teaching efficacy

A study on Middle Grade Teachers' Perceptions of their Chemistry Teaching Efficacy (Gado, Verma & Simonis, 2008) found that knowledge of Chemistry concepts positively affected these teachers' confidence and readiness in using Conceptual Chemistry units in their classroom. Teachers gained knowledge through a one-year Professional Development (PD) programme, which they felt would enable them to teach the concepts to their learners. Participants said they learned teaching strategies necessary to effectively teach their own learners, using the PD experiences. They said the understanding of Science concepts would make them more effective in teaching Chemistry in their own classrooms (Gado, Verma & Simonis, 2008).

Teachers, according to Jones and Levin (1994) and Van Zee and Roberts (2001, in Gado *et al., 2008*), may teach in ways similar to their own learning experiences as they may not have the knowledge and confidence to use pedagogically sound strategies in their classrooms. Professional development opportunities should facilitate teachers' understanding on inquiry-based teaching in the classroom. Gallagher (1994, in Gado *et al., 2008*), highlights that teacher enthusiasm and inquiry-based teaching in middle school years are the best predictors of student persistence in school Science. Unless inquiry-oriented classes are a part of their own educational experiences, elementary and middle school Science teachers typically lack ways to implement Science content and inquiry processes in their classrooms (Hammer, 2000; Jones & Levin, 1994). In addition, teachers often claim that inquiry is time-consuming and may be too advanced for learners (Bybee, 2000). Therefore, quality Professional Development materials and opportunities guided by research-based ideas are essential to develop robust Science knowledge and skills to implement inquiry-based teaching in the classroom.

A study by Sun (2003, cited in Liu, Jack and Houn-Lin 2007) explored the concept and measure of teacher efficacy among Taiwanese in-service Science teachers. The study found that teacher efficacy is multidimensional in nature, comprising of the following factors, instructional efficacy, efficacy to assess learning progress, efficacy to communicate with parents, efficacy to enlist teaching reform, and efficacy to change the environment (Liu, Jack & Houn-Lin, 2007).

3.7 Conclusion

This chapter provided a detailed summary on Bandura's Social Cognitive theory, the sources of teacher efficacy, measurement of, as well as factors influencing teaching efficacy. Table 3.1 gives a summary of this chapter.

Table 3.1: Summary on self-efficacy and teaching

Self-efficacy and teaching		
Sources of teacher efficacy	**Measurement of teacher efficacy**	**Factors influencing efficacy**
• Mastery experience • Vicarious experience • Verbal persuasion • Physiological states	• Rotter's theory and RAND studies • Bandura's theory	• Classroom behaviour • Teaching experience • Support and leadership • Teacher preparation • Teaching practice • Instruction • Gender • Subject knowledge

The research methodology for this study, which is to measure the Science self-efficacy beliefs of the Free State province's secondary school Science teachers, will be presented in the next chapter.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

This chapter presents the research methodology used in this study. The rationale for the selection of the research design, population and sample, data collection techniques and methods of analysis are explained. Issues of validity, the reliability of the instruments and ethical considerations are addressed in this chapter.

4.2 Research methodology

4.2.1 Research design

Research design is the complete strategy of attack on the central research problem. It refers to one's overall research approach with regards to the problem under investigation (Imenda & Muyangwa, 2006). A research design describes how the study is to be conducted. It summarises the procedures for conducting the study, including when, from whom, and under what conditions the data will be obtained. In other words, the research design indicates the general plan: how the research is set up, what happens to the subjects, and what methods of data collection are to be used. The purpose of a research design is to specify a plan for generating empirical evidence that will be used to answer the research questions (McMillan & Schumacher, 2006).

This study used a mixed methods approach. A mixed methods approach involves both quantitative and qualitative methods. Creswell (2008:552) states that "the basic assumption is that the use of both quantitative and qualitative methods, in combination, provides a better understanding of the research problem and questions than either method by itself". Using both quantitative and qualitative data allows the researcher to simultaneously generalise results from a sample to a population and to gain a deeper understanding of the phenomenon of interest. Qualitative research methods aim at establishing the socially constructed nature of reality, to stress the relationship between the researcher and the object of study, as well as to emphasise the value-laden nature of the inquiry. Quantitative research methods do not involve the investigation of the processes, but emphasise the measurement and analysis of causal relationships between variables within a value-free context (Welman, Kruger & Mitchell, 2005). The main objective of qualitative study, according to Kumar (2005:14), is to describe the variation in a phenomenon, situation or attitude, whereas quantitative research helps the researcher to quantify the variation.

The differences between quantitative and qualitative research methods are as follows (Kumar, 2005:17-18):

DIFFERENCE WITH RESPECT TO:	QUANTITATIVE RESEARCH	QUALITATIVE RESEARCH
Underpinning philosophy	Rationalism: Humans being achieve knowledge because of their capacity to reason.	Empiricism: The only knowledge that human beings acquire is from sensory experiences.
Approach to inquiry	Structured/rigid/predetermined methodology	Unstructured/flexible/open methodology
Main purpose of the investigation	To quantify extent of variation in a phenomenon, situation, issue, etc.	To describe variation in a phenomenon, situation, issue, etc.
Measurement of variables	Emphasis on some form of either measurement or classification of variables.	Emphasis on description of variables.
Sample size	Emphasis on greater sample size	Fewer cases
Focus of inquiry	Narrows focus in terms of extent of inquiry, but assembles required information from a greater number of respondents.	Covers multiple issues, but assembles required information from fewer respondents.

Dominant research value	Reliability and objectivity (value-free)	Authenticity, but does not claim to be value free.
Dominant research topic	Explains prevalence, incidence, extent, nature of issues, opinions and attitudes; discovers regularities and formal theories.	Explores experiences, meanings, perceptions and feelings.
Analysis of data	Subjects variables to frequency distributions, cross-tabulations or other statistical procedures.	Subjects responses, narratives or observation data to identification of themes and describes these.
Communication of findings	Organisation more analytical in nature, drawing inferences and conclusions and testing magnitude and strength of relationship.	Organisation more descriptive and narrative in nature.

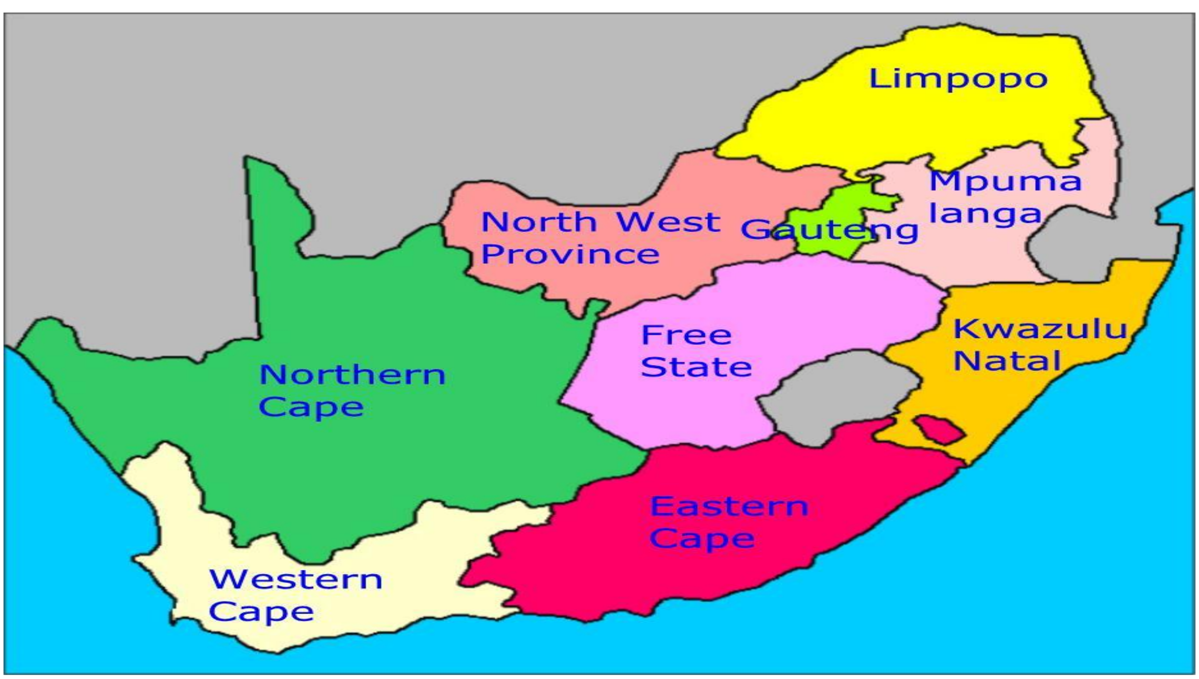
This study used an explanatory mixed methods approach - the quantitative data and results provide a general picture of the research problem; more analysis, specifically through qualitative data collection, is needed to refine, extend, or explain the general picture. The advantages of this design are that the researcher does not need to converge or integrate two different forms of data as the quantitative and qualitative parts are clearly identified. Such a design captures the best of both quantitative and qualitative data. The drawbacks of this design are that it is labour intensive, and it requires expertise and time to collect both quantitative and qualitative data. In addition, the researcher needs to determine what aspect of the quantitative results to use in the follow-up. This design, according to Creswell (2008), is probably the most popular form of mixed methods design in educational research.

A mixed methods approach that is QUANTI-quali is appropriate for this study since a relationship is established between the respondents' biographical data, their level of preparedness in Science, and their Science teaching efficacy. Furthermore, for the qualitative method, the researcher tries to understand the significance which respondents attach to their environment (Welman *et al*., 2005:8). The analytical procedure used in this study is explaining results by conducting a quantitative survey to identify how two or more groups compare on a variable. This is then followed up with qualitative semi-structured interviews to explore the reasons why these differences were found. Thus, the selected research design is appropriate for this study to assess Science teachers' self-efficacy whereby their demographic factors, subject knowledge and assessment skills as independent variables were investigated and their relationship to efficacy was deduced.

4.2.1.1 Population

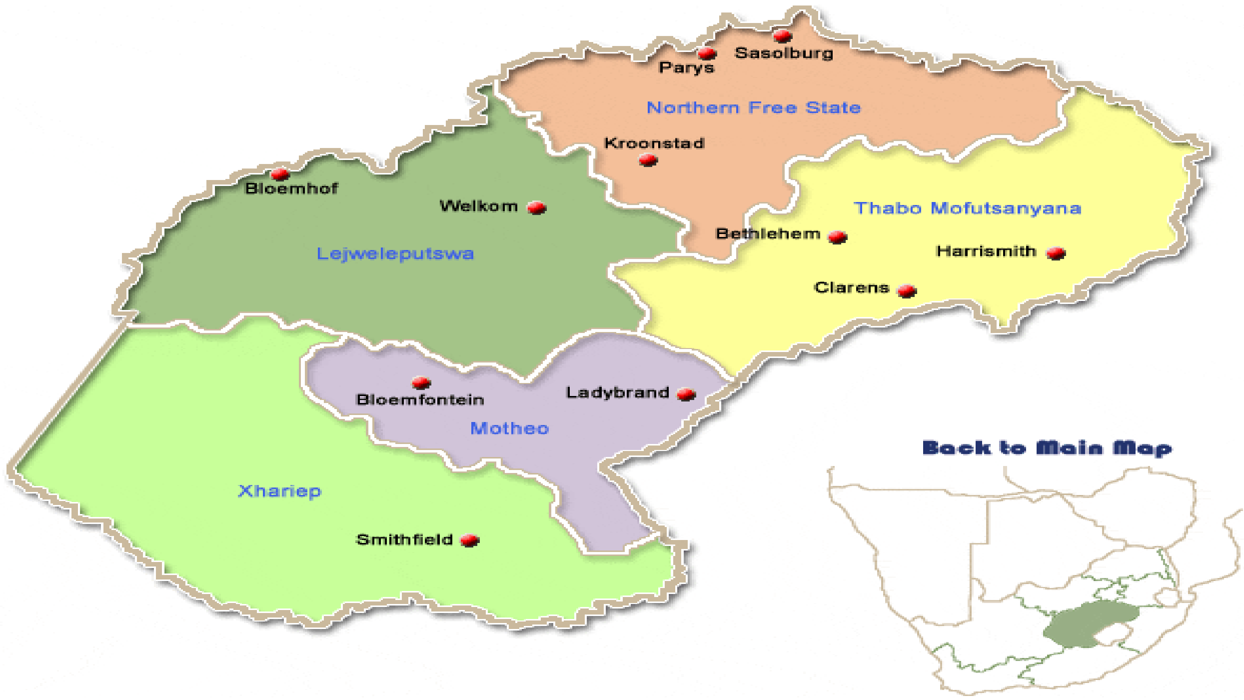
McMillan and Schumacher (2006:119) define a population as a group of elements or cases, whether individuals, objects or events, that conform to specific criteria and to which we intend to generalise the results of the research. The target population for this study is all secondary school Physical Science teachers in the Free State province of the Republic of South Africa. A map of South Africa showing the Free State and the other eight provinces is shown in Figure 4.1.

Figure 4.1: The map of South Africa



The map of the Free State Province with the five districts is shown in Figure 4.2

Figure 4.2: The map of the Free State province



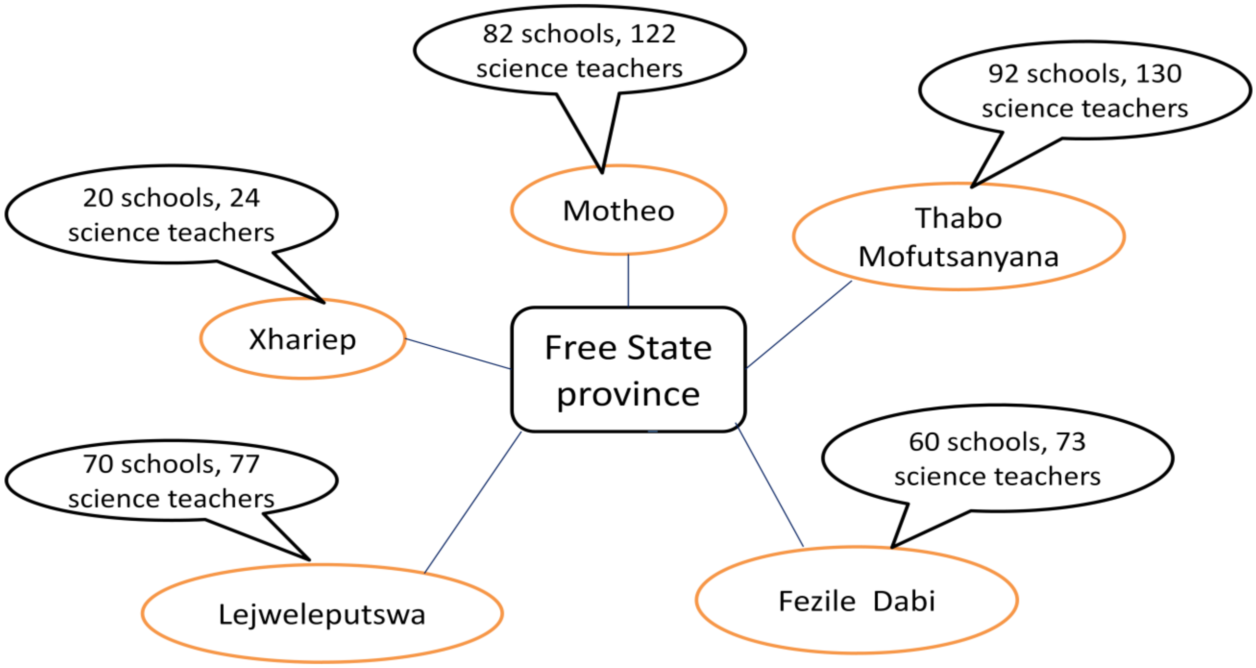
4.2.1.2 Sample

A research sample is a group of people taking part in a given study and about whom information is collected (Imenda & Muyangwa, 2006). The research sample for this study consisted of 190 secondary school Physical Science teachers from the five districts of the Free State province.

4.2.1.2.1 Sampling procedure

The Free State province had 324 secondary schools that offer Physical Science and 426 Physical Science teachers during the time of this study. The illustration below shows the geographic distribution of how the schools and teachers are distributed across the five districts.

Figure 4.3: Geographic distribution of schools and teachers across the districts



From this geographic distribution of secondary schools in the Free State province, cluster sampling was used to select 100 schools. In cluster sampling, the unit of sampling is not the individual, but rather a naturally occurring group of individuals. It is used when it is more feasible or convenient to select groups of individuals than it is to select individuals from a defined population (McMillan & Schumacher, 2006). Cluster sampling was used in this study to select schools to represent the different geographic locations (urban, semi-urban and rural) of the schools of the five districts of the Free State province.

In cluster sampling, the researcher identifies convenient, naturally occurring groups such as neighborhoods, schools, districts and regions (McMillan & Schumacher, 2006:123). The advantage of cluster sampling is that it gives the researcher an opportunity to select the sample that best suits the purpose of research based on their knowledge of the population. This method also has the advantage of concentrating the field of study in a specific section of the geographical area and thus helps to save costs and time (White, 2005:119). Cluster sampling was used in this study to ensure that township, farm and former Model C schools were included. For the purpose of this study, township schools refer to the schools mostly located in semi-urban areas. Townships are those areas that were reserved for blacks during the apartheid era. The term is still used. Former Model C schools are the schools that were formally for whites. They are better resourced schools than the schools in the townships. Farm schools are located in the rural areas.

From the 100 schools that were selected, 200 teachers were selected using stratified random sampling to constitute the sample for the study. In stratified random sampling, the proportion of subjects randomly selected from each group is usually the same as the proportion of that group in the population (Imenda & Muyangwa, 2006:100). Stratified sampling assures the researcher that the sample will be representative of the population in terms of certain critical factors that have been used as a basis for stratification, and also assures him/her of adequate cases for sub-group analysis (Imenda & Muyangwa, 2006:101). In this study, the sampling frame was stratified, that is, divided into rural, semi-urban and urban schools per district, since the geographic location of the school was used as a stratification variable. The type of stratified sampling used was proportional stratified sampling because it ensured that the sub-samples (e.g. the samples of rural, semi-urban and urban schools) were proportional to their sizes in the population. Other stratification variables used in this study were gender, age and grade level taught. The sample profile is provided in Table 4.1 below.

Table 4.1: Representation of the geographic locations of the schools per respondents

District	Motheo	Xhariep	Thabo Mofutsanyana	Fezile Dabi	Lejwele-putswa	Total
Urban	22	1	6	4	8	41
Semi-urban	62	8	10	11	33	124
Rural	7	2	3	0	4	16
Did not indicate	1	5	0	3	0	9
Total	92	16	19	18	45	190

Of the targeted sample of 200 teachers, 190 returned the questionnaires, thus yielding a good response rate of 95 percent.

4.2.2 Research instruments

Two research instruments were used in this study, namely a questionnaire and semi-structured interviews.

4.2.2.1 Questionnaires

A questionnaire was used as the main data-gathering instrument in this study. A questionnaire is a self-report data collection instrument that each research participant fills out as part of a research study (Johnson & Christensen, 2012:162). This study used a questionnaire that comprised of the Science Teachers' Efficacy Belief Scale (STEBI-A), which was designed by Riggs and Enochs in 1990 and was tested for reliability, and the self-constructed questionnaire that required information on teachers' biographical data and their level of preparedness in teaching Physical Science.

The STEBI-A is an existing, valid and reliable instrument related to the construct under investigation in this study. The two sub-scales in the STEBI-A, which is designed for in-service teachers, are entitled Personal Science Teaching Efficacy Belief (self-efficacy dimension) and Science Teaching Outcome Expectancy Scale (outcome expectancy dimension). The long version of the STEBI-A consists of 25 items, 13 positively written and 12 negatively. The co-efficient alpha of the Personal Teaching Efficacy Belief is 0.92, while the alpha for the Science Teaching Outcome Expectancy Scale is 0.77 (Riggs & Enochs, 1990). This is recommended for use with in-service teachers. This scale asks for a self-report of teacher beliefs and is constructed using a five-point Likert-type response scale with the options of strongly agree, agree, uncertain, disagree, and strongly disagree, according to the scale 1 to 5, respectively.

The criterion variable, teachers' self-efficacy, measured by the STEBI-A, used a five-choice, 25 item Likert-type response scale for in-service Physical Science teachers. Of the 25 items in the instrument, 13 items apply to Personal Science Teaching Efficacy (PSTE), and the other 12 items address teachers' Science Teaching Outcome Expectancy (STOE). For positively written statements, the values for each response are: SA = 5, A = 4, U = 3, D = 2, and SD = 1. For the negative responses, the scoring is reversed: SA = 1, A = 2, U = 3, D = 4, and SD = 5 (Enochs & Riggs, 1990). According to the authors of the STEBI: "Reversing these items will produce high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs" (Enochs & Riggs, 1990:30).

Variables of Interest in the Study

The dependent variables in this study were Personal Science Teaching Efficacy and Science Teaching Outcome Expectancy, measured by the STEBI-Form A. The dependent variable is "an attribute or characteristic that is dependent on or influenced by the independent variable. They may be called the outcome, effect, criterion, or consequence variables" (Creswell, 2002:136). The composite score of 13 items on the PSTE sub-scale, questions 2, 3, 5, 6, 8, 12, 17, 18, 19, 21, 22, 23, and 24, was used as self-efficacy measure. The total composite PSTE score was 65. The total composite score of 12 items on the STOE sub-scale, questions 1, 4, 7, 9, 10, 11, 13, 14, 15, 16, 20, and 25, was used as outcome expectancy measure. The total composite STOE score was 60.

The independent variables in this study were the demographic factors (respondents' gender, age, educational background, teaching experience, geographic location of the school, grades taught); and respondents' preparedness and confidence to teach Physical Science (subject knowledge and assessment). Norusis (2002:143) states: "An independent variable is a variable that is thought to influence another variable, the dependent variable".

The relationship between the variables in this study is shown in the figure below:

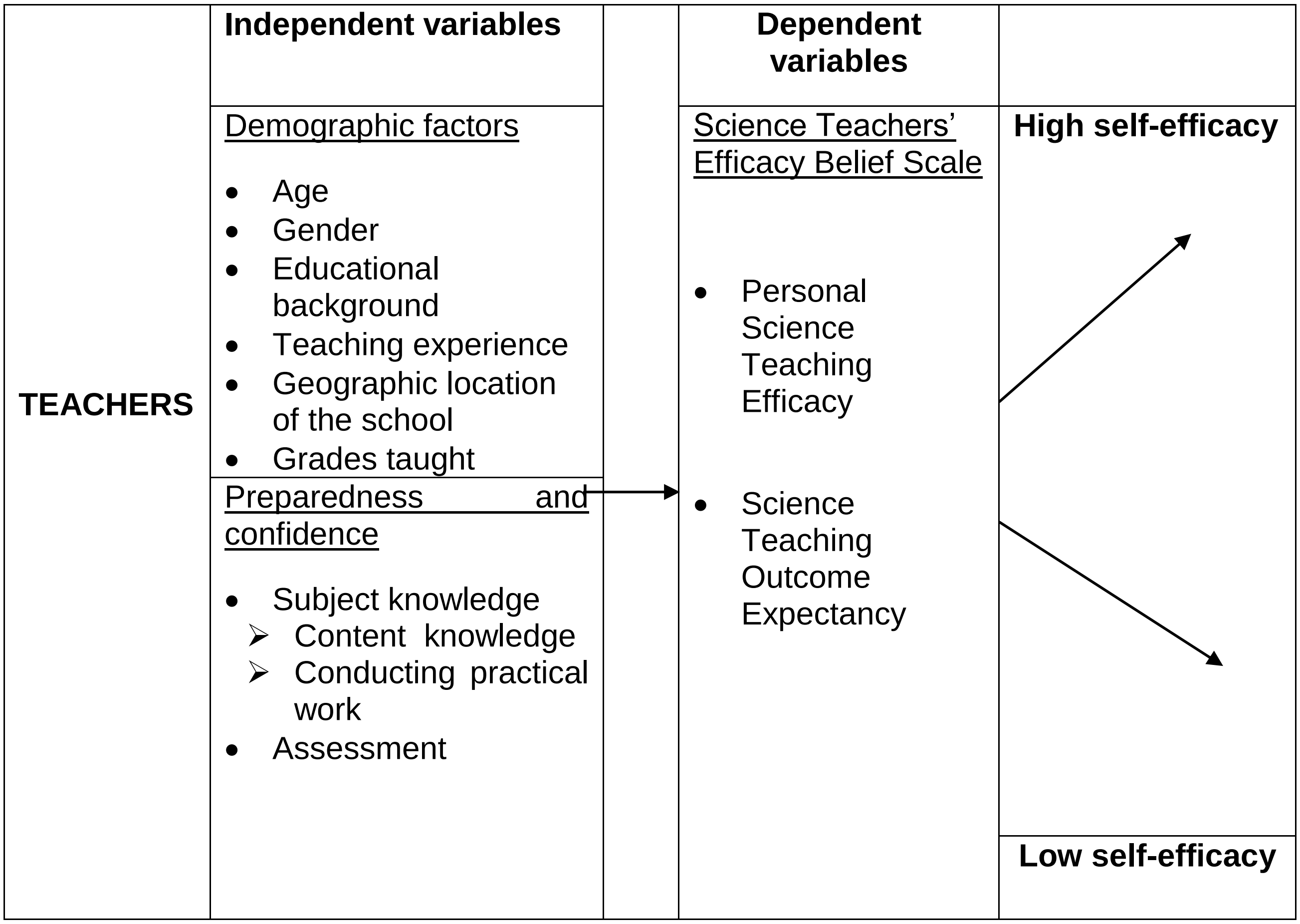


Figure 4.4*:* Relationship between research variables

Reliability of STEBI-Form A

The test developers reported Cronbach reliability coefficients to determine internal reliability for both scales. The reliability of any instrument is calculated by a reliability coefficient (Gall, Gall and Borg, 2007). Reliability coefficients usually range between 0.00 and 1.00 - the higher the value, the more reliable the instrument, free of errors (Gall *et al.,* 2007). A Cronbach alpha specifically measures the internal consistency of test items based on the respondents' answers and how they respond to specific statements that are stated in similar ways.

Enochs and Riggs performed a Cronbach reliability coefficient on both sub-scales of this instrument. For the Personal Science Teaching Efficacy Belief Scale (PSTE), coefficient alpha = 0.92 (p = 0.05), and for the Science Teaching Outcome Expectancy Scale (STOE), coefficient alpha = 0.77 (p = 0.05) (Enochs & Riggs, 1990). Enochs and Riggs believed this lower value for the STOE sub-scale seemed adequate based on the construct, which past researchers have had difficulty defining and measuring. The authors suggested a lower reliability might also be due to multiple variables contributing to the construct. The authors stated: "This lower reliability might be due to multiple variables contributing to the construct as defined by the item set. For example, teachers' science background, inadequacy of students' science background, and low-motivated students" (Enochs & Riggs, 1990:633). In addition, Riggs and Enochs (1990:633) stated: "Teachers may more consistently evaluate their own personal behaviours as in the Personal Science Teaching Efficacy Belief scale than to decide possible outcomes dependent upon what they may view as external factors".

Validity of STEBI-Form A

Evidence of validity for the STEBI-Form A is reviewed from four aspects. These are face, criterion, construct, and content validity (Gall *et al*., 2007). Face validity assures that the items "look as though they measure what is important" (Gall *et al*., 2007:193). Face validity is a causal look or subjective overview to see if the items are truly measuring what is intended to be measured. Criterion validity of an instrument is established when the developers are able to use an outside source or measurement that is related by an individual variable or criterion to measure the behaviour under investigation. Construct validity is "the extent to which a measure used in research correctly operationalizes the concepts being studied" (Gall *et al.,* 2007:477). Usually construct validity is used for a certain trait or personality that the researcher would like to measure, in this case it is self-efficacy. Content validity is explored at the instrument developmental stages because the constructs being studied must have appropriate constitutional and operational definitions in order to measure what is intended to be measured on a particular instrument. Content validity is important to ensure that all of the content that the researcher is interested in measuring clearly appears on the instrument.

For face validity, the STEBI authors piloted the instrument in the construction and validation phase of the scale by taking the revised scale, which consisted of 29 items and administered it to a sample of 331 practicing elementary teachers in Kansas and Kansas City school districts and performed item analysis on the results. "Items which did not have a high positive discrimination index were rejected" (Riggs & Enochs, 1990:629). The 25 items on the final version of the survey seem to be measuring the construct that was under investigation (Riggs & Enochs, 1990).

Criterion validity was established for this instrument by evaluating seven other self-report items. Using self-reported items of: (a) years spent teaching at the elementary level, (b) subject preferred, (c) time spent teaching Science, (d) utilisation of activity-based Science instruction, (e) acceptance of responsibility for Science teaching, (f) self-rating of effectiveness in Science teaching, and (g) an appraisal of Science teaching effectiveness by the principal, researchers calculated and assessed a Pearson Product-Moment Correlation. The researchers assessed and reported responses as Pearson's r for the seven criteria. All criteria assessed were significantly correlated with at least one scale and were in a positive direction.

Construct validity is determined by way of factor analysis by showing a correlation between the two scales incorporated, the Personal Science Teaching Efficacy Belief Scale and the Science Teaching Outcome Expectancy Scale. The authors state: "All criteria assessed within the major study were significantly correlated with at least one scale and were in a positive direction. These results provided good general support for the construct validity of the scales" (Riggs & Enochs, 1990:632). The two scales positively correlated with an r value = 0.19 at the level $p < 0.01$ (Riggs & Enochs, 1990). Lastly, expert judges edited items for clarity and rated the entire scale for accuracy to determine content validity. Items that were inconsistently classified by more than half the judges were eliminated (Riggs & Enochs, 1990). A psychometric review provided evidence to support that STEBI-Form A is a reliable and valid instrument for in-service Science teachers' self-efficacy.

The first section of the self-constructed questionnaire begins with 13 questions designed to gather data on teachers' demographic factors, such as age, gender, educational background, teaching experience, geographic location of the school, and the grades they teach. Section B involves the Science Teaching Efficacy Belief Instrument, whilst Section C gathers data on their level of preparedness and confidence to teach Physical Science. This includes the teachers' understanding of subject knowledge (theory and practical work) and assessment skills (refer Appendix E). The questions on the selected concepts were based on an extensive literature review on common problematic areas in Physical Science, and were in line with CAPS. The questionnaire also addressed the assessment skills of Science teachers. The last part focused on general problems encountered by teachers in teaching Science, and possible solutions. The study determined whether all the mentioned variables would influence the teachers' perceptions of their teaching efficacy, as measured by the Science Teachers Efficacy Belief Scale.

The next section reports on the second instrument used for collecting data, namely the semi-structured interviews.

4.2.2.2 Interviews

An interview is a data-collecting method in which an interviewer (the researcher) asks questions of an interviewee (the research participant). Thus, the interviewer collects the data from the interviewee, who provides the data (Johnson & Christensen, 2012:198). Interviews are used to collect facts, for example, information about people's place of work, age, etc., but such questions are usually no more than opening items which precede the main substance. The bulk of interview questions seek to elicit information about attitudes and opinions, perspectives and meanings. They are widely used because they are a powerful means of both obtaining information and gaining insights. They are used because they give an idea of "what makes people tick", of the personality and the motivations of the interviewee. Semi-structured interviews were used in this study.

Semi-structured interviews were conducted with a conveniently selected number of teachers. Initially, lowest scoring and highest scoring teachers on the STEBI-A were to be considered, but teachers had to be interviewed based on their availability since not everybody selected was willing to participate. According to Opie (2004), semi-structured interviews are a more flexible version of structured interview, which will allow for a depth of feeling to be ascertained by providing opportunities to probe and expand the interviewee's responses. It also allows for deviation from a pre-arranged text and to change the wording of questions or the order in which they are asked (Opie, 2004:118). Semi-structured interviews were used in order to form a detailed picture of participants' beliefs and conceptions about their Science teaching efficacy beliefs and related factors. A semi-structured interview allows the researcher to follow up particularly interesting avenues that emerge in the interview (De Vos *et al.*, 2011). In semi-structured interviews, the researcher has a list of themes and questions to be covered, although these may vary from one interview to the next (Welman *et al.,* 2005:166). An interview schedule was drawn up in this study in order to avoid the omission of important information during the interview.

To ensure that responses were captured efficiently, an audio recorder was used to record the interviews per participants' consent, and detailed notes were also taken. According to Yin (1994 in Hundley, 2006), interviews are one of the most important sources of information. They focus directly on the participants by providing them with the opportunity to express their insights and opinions first-hand. The use of interviews conveys to the respondents that the researcher values their opinions (Hundley, 2006).

Verbatim transcriptions of the recordings were done, and subsequently, themes were identified. Data collection and analysis were done continuously in order to build a coherent interpretation of the data. According to De Vos *et al*. (2011), continuous analysis gives the researcher the opportunity to check the data, as well as identify the emerging trends and the ideas that need to be followed up.

4.2.3 Data collection

4.2.3.1 Gaining access

The following procedure was followed in gaining access to the schools:

i. A letter requesting permission to conduct research in selected schools in the Free State province was sent to the Provincial Department of Education (Appendix A). It should be noted that the title was slightly amended from the initial one that reads "Assessing the self-efficacy of Science teachers in secondary schools in the Free State province", as it appears on the letter.
ii. Copies of the letter and the response from the Department were given to the schools that were selected for the study (Appendix B).
iii. Permission was requested from the principals (Appendix C).
iv. Science teachers within the selected schools were also given letters requesting their participation as respondents (Appendix D).

4.2.3.2 Questionnaire administration

The questionnaires were faxed, e-mailed and posted to the respective schools, and where accessible, they were hand delivered to the schools. The researcher guided the respondents while waiting for them to complete the questionnaires.

Bandura (2006) suggests that to encourage frank answers from the teachers, researchers have to inform them that the self-efficacy scale is identified by code number rather than name. They should also be assured that their responses will remain confidential and be used only with code numbers by the researcher. With this in mind, all the above points are emphasised in the cover letter to the teacher participants. Where possible, the researcher also explained to the teacher respondents the importance of their contribution to the research and informed them that the knowledge it provided would increase understanding and guide the development of programmes designed to assist teachers to manage their life situations.

4.2.3.2.1 Pilot study

In the words of Welman, Kruger and Mitchell (2005), the purpose of a pilot study is to detect possible flaws in the measurement procedures, to identify unclear or ambiguously formulated items, and to give an opportunity to the researcher to notice non-verbal behaviour on the part of the participants that may possibly signify discomfort or embarrassment about the content or wording of the questions (Welman *et al.*, 2005:148). Similarly, Cohen, Manion and Morrison (2007) warn that clarity of wording and simplicity of the design is of paramount importance.

The pilot study included a testing of the instrument of measurement, the questionnaire. The questionnaire, therefore, was piloted with 20 Physical Science secondary school teachers willing to give forthright comments and offer valuable criticism.

Aim of the pilot study

A pilot study was conducted to determine whether the proposed study was viable. The purpose of the pilot study was to determine how long it would take respondents to complete the questions, to check whether all questions and instructions were clear, and to enable the researcher to delete items that did not yield relevant data. Errors in the questionnaire were corrected and some of the questions were rephrased, where necessary, before the questionnaires were administered to the final sample.

The pilot sample

A pilot study of the research instrument was conducted among 20 teachers from different schools in the Lejweleputswa district of the Free State province. These teachers did not form part of the sample of the main study.

Administration of the instrument in the pilot study

The pilot study was conducted during a training session of Physical Science teachers in the Lejweleputswa district.

Influence of pilot results on the actual study

Results of the pilot study showed that the questionnaire was relevant and appropriate to the Science teachers. The overall responses rated teachers who are highly efficacious and confident that they can plan and prepare, facilitate teaching and practical work, and also conduct assessments in their classrooms.

Changes made

The feedback received from the pilot study in terms of the instructions, lack of clarity of what was actually been questioned, ambiguity of questions, terms that could not be understood, and the length of the questionnaire were reviewed. A number of questions were adjusted to remove ambiguity and misleading phrases. Most of the changes involved the paradigm shift from the NCS to CAPS. Since the respondents revealed high levels of competence on facilitation skills, the section on facilitation and all the NCS technical terms, such as learning outcomes, developmental outcomes, assessment standards, etc., used in the pilot were removed. The Physical Science content concepts and practical activities were aligned as per the CAPS guidelines in terms of the assessment weights. The initial nine-page pilot questionnaire was modified into the final seven-page questionnaire.

Adjustment to the layout and design was also essential. The seven-page self-constructed questionnaire consisted of three sections:

- Biographical data
- Subject knowledge
- Assessment skill

Each of the sections contained the following:

1. In Section A of the questionnaire teachers were asked to provide information on their name, their age, their gender, their academic and professional qualifications, the name of the school where they teach and the geographic location of the school, the grade they currently teach and their Physical Science teaching experience.
2. The next section of the questionnaire, Section B, was the Science Teaching Efficacy Belief Instrument for in-service teachers (STEBI-A) that focused on the Science teaching efficacy beliefs of teachers, with a scale measuring two constructs of personal self-efficacy (PSTE) and outcome expectancy (STOE). This instrument uses a five-point 25-item Likert-type scale (1=strongly disagree, 2=disagree, 3=not sure, 4=agree, and 5=strongly agree). STEBI-A has two scales: Personal Science Teaching Self-efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). To calculate the individual score, individual scores on each of the scales were added up, remembering to reverse score the negative ones. For instance, PSTE questions are items numbered 2+3+5+6+8+12+18+19+21+22+24 (the score for Questions 3, 6, 8 ,17, 19, 21, 22, 24 were reversed, i.e. Strongly Agree is a 1, whereas for the positive questions Strongly Agree is a 5). With this instrument, the Science self-efficacy of the Free State secondary school teachers was determined. The relationships of STEBI with biographical data and level of preparedness to teach Science was established.
3. Section C focused on the pedagogical skills involved in teaching Physical Science that dealt with content knowledge and practical skills. In the first part of Section C, teachers were asked to rate their confidence in Physical Science subject knowledge. Each of the areas was rated on a three-point scale from confident, to slightly confident, and not confident. The second part of Section C covered the practical work section, where respondents were requested to rate the extent to which practical work is conducted in their classroom, and also to rate their level of confidence in conducting the selected experiments as per CAPS requirements. The extent to which practical work is conducted was

determined according to the following three-point Likert scale: 0 = never, 1 = rarely, 2 = occasionally, and 3 = often. They were requested to rate their confidence in conducting these experiments according to a four-point Likert scale: 1 = fully confident, 2 = confident with a little guidance, 3 = I can manage but depend on advice from others, 4 = I need help to develop my knowledge and skills. In the third part of Section C, teachers were asked to rate their confidence in their teaching and assessment skills in Science to enable them to plan their lessons and to assess their learners accordingly. The extent to which the teachers utilised the outlined assessment strategies was rated on a four-point scale from 0= never, 1 = rarely, 2 = occasionally, and 3 = often.

Each section of the questionnaire ended with open-ended questions, seeking information on any other problems teachers encounter in the teaching of Science relating to content knowledge, practical skills and facilitation skills.

A number of modifications were made to the wording in the STEBI-A form. The word “elementary” in the form (Question 12) was changed to “secondary” Science since this study was aimed at teachers in the FET Phase. The word “student” was changed to “learner” since in the South African context a “student” refers to somebody in a higher institution of learning; and “educator” was changed to “teacher”.

Through the teachers’ responses to the questions in the self-constructed questionnaire that was filled in alongside the STEBI-A, a better understanding of their Science-related antecedents and experiences would be gained to identify the relationship between the dependent and independent variables. This information was used to identify suitable candidates for the interviews.

4.2.3.2.2 Actual study

The final sample of this study consisted of 190 Physical Science teachers who teach in the secondary schools across the five districts of the Free State province. These districts are Motheo, Xhariep, Thabo Mofutsanyana, Lejweleputswa and Fezile Dabi.

Administration of the instrument in the final sample

A total of 190 respondents from the five districts participated in the study. Lejweleputswa district was the first district where questionnaires were administered. Questionnaires were distributed during a training session in the Lejweleputswa district. For the Xhariep and Motheo districts, questionnaires were distributed during a workshop. The workshop was held in the Motheo district, where the researcher resides. One-hundred-and-twenty questionnaires were distributed and a total of 108 questionnaires were returned. For the Thabo Mofutsanyana and Fezile Dabi districts, questionnaires were distributed in schools.

Data collection procedures

The purpose of this study was to shed light on the teaching efficacy of Science teachers in the Free State province. Data was collected from schools by means of questionnaires and interviews.

4.2.4 Data analysis

The Statistical Package for the Social Sciences (SPSS version 20) was used to analyse the data gathered both descriptively and inferentially. In order to find the answers to the research questions, multivariate analysis of variance (MANOVA) was conducted.

4.2.4.1 Questionnaire data

Descriptive statistics

Descriptive statistics refer to what is typical and how much data variation there is and they are calculated so that one can know the essential characteristics of data sets without having to refer to each individual measure (Tanner, 2012:20). Descriptive statistics include frequencies, percentages, frequency distribution, means and standard deviation. The purpose of running descriptive statistics is (1) to provide general descriptive information of the variables included in this study, (2) to provide data distribution to satisfy assumptions of conducting inferential statistics, and (3) to examine the relationships between dependent and independent variables in this study. Eight independent variables were also included in this study: type of school, geographic location of the school, teacher's gender, teacher's age, teacher's Science teaching experience, and teacher's qualification status in Science, teacher's content knowledge, and assessment skills.

Inferential statistics: MANOVA

Inferential statistics are concerned with inferences that can be made about population indices on the basis of the corresponding indices obtained from samples drawn randomly from the populations (Welman, Kruger & Mitchell, 2005:236). The domain of inferential statistics allows anyone dealing with quantitative data to have economy in their analysis by revealing the larger group through the smaller group's characteristics (Tanner, 2012:20). Inferential statistics involved in this study are chi-square tests and multivariate analysis of variance (MANOVA). Chi-square analysis is used to make inferences when the data can be divided into different categories. MANOVA was employed in this study because it analyses any number of groups for significant differences, accommodating more than one independent variable.

MANOVA evaluates whether the population means on a set of dependent variables vary across the levels of a factor or factors. In MANOVA, the combination of the three variables distinguishes the groups, in one analysis. There is a two-way or two-factor MANOVA that has two independent variables and two or more quantitative dependent variables. A doubly multivariate or mixed MANOVA has a between-groups independent variable and a repeated measures (within groups) independent variable and two or more quantitative dependent variables. Mixed MANOVAs are one way to analyse intervention (experimental) studies that have more than one dependent variable.

If the one-way MANOVA is significant, follow-up analyses can assess whether there are differences among groups on the population means for certain dependent variables and for particular linear combinations of dependent variables. A popular follow-up approach is to conduct multiple ANOVAs, one for each dependent variable, and to control for Type I error across these multiple tests using one of the Bonferroni approaches (e.g., α / number of dependent variables). If any of these ANOVAs yield significance and the factor contains more than two levels (with two levels, a comparison of group means is conducted), additional follow-up tests are performed. These tests typically involve post hoc pairwise comparisons among levels of the factor, although they may involve more complex comparisons. The procedure described above was followed in this study.

Assumptions underlying the One-Way MANOVA (Green & Saalkind, 2003: Leech, Barret & Morgan, 2005):

Assumption 1 (multivariate normality): The dependent variables are multivariately normally distributed for each population, with the different populations being defined by the levels of the factor.

The dependent variable should be normally distributed within groups. Overall, the *F* test is robust to non-normality, if the non-normality is caused by skewness rather than by outliers. Tests for outliers should be run before performing a MANOVA, and outliers should be transformed or removed.

If the dependent variables are multivariately normally distributed, each variable is normally distributed ignoring the other variables and each variable is normally distributed at every combination of values of the other variables. It is difficult to imagine that this assumption could be met. To the extent that population distributions are not multivariately normal and sample sizes are small, the *p* values may be invalid. In addition, the power of the MANOVA test may be reduced considerably if the population distributions are not multivariately normal and, more specifically, thick-tailed or heavily skewed. The Shapiro-Wilk test can be used to test univariate normality for each dependent variable, which in turn gives insight into the multivariate normality assumption (as univariate normality is a necessary condition of multivariate normality).

Assumption 2 (Homogeneity of Variances and Covariances)**:** The population variance and covariances among the dependent variables are the same across all levels of the factor. That is, variances for each dependent variable are approximately equal in all groups, plus covariances between pairs of dependent variables are approximately equal for all groups. This is commonly referred to as the assumption of homogeneity of variance-covariances matrices.

In the event that the sample sizes are disparate and the variances and covariances are unequal, MANOVA yields invalid results. SPSS allows researchers to test the assumption of homogeneity of the variance-covariance matrices with *Box's M* statistics. The *F* test from *Box's M* statistics should be interpreted cautiously in that a significant result may be due to violation of the multivariate normality assumption for the *Box's M* test, and a non-significant result may be due to a lack of power. It is advised to use $p < .001$ as the criterion for testing significance.

Assumption 3 (assumption of independence)**:** The participants are randomly sampled, and the score on a variable for any one participant is independent from the scores of this variable for all other participants. That is, subjects' scores on the dependent measures should not be influenced by or related to scores of other subjects in the condition or level.

MANOVA should not be conducted if the independence assumption is violated. MANOVA is robust to violations of multivariate normality and to violations of homogeneity of variance-covariance matrices if groups are of nearly equal size (*N* of the largest group is no more than 1.5 times the *N* of the smallest group).

SPSS reports a number of statistics to evaluate the MANOVA hypothesis, labeled *Wilks' Lambda*, *Pillai's Trace*, *Hotelling's Trace* (*T*), and *Roy's Largest Root*. Each statistic evaluates a multivariate hypothesis that the population means on the multiple dependent variables are equal across groups. For the purpose of this study, *Wilks' Lambda, λ*, was used.

In order to test the differences between scores on each of the sub-scales by independent variables, a two-way MANOVA was conducted. Furthermore, where significant results were found, effect sizes were calculated in order to provide an indication of the practical significance of the results. Effect sizes were determined using partial eta squared, η^2, which estimates the percentage of variance explained by the effect.

Assumption 4 (Outliers): Like ANOVA, MANOVA is extremely sensitive to outliers. Outliers may produce either a Type I or Type II error and give no indication as to which type of error is occurring in the analysis. There are several programs available to test for univariate and multivariate outliers.

Assumption 5 (Multicollinearity and Singularity): When there is high correlation between dependent variables, one dependent variable becomes a near-linear combination of the other dependent variables. Under such circumstances, it would become statistically redundant and suspect to include both combinations.

Assumption 6 (Homogeneity of Variances): Homogeneity of variances assumes that the dependent variables exhibit equal levels of variance across the range of predictor variables.

4.2.4.2 Interview data

The individual respondents were interviewed by the researcher in a semi-structured interview that lasted between 20 and 30 minutes. Some of the interviews were recorded with the permission of the teachers being interviewed. In cases where the respondents did not give the researcher the permission to record them, they were then requested to respond to the questions in writing. It was re-affirmed to the respondents that their names and the names of their schools would remain confidential. After the interviews, the recordings were transcribed. All the interview transcripts were read by the researcher and coded. Five category headings were generated from the data and under these all the data were accounted for. Different themes emerged from these categories. These themes mostly address the factors that influence the teaching efficacy of secondary school teachers in the Free State province.

4.2.5 Ethical considerations

Ethics are principles and guidelines that help us uphold the things we value (Johnson & Christensen, 2012). Ethical aspects, such as access and acceptance, informed consent, privacy and confidentiality, and misinterpretation and misrepresenting of data were taken into consideration as this study dealt with schools, focusing directly on teachers. Opie (2004) emphasises that research comes into the lives of people who are the focus in various ways, taking their time, involving them in activities they would not otherwise have been involved in, providing researchers with privileged knowledge about them, and therefore potentially power over them. A letter seeking permission to conduct the study in the secondary schools of the Free State province was written to the Free State Department of Education (see Appendix A).

The first ethical issue of access and acceptance was addressed, as Cohen, Manion and Morrison (2007:55) state, that "the relevance of the principle of informed consent becomes apparent at the initial stage of a research project - that of access to the institution or organization where the research is to be conducted, and acceptance by those whose permission one needs before embarking on the task". Furthermore, "access to personal records, both as a primary or secondary source of data, must be approached both ethically and legally" (Anderson & Arsenault, 1998:21). In this research, respondents' demographic details such as age, gender, educational background, teaching experience, geographic location of the school, and the grades that they teach were investigated. Their level of preparedness and confidence to teach Physical Science was also investigated. This included the teachers' understanding of subject knowledge (theory and practical work) and assessment. Therefore, permission was needed from the Free State Department of Education, the schools' principals (see Appendix C) and the teachers (see Appendix D) concerned with this research. All the stakeholders were given information about the aims, nature and procedures of this research. The researcher hoped that the information would assist in obtaining access to the respondents and gaining acceptance for the research. Through this access and acceptance, the questionnaires could be administered, and at a later stage, the semi-structured interviews could be conducted. Hence, the researcher realised that "achieving goodwill and co-operation is especially important where the proposed research extends over a period of time" (Cohen *et al.*, 2007:55), since this research was not going to be a once-off activity.

The informed consent offered information to the participants on "the nature and the purpose of the research, the risks, and benefits" (Anderson & Arsenault, 1998:18). According to Anderson and Arsenault (1998), informed consent involves the purpose of the research, risks and discomfort, benefits, participant's rights and statements. Informed consent has to "ensure the individual's mental capacity, disclose sufficient information, provide sufficient time and privacy, provide the safeguard, ensure the individual's awareness" (Antle & Regehr, 2003:137).

This research involved semi-structured interviews, which included participants' subjective opinions, details on their personal experiences, and their life stories. The ethics requirements were met through providing the list of interview questions (see Appendix F) to the participants. Information regarding the time involved and the process of interviews was also given.

The privacy of the participants and their confidentially was addressed. Some of the stories told related to the teachers' personal experiences, such as their misunderstandings, incompetence, etc. Therefore, their individual privacy had to be respected. "It is the duty of researcher to protect the identity of individuals, there is a distinction between one's public role and private life" (Anderson & Arsenault, 1998:21). "Having empathy can be beneficial in research… if [the confidential information is] not handled correctly, can cause discomfort and even a job loss". Keeping the participants and their schools anonymous, using the promise of confidentiality (Anderson & Arsenault, 1998; Cohen Manion & Morrison, 2000), was vitally important.

Moreover, adequate interpretation and representation of data had to be addressed. The researcher's subjectivity can influence the research process, leading to the possibility of misinterpretation and misrepresentation of data. With the open-ended questions in the questionnaires and the interviews, the responses were handled with the utmost caution so that the narrative was not wrongly interpreted. The respondents were asked to comment on relevant parts of the report which represent their perceptions, behaviour and cultural context (Cohen *et al*., 2000). Therefore, the researcher needed to "be compassionate to individuals and avoid language that discriminates on basis of gender, sexual orientation, race or ethnic group" (Creswell, 2005:11). The appropriate language helped to avoid any uncomfortable situations.

4.3 Conclusion

This chapter focused on the research design and the methodology to be utilised to accomplish the objectives of the study. Firstly, the structure of the research methods employed in this study was discussed, and the considerations that were taken into account in adopting the research methodology were presented. Secondly, detailed descriptions of the population of the study, the data collection instrument, and the main survey procedures were provided. Finally, the ethical considerations were described. The presentation and analysis of data collected through these methods will be presented in the next two chapters.

CHAPTER 5

QUANTITATIVE DATA PRESENTATION AND ANALYSIS

5.1 Introduction

This chapter presents data that have been gathered through the use of the self-constructed questionnaire, including the STEBI-A. The data are broken down into demographics, analysis of responses to the STEBI-A, and the analysis of responses to the self-constructed questionnaire.

5.2 Teacher demographic details

This section presents the demographic data emanating from Section A of the self-constructed questionnaire (Appendix F). The aim of the items in Section A of the questionnaire was to gather general details about demographic factors such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels that the respondents taught. The demographic data provide information about the Physical Science teachers and the secondary schools in which they teach. Development of the questionnaire allowed understanding of the respondents' background and investigating the relationship between Physical Science teachers' self-efficacy in teaching Science and related variables.

The tables that follow below summarise demographic data of the respondents in all the districts who participated in the study.

5.2.1 Type of school

Table 5.1 presents data on the types of schools of the five districts of the Free State province which participated in the study. The types of schools are classified as independent, public and farm schools.

Table 5.1: Respondents by school type (N=190)

Type of school	Frequency	%
Independent	6	3.2
Public	183	96.3
Farm	1	.5
Total	190	100.0

It can be seen from the data in Table 5.1 that the majority of the schools that participated in the study across the five districts are public schools (96.3%), followed by 3.2% independent schools, and 0.5% farm schools. It is worth noting that all the schools from the Xhariep and Thabo Mofutsanyana districts that participated in this study are public schools. Four of the six independent schools are in the Motheo district and the only farm school is in the Lejweleputswa district.

The next section looks into the geographical location of the schools.

5.2.2 Geographical location of schools

Table 5.2 presents data on the geographical location of the schools. The location can be regarded as urban, semi-urban or rural.

Table 5.2 Respondents by geographic location of school (N=190)

	Frequency	%
Urban (town)	41	21.6
Semi-urban (township)	124	65.3
Rural (farm)	16	8.4
Total	181	95.3
Missing System	9	4.7
Total	190	100.0

The geographic location of the schools, according to this study, can either be in urban, semi-urban or in rural areas. From Table 5.2, it is apparent that the majority of the teachers taught in semi-urban schools (65.3%); these are the schools that are mostly found in townships. A township usually refers to the underdeveloped semi-urban living areas that, from the late 19th century until the end of apartheid, were reserved for non-whites and were built on the periphery of towns and cities (www.wikipedia.org/wiki). Urban schools, which are former model C schools located in towns, scored second with 21.6 %, whereas thirdly (8.4%) are schools situated in the rural areas.

The next section looks into the gender of the respondents.

5.2.3 Gender of respondents

Table 5.3 provides the distribution of gender of the Physical Science teachers of the Free State province who participated in the study.

Table 5.3 Respondents by gender (N= 190)

Gender	Frequency	%
Male	104	54.7
Female	83	43.7
Total	187	98.4
Missing System	3	1.6
Total	190	100.0

The distribution of gender in the study population for the five districts was also determined. The majority of the Physical Science teachers who responded to this survey were male (54.7%), and 43.7% were female. Out of 190 respondents, only three did not respond to this question.

The next section examines the age of the respondents.

5.2.4 Age of respondents

The age distribution of the respondents is presented in Table 5.4.

Table 5.4: Respondents by age in years (N=190)

Age in years	Frequency	%
<24	12	6.3
25-30	31	16.3
31-35	36	18.9
36-40	47	24.7
41-45	27	14.2
46-50	17	8.9
51-55	13	6.8
56+	6	3.2
Total	189	99.5
Missing System	1	.5
Total	190	100.0

The age of the teacher is one variable that is under investigation on how it relates to teaching efficacy. Most of the Physical Science teachers of the Free State province are between 25 and 40 years. There is a relationship between the youngest and oldest teachers, where the percentage is the lowest at almost 6%.

The next section looks into the academic qualifications of the respondents.

5.2.5 Educational qualifications of respondents

The educational qualification obtained is another factor that defines the educational background of the respondents involved in the study. For the purpose of this study, academic qualifications refer to the respondents' main field of specialisation in Science and in non-Science fields; and professional qualifications refer to the respondents' qualification in education.

Table 5.5: Respondents by specific professional and academic qualification (N= 190)

Academic Qualification	Frequency (%)	Professional Qualification	Frequency (%)
B.Sc	53 (27.9%)	B.Sc (Ed)	23 (12.1%)
B. degree other than Science	27 (14.2%)	B.Ed (FET)	34 (17.9%)
Advanced studies	19 (10%)	HED,UED,HOD	57 (30.0%)
		Certificates in education	28 (14.7%)
Total	99 (52.1%)	Total	142 (74.7%)

Table 5.5 shows teachers' specific academic qualifications and indicates that 72 (37.9%) of the teachers have qualifications in pure Sciences, and 27 (14.2%) teachers have Bachelor's degrees in any other field other than Science. It is worth noting that the 19 (10%) teachers with postgraduate degrees in Science might either have their undergraduate degrees in Science or in Education. In this study, 91 (47.9%) respondents did not respond to this question; it might be due to the fact that most of them studied towards their professional qualifications by initially pursuing the field of Education.

Table 5.5 further reports on the respondents' specific professional qualifications; it shows that 142 (74.7%) of the respondents attended a course in Science teaching methods and thus are qualified to teach Science. Forty-eight (25.3%) teachers did not respond to this question, probably because their main field of study is not in Education. A total of 104 (60%) teachers have specific professional qualifications to teach Science, i.e. B.Sc (Ed), B.Ed (FET) or diplomas in education. The study found that 27 (14.2%) of the teachers have a Postgraduate Certificate in Education (PGCE). This 14.2% might be a portion of the 27 teachers whose undergraduate degrees were not in Education. PGCE is a one-year full-time certificate intended to equip candidates with a qualification in Education.

5.2.6 Physical Science teaching experience of respondents

The respondents were requested to give their Physical Science teaching experience. It ranges from less than one year to 30 years and more, as presented in Table 5.6.

Table 5.6 Respondents by Physical Science teaching experience in years (N=190)

Years of teaching Physical Science	Frequency	%
less than 1 year	13	6.8
1 to 5 years	61	32.1
6 to 10 years	40	21.1
11 to 15 years	36	18.9
16 to 20 years	19	10.0
21 to 25 years	11	5.8
26 to 30 years	4	2.1
31 +	5	2.6
Total	189	99.5
Missing System	1	0.5
Total	190	100.0

The years of Physical Science teaching experience can have an impact on how confident the teachers perceive themselves to do the job. The largest population category was 32.1%, whereby 61 respondents had Physical Science teaching experience of one to five years; the lowest percentages of 2.1 and 2.6 were in the 26 to 30 years, and 31 years and more categories, respectively. Teachers with the most experience - of 31 years and more - included five teachers (2.6%).

The next section looks into the major Science subjects taken by respondents during their formal training as teachers.

5.2.7 Respondents' major Science subjects taken during pre-service training

Information on the major Science subjects taken by respondents during their tertiary training was requested in order to determine the Science exposure the respondents had during their formal training as teachers.

Table 5.7: Chemistry and Physics as major subjects during training (N=190)

Chemistry	Frequency	Physics	Frequency
Yes	142 (74.7%)	Yes	146 (76.8%)
No	43 (22.6%)	No	39 (20.5%)
Total	185 (97.4%)	Total	185 (97.4%)
Missing System	5 (2.6%)	Missing System	5 (2.6%)
Total	190 (100.0%)	Total	190 (100%)

It can be seen from Table 5.7 above that 142 (74.7%) teachers majored in Chemistry and 76.8% majored in Physics. Respondents seem to be well-prepared in terms of Chemistry and Physics content preparedness. Three-quarters of the participants took both components of Physical Science as major subjects during their studies.

5.2.8 Sections of Physical Science taught by respondents

This study focused on Grade 10 to Grade 12 Physical Science teachers. They either teach Physics or Chemistry, or both as Physical Science. The sections of Physical Science that they teach were explored here.

Table 5.8: Physical Science sections respondents currently teach (N=190)

	Frequency	%
Physics	5	2.6
Chemistry	14	7.4
Chemistry and Physics	167	87.9
Total	186	97.9
Missing System	4	2.1
Total	190	100.0

It is worth noting from Table 5.8 that 14 (7.4%) of the teachers teach Chemistry only, and 167 (87.9%) teach both Chemistry and Physics; that gives a total of 172 (95.5%) of the teachers teaching Chemistry. This contradicts the results in Table 5.7 above that indicated that 74.4% of the teachers majored in Chemistry during their training. This shows that 21.1% of the teachers do not qualify to teach Chemistry.

The next section looks into the grade levels taught by the respondents.

5.2.9 Grade levels taught by respondents

A secondary school in this study refers to a school that offers classes from Grade 10 to Grade 12. Table 5.9 presents data on the grades that the respondents are currently teaching. They can teach Grade 10, Grade 11, Grade 12, or a combination of any of the three.

Table 5.9: Grades taught by respondents (N = 190)

Do you currently teach?	Grade 10	Grade 11	Grade 12
Yes	136 (71.6 %)	118 (62.1 %)	109 (57.4 %)
No	46 (24.2 %)	64 (33.7 %)	73 (38.4 %)
Total	182 (95.8 %)	182 (95.8 %)	182 (95.8 %)
Missing System	8 (4.2 %)	8 (4.2 %)	8 (4.2 %)
Total	190 (100.0 %)	190 (100 %)	190 (100 %)

Table 5.9 reveals that most of the teachers (71.6%) teach Grade 10, followed by 62.1% teaching Grade 11, and 57.4% Grade 12. It is worth noting that there is an overlap in the grades that the respondents teach.

SYNOPSIS OF BIOGRAPHICAL DATA

A synopsis of the biographical data of respondents is as follows:

- Fifty-four percent of the respondents are male and 43.7% are female.
- 22.6 % of the respondents are less than 30 years old, 43.6% are between 31 and 40 years, 23.1% are between 41 and 50 years and only 10% are above 50 years.
- 60% of the participants have teaching experience of less than 10 years.

- In terms of professional qualifications, 30% of the respondents are in possession of a National Diploma in Education, 17.9% B.Ed (FET), 14.2% PGCE, 12.1% B.Sc (Ed) and 0.5% ACE. In regards to academic qualifications, 27.9% of the respondents are in possession of a B.Sc, 14.2% have a Bachelor's degree other than Science, 7.4% have a B.Sc (honours) and 2.6% have a MSc.
- A total of 96% of the schools that participated in this study are public schools, 3.2% are independent schools, and 0.5% farm schools.
- The majority of the schools, 65.3%, are geographically located in semi-urban areas (townships), 21.6 % are in urban areas, and 8.4% are in rural areas.
- The majority of the respondents are from the Motheo district (48.4%), followed by Lejweleputswa (23.7%), Thabo Mofutsanyana (10%), Fezile Dabi (9.5%), and Xhariep (8.4%). Most of the schools that participated in this study are from the poorest quintiles, with quintile 1 at 23.7%, quintile 2 at 27.4%, quintile 3 at 21.1%, while the least poor quintiles 4 and 5 are at 8.4% and 11.1%, respectively.

5.3 TEACHERS' SELF-EFFICACY BELIEFS ABOUT TEACHING PHYSICAL SCIENCE (ANALYSIS OF STEBI-A DATA)

This section presents data emanating from Section B of the questionnaire on the Science Teaching Efficacy Belief Instrument (STEBI-A). STEBI-A, as described in the chapter on research methodology, is a standardised instrument used to measure the self-efficacy beliefs of teachers in teaching Physical Science. Teachers' self-efficacy beliefs were measured on a five-point Likert type scale as follows: Strongly Agree (SA) = 5; Agree (A) = 4; Uncertain (U) = 3; Disagree (D) = 2; and Strongly Disagree (SD) = 1.

The responses from the Physical Science teachers to each item in the STEBI-A appear in Table 5.10. The responses are presented by districts per sub-scales. For each district, the responses are given as percentages, means and standard deviations. The results of the two sub-scales; the Personal Science Teaching Efficacy sub-scale (PSTE) and the Science Teaching Outcome Expectancy sub-scale (STOE) are given in Tables 5.11 and 5.12 respectively.

5.3.1 Science Teaching Efficacy Belief Instrument (STEBI-A) full scale

Table 5.10 presents data on the scores on the full scale of the STEBI-A for the Physical Science teachers of the secondary schools of the Free State province.

Table 5.10: Full scale STEBI-A of secondary school Science teachers in Free State (N=190)

Item	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Mean & (Standard Deviation)
	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	
1	10 (5.3%)	23 (12.1%)	12 (6.3%)	81 (42.6%)	64 (33.7%)	3.87 (1.16)
2	0 (0%)	0 (0%)	9 (4.7%)	118 (62.1%)	63 (33.2%)	4.28 (0.55)
3*	53 (27.9%)	67 (35.3%)	31 (16.3%)	30 (15.8%)	9 (4.7%)	3.66 (1.18)
4	0 (0%)	18 (9.5%)	23 (12.1%)	84 (44.2%)	65 (34.2%)	4.03 (0.92)
5	0 (0%)	6 (3.2%)	29 (15.4%)	104 (55.3%)	49 (26.1%)	4.04 (0.74)
6*	36 (18.9%)	94 (49.5%)	28 (14.7%)	28 (14.7%)	4 (2.1%)	3.68 (1.01)
7	39 (20.5%)	64 (33.7%)	33 (17.4%)	37 (19.5%)	17 (8.9%)	2.65 (1.26)
8	82 (43.2%)	77 (40.5%)	21(11.1%)	7 (3.7%)	3 (1.6%)	4.19 (0.89)
9	5 (2.6%)	24 (12.6%)	29 (15.3%)	86 (45.3%)	46 (24.2%)	3.76 (1.04)
10*	8 (4.2%)	18 (9.5%)	18 (9.5%)	77 (40.5%)	69 (36.3%)	2.03 (1.09)
11	5 (2.6%)	23 (12.1%)	24 (12.6%)	84 (44.2%)	54 (28.4%)	3.84 (1.05)
12	2 (1.1%)	4 (2.1%)	17 (8.9%)	80 (42.1%)	87 (45.8%)	4.29 (0.80)
13*	21 (11.1%)	47 (24.7%)	25 (13.2%)	73 (38.4%)	24 (12.6%)	2.79 (1.24)
14	6 (3.2%)	41 (21.6%)	29 (15.3%)	84 (44.2%)	30 (15.8%)	3.48 (1.09)
15	5 (2.6%)	31 (16.3%)	24 (12.6%)	98 (51.6%)	32 (16.8%)	3.64 (1.03)
16*	5 (2.6%)	21 (11.1%)	36 (18.9%)	97 (51.1%)	31 (16.3%)	3.67 (0.96)
17	61 (32.1%)	94 (49.5%)	19 (10.0%)	15 (7.9%)	1 (0.5%)	4.05 (0.88)
18*	3 (1.6%)	10 (5.3%)	11 (5.8%)	111 (58.4%)	55 (28.9%)	4.09 (0.82)
19*	78 (41.1%)	68 (35.8%)	25 (13.2%)	14 (7.4%)	5 (2.6%)	3.83 (1.22)
20*	38 (20.0%)	45 (23.7%)	23 (12.1%)	56 (29.5%)	28 (14.7%)	3.07 (1.38)
21	78 (41.1%)	78 (41.1%)	14 (7.4%)	10 (5.3%)	10 (5.3%)	4.07 (1.08)
22*	71 (37.4%)	84 (44.2%)	18 (9.5%)	14 (7.4%)	3 (1.6%)	4.08 (0.95)
23	3 (1.6%)	1 (0.5%)	6 (3.2%)	63 (33.2%)	117(61.6%)	4.53 (0.73)
24	64 (33.7%)	86 (45.3%)	26 (13.7%)	11 (5.8%)	3 (1.6%)	4.04 (0.92)
25	35 (18.4%)	47 (24.7%)	27 (14.2%)	53 (27.9%)	28 (14.7%)	3.03 (1.36)

The respondents' scores on the STEBI-A scores were analysed by descriptive statistics. Negatively written statements were reversed at the beginning of the analysis to ensure consistency between the positively and negatively worded items. Due to the reverse score, the higher the mean scores on negatively worded items reflects positive teaching efficacy.

The in-service secondary school teachers' scores of the STEBI-A indicated that they had a highly positive sense of efficacy beliefs in teaching Physical Science (M=92.67). A total of 76.3% of the teachers indicated that they continually found better ways to teach Science; 81.4% stated that they knew the necessary steps to teach Science concepts effectively, whereas 83.7% agreed that the inadequacy of learners' Science background could be overcome by good teaching.

Less than one-fourth of the respondents (13.7%) believed that the teacher was to be blamed for the low Science achievement of their learners, whereas 60% agreed that the teacher is generally responsible for the achievement of learners in Science.

More than half of the respondents (54.2%) disagree that if learners are underachieving in Science, it is most likely due to ineffective Science teaching, while 78.4% agree that when the Science grades of learners improve, it is often due to their teacher having found a more effective teaching approach, and 67.4% agree that if parents comment that their child is showing more interest in Science at school, it is probably due to the performance of the child's teacher.

The following tables (5.11 and 5.12) present data on the PSTE and STOE of the five districts.

5.3.2 Personal Science Teaching Efficacy (PSTE) sub-scale

The PSTE sub-scale of the STEBI-A has 13 items that give a description on the respondents' self-belief in their confidence in Physical Science as described in Section 4.2.2.1. Table 5.11 presents data on the average mean per item of the 13 items of the PSTE sub-scale and their standard deviations. For the PSTE sub-scale, the possible minimum score is 13 and the highest possible score is 65 because of its 13 items with the five-category response scale (13 x 5 = 65). Data is given in the table below.

Table 5.11: Personal Science Teaching Efficacy sub-scale per district (N=190)

Item	Xhariep		Motheo		Thabo Mofutsanyana		Fezile Dabi		Lejweleputswa	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	4.13	0.48	4.33	0.55	4.32	0.46	4.22	0.42	4.27	0.61
3*	3.52	1.10	3.55	1.22	4.00	0.92	3.56	1.01	3.89	1.19
5	3.81	0.95	4.11	0.75	4.11	0.64	3.94	0.70	4.00	0.63
6*	3.31	0.85	3.59	1.14	3.68	1.03	3.56	0.96	3.93	0.68
8*	4.1	1.87	4.30	0.88	4.26	0.64	4.11	0.57	4.02	1.04
12	3.56	0.49	4.39	0.74	4.58	0.59	4.12	0.89	3.93	0.90
17*	3.49	0.53	3.97	0.95	4.37	0.58	3.83	0.89	4.11	0.89
18	4.31	0.77	4.09	0.71	4.32	0.73	3.78	0.78	4.02	1.02
19*	4.38	0.86	4.08	0.99	4.32	0.92	3.61	1.21	3.98	1.04
21*	3.81	0.63	4.11	1.09	4.16	0.99	3.94	1.13	3.98	1.18
22*	3.19	0.81	4.19	0.89	4.32	0.73	4.06	1.08	3.87	1.07
23	4.19	1.07	4.62	0.64	4.53	0.68	4.56	0.49	4.44	0.80
24*	4.01	1.09	4.11	0.90	4.00	0.79	3.83	0.83	4.02	0.95
Total	49.8		53.40		54.95		51.17		52.47	
Overall mean	3.83		4.11		4.23		3.94		4.04	

*items reverse scored

Table 5.11 presented data per item on the PSTE sub-scale of the STEBI-A scale. Teachers in the Free State province believe highly in their personal capabilities that they can teach Physical Science effectively, as revealed by the high PSTE scores above.

The highest scoring district is Thabo Mofutsanyana, followed by Motheo, Lejweleputswa, Fezile Dabi, and lastly, Xhariep.

5.3.3 Science Teaching Outcome Expectancy (STOE) sub-scale

The second sub-scale of the STEBI-A, the STOE, has 12 items that give a description of the respondents' belief in their capability to influence learners' outcomes (cf. Section 4.2.2.1). For the STOE sub-scale, the possible minimum score is 1 and the possible maximum score is 60 because of its 12 items with a five-category rating scale (12 x 5 = 60). A comparison of the items of the STOE of the five districts is provided in the next table:

Table 5.12: Science Teaching Outcome Expectancy sub-scale per district (N=190)

Item	Xhariep		Motheo		Thabo Mofutsanyana		Fezile Dabi		Lejweleputswa	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	4.13	0.99	3.82	1.21	4.26	0.96	4.22	0.92	3.60	1.18
4	4.07	0.70	4.07	0.95	4.21	0.89	3.94	0.97	3.96	0.87
7	3.19	1.38	2.59	1.29	2.89	1.21	2.44	1.21	2.56	1.12
9	3.88	1.11	3.76	1.07	3.89	0.85	3.44	0.89	3.80	1.05
10*	4.06	1.03	1.96	1.07	1.79	0.76	2.06	1.18	2.31	1.18
11	4.38	0.86	3.91	1.04	4.11	0.79	3.56	1.17	3.49	1.05
13*	3.06	1.08	2.65	1.21	2.89	1.45	2.78	1.18	2.98	1.24
14	3.50	1.11	3.55	1.00	3.63	0.98	3.06	1.35	3.42	1.13
15	3.50	1.00	3.67	1.01	3.84	0.99	3.61	1.06	2.98	1.04
16	4.00	0.61	3.65	1.00	3.95	0.94	3.61	0.83	3.42	0.98
20	2.94	1.34	3.04	1.39	3.00	1.26	3.22	1.55	3.56	1.35
25	2.81	1.33	2.96	1.37	3.53	1.46	2.50	1.01	3.51	1.30
Total	41.63		39.61		42.00		38.44		39.38	
Overall mean	3.47		3.30		3.50		3.20		3.28	

*items reverse scored

Table 5.11 presents data on the STOE sub-scale which represents teachers' belief in their ability to influence learners' learning positively to bring about desired results. As with the PSTE sub-scale, Thabo Mofutsanyana district shows the highest score, followed by Xhariep, Motheo, Lejweleputswa, and Fezile Dabi.

The following section is organised according to the research questions of the study.

5.4 Relating the STEBI-A to the general teaching efficacy

5.4.1 The general teaching efficacy level of Science teachers in secondary schools in the Free State province

The average PSTE and STOE scores for each district was determined, as shown in Table 5.13 below. A relationship was then determined between the two sub-scales of the STEBI-A.

Table 5.13: PSTE and STOE scores per district (N=190)

District	Mean PSTE	Mean STOE	Mean difference
Motheo	53.40	39.61	13.79
Xhariep	49.81	41.63	8.18
Thabo Mofutsanyana	54.95	42.00	12.95
Fezile Dabi	51.17	38.44	12.73
Lejweleputswa	52.47	39.38	13.09

Table 5.13 gives the PSTE and STOE sub-scales scores for the five districts. According to this table, Thabo Mofutsanyana is the leading district with the highest total STEBI-A, as well as in the two sub-scales' scores. The average PSTE score for all the five districts is 52.36 and the STOE is 40.21; together the two sub-scales give a total STEBI score of 92.57 for the five districts of the province. These scores confirm that the general teaching efficacy of the Physical Science teachers of the Free State province is high (74.1%). Figure 5.1 shows that the PSTE is higher than the STOE for all the districts.

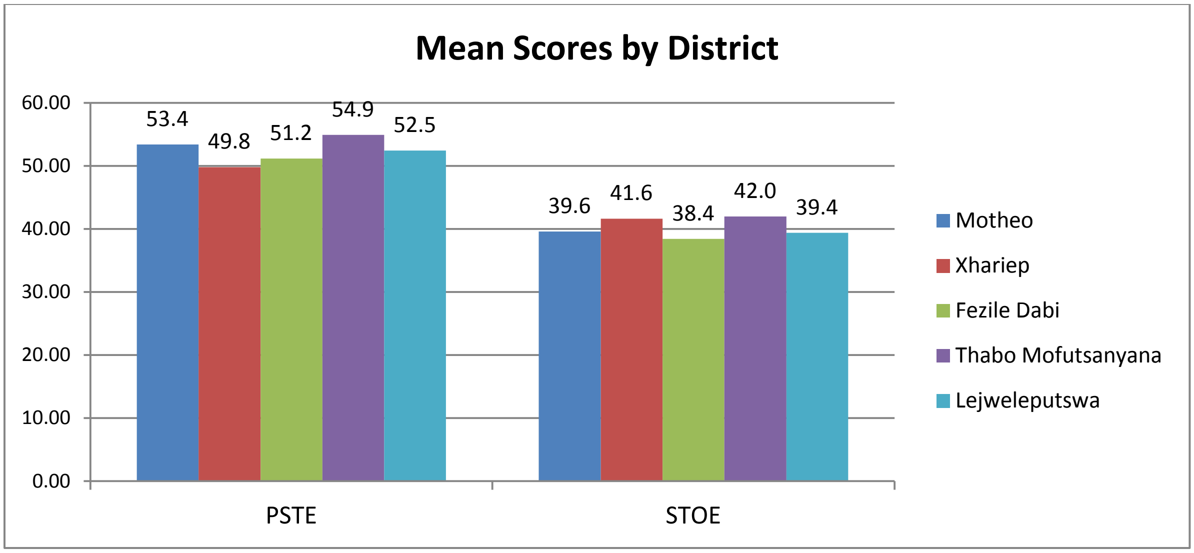


Figure 5.1: Mean PSTE and STOE by district

The next section focuses on the general teaching efficacy level of Science teachers of the Free State province as a whole; the descriptive statistics of PSTE is given first, followed by the STOE. Tables 5.14 and 5.15 present data on the descriptive statistics of the PSTE and STOE, respectively.

Table 5.14(a): Descriptive statistics of the PSTE sub-scale

			Statistic	Std. Error
The Personal Science Teaching Efficacy sub-scale (PSTE) total	Mean		52.8211	.41390
	95% Confidence Interval for Mean	Lower Bound	52.0046	
		Upper Bound	53.6375	
	5% Trimmed Mean		52.8977	
	Median		53.0000	
	Variance		32.550	
	Std. Deviation		5.70524	
	Minimum		37.00	
	Maximum		65.00	
	Range		28.00	
	Interquartile Range		8.00	
	Skewness		-.100	.176
	Kurtosis		-.426	.351

The PSTE mean score of the Free State province is 52.82, showing that teachers have 81.26% confidence in their teaching abilities.

Table 5.14(b): Tests of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
PSTE sub-scale total	.053	190	.200	.989	190	.164

The Shapiro-Wilk statistic shows normal distribution of data.

Table 5.14(c): Reliability analysis

Reliability Statistics

Cronbach's Alpha	N of Items
.716	13

Internal consistency reliability is concerned with the homogeneity of the items within a scale. A scale is internally consistent to the extent that its items are highly inter-correlated (DeVellis, 2012). From Table 5.13 (c), it can be seen that the Cronbach's alpha shows that the internal consistency of the scale is 0.716, which is an adequate reliability. This is an acceptable alpha value, even though values higher than 0.8 are desirable.

Table 5.14(d): Item-total statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item -Total Correlation	Cronbach's Alpha if Item Deleted
I am continually finding better ways to teach Physical Science	48.545	31.047	.222	.712
Even when I try very hard, I don't teach Science as well as I do most subjects	49.159	26.379	.415	.688
I know the steps necessary to teach Science concepts effectively	48.794	29.409	.343	.699
I am not very effective in monitoring Science experiments	49.148	27.903	.353	.697
I do not teach Science effectively	48.640	29.061	.297	.704
I understand Science concepts well enough to be effective in teaching secondary Science	48.534	29.357	.310	.702
I find it difficult to explain to learners why Science experiments work	48.788	27.381	.489	.680
I am typically able to answer learners' Science questions	48.741	28.895	.354	.697
I wonder if I have the necessary skills to teach Science	49.005	26.665	.360	.698
Given a choice, I would not invite the principal to evaluate my Science teaching	48.762	28.831	.233	.715
When a learner has difficulty understanding a Science concept, I am usually at a loss as to how to help the learner understand it better	48.746	28.573	.317	.702
When teaching Science, I usually welcome learners' questions	48.307	29.384	.350	.699
I don't know what to do to attract learners to Science	48.799	27.970	.398	.691

The next section focuses on the descriptive statistics of the STOE sub-scale.

Table 5.15(a): Descriptive statistics of the STOE sub-scale

Descriptives

			Statistic	Std. Error
The Science Teaching Outcome Expectancy sub-scale total	Mean		39.8526	.45572
	95% Confidence Interval for Mean	Lower Bound	38.9537	
		Upper Bound	40.7516	
	5% Trimmed Mean		39.9503	
	Median		40.0000	
	Variance		39.460	
	Std. Deviation		6.28169	
	Minimum		18.00	
	Maximum		55.00	
	Range		37.00	
	Interquartile Range		7.25	
	Skewness		-.243	.176
	Kurtosis		.411	.351

The STOE mean score of the secondary schools' Science teachers of the Free State province is 39.85, which shows 66.42% efficacy of the teachers' belief that learners' learning can be positively impacted by their effective teaching.

Table 5.15(b):Tests of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
The Science Teaching Outcome Expectancy sub-scale total	.071	190	.022	.988	190	.124

The Shapiro-Wilk statistic shows normal distribution of data.

Table 5.15(c): Reliability analysis

Reliability Statistics

Cronbach's Alpha	N of Items
.657	12

From the table above, it can be seen that the Cronbach's alpha shows that the internal consistency of the scale is adequate at 0.657, even though a bit lower than the PSTE sub-scale.

Table 5.15 (d): Item-total statistics

Item -Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
When a learner does better than usual in Physical Science, it is often because the teacher exerted a little extra effort	35.979	34.412	.271	.642
When the Science grades of learners improve, it is most often due to their teacher having found a more effective teaching approach	35.821	34.645	.367	.629
If learners are underachieving in Science, it is most likely due to ineffective Science teaching	37.205	33.328	.311	.635
The inadequacy of a learner's Science background can be overcome by good teaching	36.095	32.933	.456	.612
The low achievement of some learners in Science cannot generally be blamed on their teachers	37.821	36.772	.111	.667
When a low achieving learner progresses in Science, it is usually due to extra attention given by the teacher	36.016	34.799	.286	.639
Increased effort in Science teaching produces little change in some learners' Science achievement	37.063	36.038	.126	.668
The teacher is generally responsible for the achievement of learners in Science	36.374	32.987	.421	.617
Learners' achievement in Science is directly related to their teacher's effectiveness in Science teaching	36.216	33.154	.443	.615
If parents comment that their child is showing more interest in Science at school, it is probably due to the performance of the learner's teacher	36.179	34.973	.312	.636
Effectiveness in Science teaching has little influence on the achievement of learners with low motivation	36.784	33.038	.282	.642
Even teachers with good Science teaching abilities cannot help some learners learn Science	36.826	33.202	.282	.642

Using Cronbach's alpha, the internal consistency of the PSTE scale was α = 0.72 and the STOE scale scored α = 0.66. Although the alpha values for both scales of STEBI-A are slightly lower than those computed for the STEBI-A by Enochs and Riggs (1990) (PSTE= 0.92 and STOE = 0.77), the trend is identical with STOE scores lower than the PSTE. Thus, the scales were considered acceptable for the study.

5.5 Relating the STEBI to demographical data

The differences in the teaching efficacy of Science teachers in terms of demographic characteristics such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels.

The tables that follow present data on the PSTE and STOE scores against the demographic characteristics per district and for the entire Free State province.

5.5.1 Relating the STEBI-A to gender

The respondents' teaching efficacy was investigated against their gender, as shown in the tables and figures that follow:

Table 5.16: Respondents' gender versus PSTE (N=190)

GENDER	Personal Science Teaching Efficacy (PSTE)					
	Motheo	Xhariep	Thabo Mofutsanyana	Fezile Dabi	Lejwelep utswa	Overall Free State province
Male	53.13	40.77	57.14	52	52.32	51.07
Female	53.64	38	53.67	49.86	52.71	49.58

Table 5.16 shows that the male respondents scored higher on PSTE than the female respondents in the Xhariep, Thabo Mofutsanyana and Fezile Dabi districts; for Motheo and Lejweleputswa the female respondents scored higher with a very small margin. This finding is in agreement with a similar finding by Enochs and Riggs (1990). It can be generalised that male Physical Science teachers have a higher PSTE than the female teachers. Thabo Mofutsanyana district scored the highest of all the districts for both male and female respondents. This is illustrated in Figure 5.2:

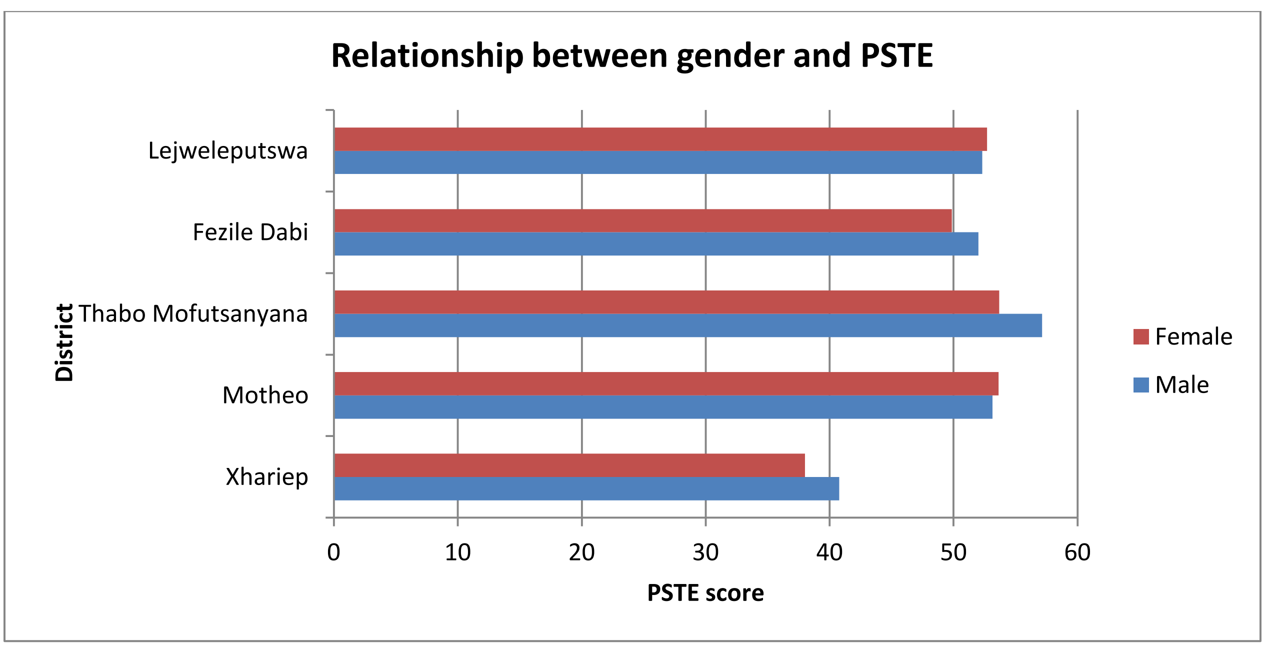


Figure 5.2: Relationship between gender and PSTE

The next section looks at the relationship between the respondents' gender and their STOE score, as shown in Table 5.17.

Table 5.17: Respondents' gender versus STOE (N=190)

GENDER	Science Teaching Outcome Expectancy (STOE)					
	Motheo	Xhariep	Thabo Mofutsanyana	FezileDabi	Lejweleputswa	Overall Free State Province
Male	40.71	44.92	46.71	39.00	39.14	42.10
Female	38.27	43.00	39.25	37.57	39.76	39.57

From the data above, it is evident that in all five districts of the Free State province, male respondents have a higher STOE than the female respondents, except for the Lejweleputswa district. Thabo Mofutsanyana has the highest STOE in males (46.71), and Xhariep has the highest in females (43.00). Fezile Dabi has the lowest STOE scores for both males and females, as shown in Figure 5.3.

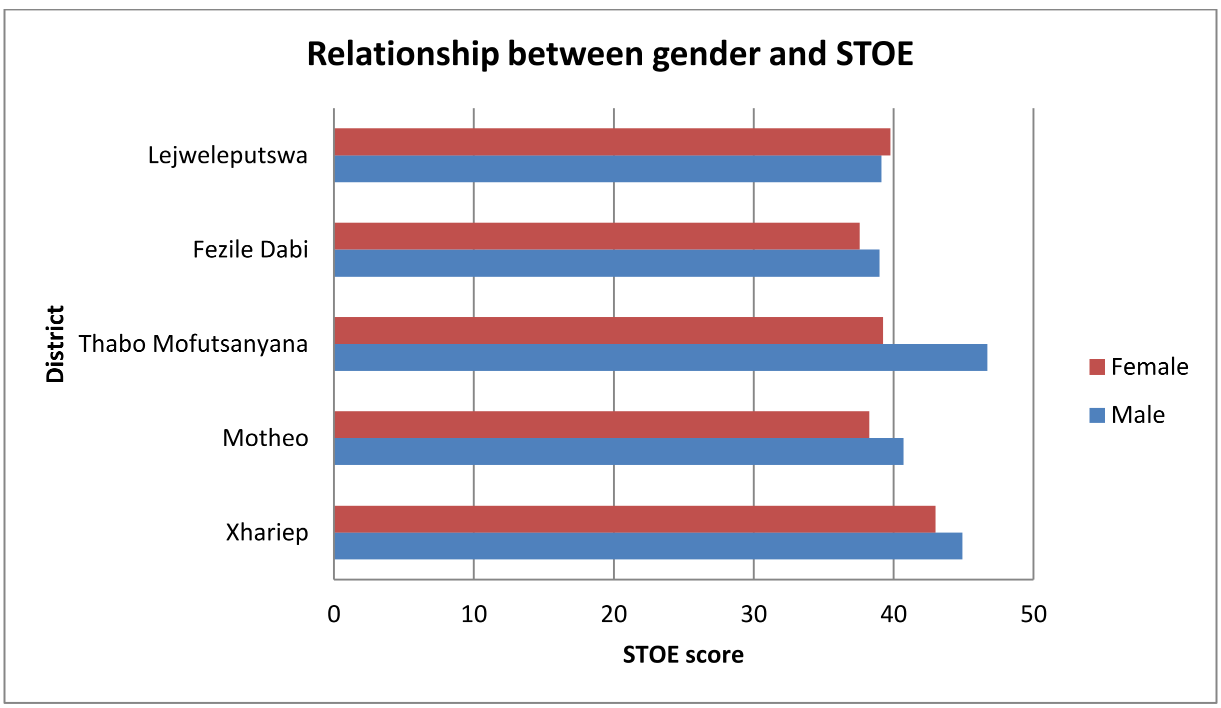


Figure 5.3: Relationship between gender and STOE

The mean scores by gender of the two sub-scales for the entire Free State province can be seen in Figure 5.4 that follows:

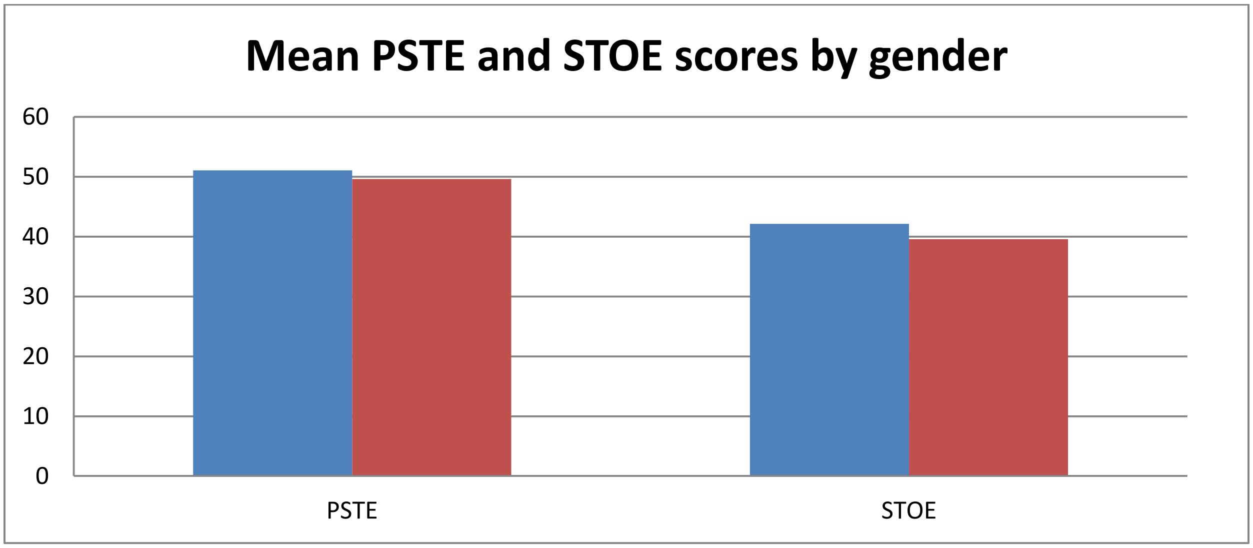


Figure 5.4: Mean PSTE and STOE scores by gender for the province

5.5.2 Relating the STEBI-A to age

Age, as one of the independent variables, was investigated against the respondents' teaching efficacy.

Table 5.18: Respondents' age versus PSTE (N=190)

	Xhariep	Fezile Dabi	Motheo	Thabo Mofutsanyana	Lejweleputswa
<25	47	0	53.83	51.33	60.5
26-30	42.5	54.5	53.86	53.33	52.7
31-35	38.2	39	52.4	45	49.63
36-40	40.25	50	42.52	60.5	54.53
41-45	41	53.75	53.79	56	46.5
46-50	0	49	52.33	59.67	54
51-55	39	53	57.25	52	55
55+	41	0	62	57	0

For most of the districts, the PSTE is higher for respondents who are younger than 30 years, and begins to decrease for those above 40 years, and increases again for older respondents who are 45 and more years. This is illustrated in Figure 5.5.

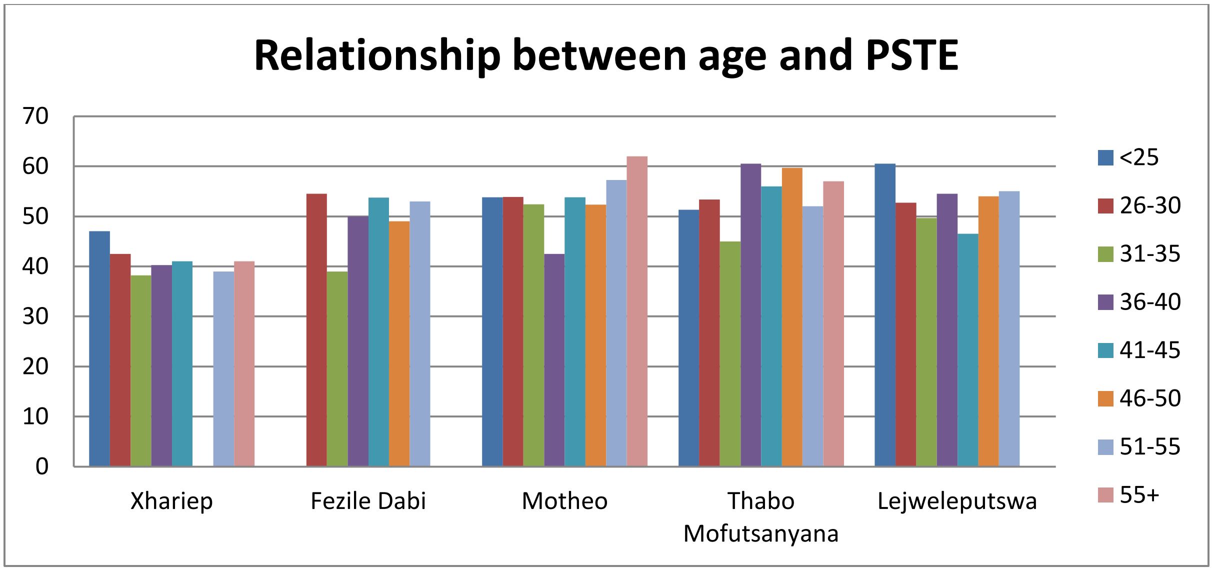


Figure 5.5: Relationship between age and PSTE

The next section looks at the relationship between the respondents' age and their STOE, as shown in Table 5.19.

From Table 5.19, it can be noted that the respondents' STOE decreases with an increase in age. It shows that teachers start off with high hopes that they can influence their learners' learning, only to have a different view as they grow older.

Table 5.19: Respondents' age versus STOE (N=190)

	Xhariep	Fezile Dabi	Motheo	Thabo Mofutsanyana	Lejweleputswa
<25	44	0	44.33	39.67	42.5
26-30	42.5	35	39.93	37	37.9
31-35	42	33	38.85	39	41.5
36-40	42.5	43	39.43	41	39.2
41-45	49	37.25	39.57	48	40.17
46-50	0	41	37.67	51.33	37
51-55	42.5	35.33	39.5	41	36.67
55+	45	0	39	40	0

Figure 5.6 shows the relationship between the respondents' age and their Science Teaching Outcome Expectancy scores.

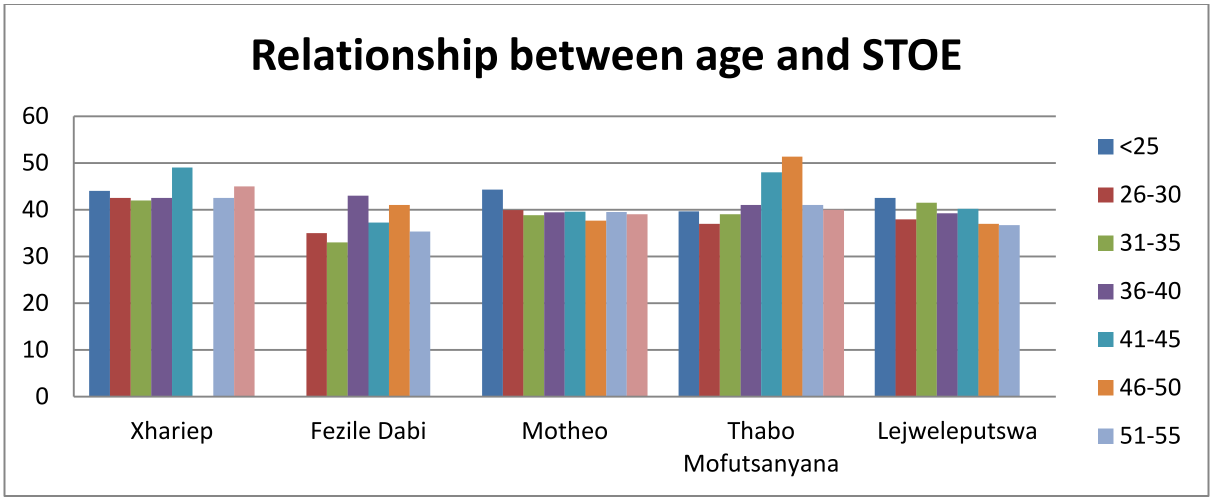


Figure 5.6: Relationship between age and STOE

The mean PSTE and STOE scores by age for the entire Free State province are shown in Figure 5.7.

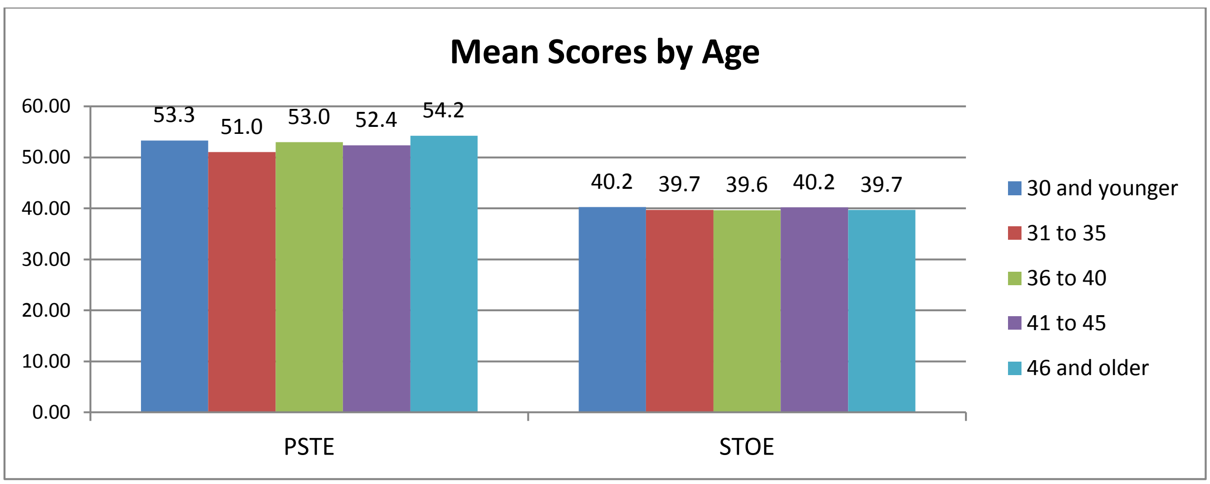


Figure 5.7: Mean PSTE and STOE scores by age

MANOVA was conducted to determine the effect of gender and age on the dependent variables, PSTE and STOE sub-scales. Tables 5.16 and 5.17 present the relevant descriptive statistics on gender, and Tables 5.18 and 5.19 present descriptive data on age. All the MANOVA assumptions were tested, and the following results showing non-violation of the assumptions were found:

Testing for univariate outliers

There were no extreme univariate outliers. Thus, this assumption was not violated.

Testing for multivariate normality

Table 5.20 (a): Age Tests of Normality

		Kolmogorov-Smirnova			Shapiro-Wilk		
	Age_recode	Statistic	df	Sig.	Statistic	Df	Sig.
The Science Teaching Outcome Expectancy (STOE) sub-scale total	30 and younger	.112	43	.200	.985	43	.845
	31 to 35	.152	36	.034	.916	36	.009
	36 to 40	.150	47	.010	.953	47	.054
	41 to 45	.112	27	.200	.979	27	.841
	46 and older	.134	36	.101	.951	36	.114
The Personal Science Teaching Efficacy (PSTE) sub-scale total	30 and younger	.080	43	.200	.968	43	.270
	31 to 35	.113	36	.200	.968	36	.371
	36 to 40	.119	47	.093	.958	47	.093
	41 to 45	.099	27	.200	.983	27	.915
	46 and older	.100	36	.200	.972	36	.488

Table 5.20(b): Gender Tests of Normality

		Kolmogorov-Smirnova			Shapiro-Wilk		
	Gender	Statistic	df	Sig.	Statistic	Df	Sig.
Science Teaching Outcome Expectancy sub-scale total	Male	.102	104	.010	.986	104	.337
	Female	.104	83	.027	.978	83	.163
Personal Science Teaching Efficacy sub-scale total	Male	.069	104	.200	.986	104	.355
	Female	.076	83	.200	.982	83	.313

There was some evidence of violation of the assumption of multivariate normality, but only for the independent variable "age". Since MANOVA is fairly robust to violations in this assumption, the test will be run anyway.

Table 5.20(c): Testing for multicollinearity

Correlations

		PSTE total	STOE total
Personal Science Teaching Efficacy sub-scale (PSTE) total	Pearson Correlation	1	.084
	Sig. (2-tailed)		.248
	N	190	190
Science Teaching Outcome Expectancy sub-scale total	Pearson Correlation	.084	1
	Sig. (2-tailed)	.248	
	N	190	190

There was no evidence of multicollinearity between the two dependent variables. There should not be too high a correlation between the two dependent variables; correlation between the two sub-scales was 0.248, and there was no evidence of multicollinearity between the two sub-scales.

Testing the assumption of linearity

There was no evidence of non-linear relationships between the two dependent variables for every level of the independent variables. This assumption was not violated

Testing for multivariate outliers

There was no evidence of multivariate outliers in the data.

Testing the assumption of equality of variance-covariance matrices

Table 5.20(d): Box's Test of Equality of Covariance Matrices[a]

Box's M	29.787
F	1.050
df1	27
df2	48699.951
Sig.	.394

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.
a. Design: Intercept + Gender + Age_recode + Gender * Age_recode

There was homogeneity of variance-covariance matrices.

The results of MANOVA determining the difference in teaching efficacy of Physical Science teachers in terms of age and gender are presented in Table 5.21 below.

Table 5.21: MANOVA for age and gender

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.992	10585.071	2.000	176.000	.000	.992
	Wilks' Lambda	.008	10585.071	2.000	176.000	.000	.992
	Hotelling's Trace	120.285	10585.071	2.000	176.000	.000	.992
	Roy's Largest Root	120.285	10585.071	2.000	176.000	.000	.992
Gender	Pillai's Trace	.035	3.229	2.000	176.000	.042	.035
	Wilks' Lambda	.965	3.229	2.000	176.000	.042	.035
	Hotelling's Trace	.037	3.229	2.000	176.000	.042	.035
	Roy's Largest Root	.037	3.229	2.000	176.000	.042	.035
Age_recode	Pillai's Trace	.023	.510	8.000	354.000	.849	.011
	Wilks' Lambda	.977	.509	8.000	352.000	.850	.011
	Hotelling's Trace	.023	.508	8.000	350.000	.851	.011
	Roy's Largest Root	.021	.922	4.000	177.000	.452	.020
Gender * Age_recode	Pillai's Trace	.048	1.084	8.000	354.000	.373	.024
	Wilks' Lambda	.952	1.088	8.000	352.000	.371	.024
	Hotelling's Trace	.050	1.091	8.000	350.000	.369	.024
	Roy's Largest Root	.046	2.035	4.000	177.000	.091	.044

As can be seen in the row highlighted in blue in Table 5.21, there was a significant main effect for gender (F=3.229; p=0.042). This means that the combined dependent variable was significantly different between males and females in teaching efficacy. As can be seen in the row highlighted in green in the table above, there was no significant main effect for age (F=0.509; p=0.850). This means that people in the different age categories did not differ in the combined dependent variable. From the row highlighted in purple in the table above can also be seen that there was no significant interaction effect between age and gender (F=1.088; p=0.371). There was no significant interaction effect between gender and age in the dependent variables.

In order to determine exactly which of the dependent variables differed between males and females, further analysis is needed. Hence, the univariate tests of between-subjects, as in Table 5.22 below.

Table 5.22: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	STOE total	461.405	9	51.267	1.321	.229	.063
	PS TE total	265.865	9	29.541	.926	.504	.045
Intercept	S TOE total	279157.338	1	279157.338	7191.047	.000	.976
	PSTE total	491582.416	1	491582.416	15404.635	.000	.989
Gender	STOE total	238.301	1	238.301	6.139	.014	.034
	PSTE total	5.925	1	5.925	.186	.667	.001
Age_recode	STOE total	16.395	4	4.099	.106	.980	.002
	PSTE total	116.545	4	29.136	.913	.458	.020
Gender * Age_recode	STOE total	223.157	4	55.789	1.437	.224	.031
	PSTE total	113.388	4	28.347	.888	.472	.020
Error	STOE total	6871.162	177	38.820			
	PSTE total	5648.306	177	31.911			
Total	STOE total	305813.000	187				
	PSTE total	528762.000	187				
Corrected Total	STOE total	7332.567	186				
	PSTE total	5914.171	186				

As can be seen in the highlighted rows in Table 5.22, there was a significant difference between males and females in the STOE sub-scale scores (F=6.139; p=0.014); but no significant difference between males and females in the PSTE sub-scale scores

(F=5.925; p=0.667). Thus, gender differed significantly on the STOE, but not in the scores on the PSTE. As can be seen in the table below, males obtained higher STOE scores than females (Male mean: 42.1; Female mean: 39.57).

Table 5.23: Mean STOE by gender

		The Science Teaching Outcome Expectancy sub-scale total	
		Mean	Count
Gender	Male	42.1	104
	Female	39.57	83

5.5.3 Relating the STEBI-A to teaching experience

Teachers' years of experience showed nonlinear relationships with the two sub-scales of the STEBI-A, as presented in Figure 5.8, increasing from early career to mid-career and then falling slightly afterwards, and eventually increasing in STOE.

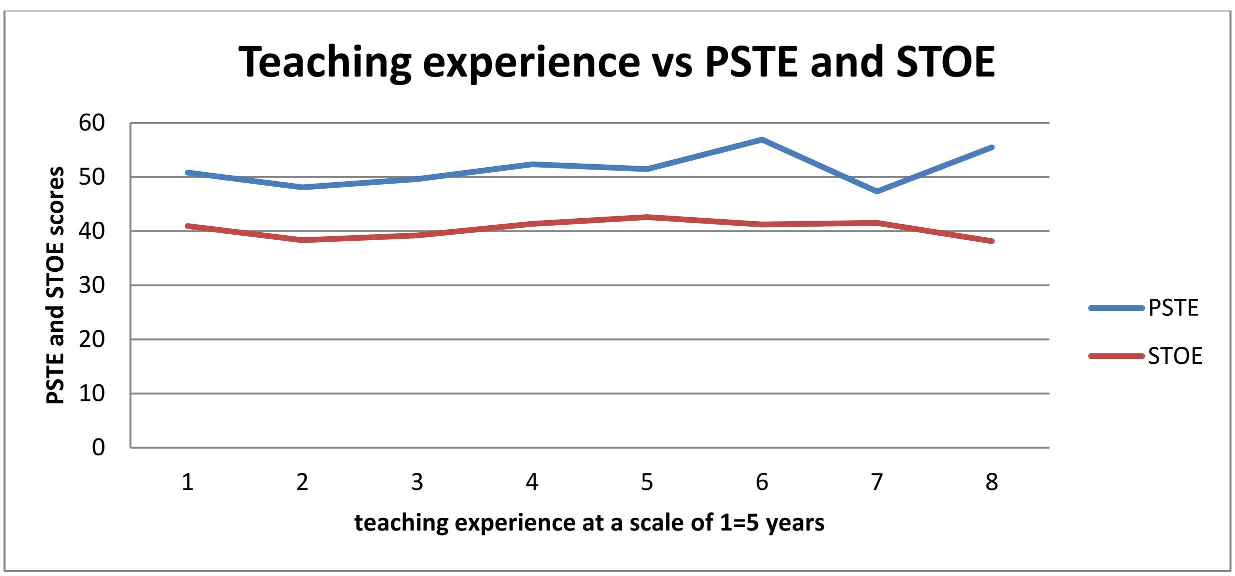


Figure 5.8: Respondents' teaching experience versus PSTE and STOE

MANOVA was conducted to determine whether there was a difference in teaching efficacy beliefs (PSTE and STOE sub-scales) between teachers with different years of teaching experience. Table 5.6 presents the relevant descriptive statistics. All the MANOVA assumptions were tested and the following results were found:

Testing for univariate outliers

There were no extreme univariate outliers in the data.

Testing for multivariate normality

PSTE and STOE scores were normally distributed for each level of "Teaching experience".

Table 5.24(a): Testing for multicollinearity

Correlations

		PSTE sub-scale total	STOE sub-scale total
Personal Science Teaching Efficacy sub-scale total	Pearson Correlation	1	.084
	Sig. (2-tailed)		.248
	N	190	190
Science Teaching Outcome Expectancy sub-scale total	Pearson Correlation	.084	1
	Sig. (2-tailed)	.248	
	N	190	190

There was no indication of multicollinearity in the data, since the correlation between the two dependent variables was smaller than 0.9.

Testing for linearity

There was no indication of a non-linear relationship between STOE and PSTE within any of the levels of teaching experience.

Testing for multivariate outliers

There were no multivariate outliers in the data, as assessed by Mahalanabois distance.

Testing for homogeneity of variance-covariance matrices

5.24(b): Box's Test of Equality of Covariance Matrices[a]

Box's M	8.901
F	.968
df1	9
df2	185249.753
Sig.	.464

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.
a. Design: Intercept + Teaching_experience_recode

The non-significant result of the Box's M test showed that homogeneity of variance-covariance matrix assumption was met for the analysis, F(0.968, 185249.753) = 0.464 p>0.001.

The results of MANOVA determining the difference in teaching efficacy between teachers with different years in teaching experience are presented in Table 5.25 that follows.

Table 5.25: MANOVA results for teaching experience

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.991	10726.828[b]	2.000	184.000	.000	.991
	Wilks' Lambda	.009	10726.828[b]	2.000	184.000	.000	.991
	Hotelling's Trace	116.596	10726.828[b]	2.000	184.000	.000	.991
	Roy's Largest Root	116.596	10726.828[b]	2.000	184.000	.000	.991
Teaching_experience_recode	Pillai's Trace	.069	2.214	6.000	370.000	.041	.035
	Wilks' Lambda	.931	2.238[b]	6.000	368.000	.039	.035
	Hotelling's Trace	.074	2.262	6.000	366.000	.037	.036
	Roy's Largest Root	.072	4.454[c]	3.000	185.000	.005	.067

The results of MANOVA in Table 5.25 show that there was a significant difference on the combined dependent variable between the different "Teaching experience" groups

(Wilks' Lambda = 0.931, F(6.000,368.000) = 2.238, p = 0.039, η^2 = .035). In order to determine exactly which of the dependent variables differed between these groups, further analysis was needed. The results can be seen in the table below.

Table 5.26: Tests of Between-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	STOE sub-scale total	89.396[a]	3	29.799	.750	.524	.012
	PSTE sub-scale total	374.050[b]	3	124.683	3.998	.009	.061
Intercept	STOE sub-scale total	278021.681	1	278021.681	6994.440	.000	.974
	PSTE sub-scale total	491776.087	1	491776.087	15767.886	.000	.988
Teaching_experience_recode	STOE sub-scale total	89.396	3	29.799	.750	.524	.012
	PSTE sub-scale total	374.050	3	124.683	3.998	.009	.061
Error	STOE sub-scale total	7353.556	185	39.749			
	PSTE sub-scale total	5769.865	185	31.188			
Total	STOE sub-scale total	307926.000	189				
	PSTE sub-scale total	533764.000	189				
Corrected Total	STOE sub-scale total	7442.952	188				
	PSTE sub-scale total	6143.915	188				

In the highlighted row in Table 5.26 above, it can be seen that teachers with different years of teaching experience differed in their scores on the PSTE sub-scale only (F=3.998; p=0.009), but not on the STOE sub-scale scores. This shows that the univariate ANOVA was significant for PSTE, F(3,185) = 3.998, p = 0.009, η^2 = 0.061. The partial eta square value of .061 represented that the 6.1% of the variance in PSTE could be explained by the respondents' teaching experience. To see exactly between which of the levels of teaching experience the differences lay, post hoc analysis was conducted. The results can be seen in Table 5.27.

Table 5.27: Multiple Comparisons

Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
The Science Teaching Outcome Expectancy sub-scale (STOE) total	5 years or less	6 to 10 years	.5655	1.23728	.968	-2.6422	3.7732
		11 to 15 years	-1.0983	1.28113	.827	-4.4197	2.2230
		16 or more years	-1.1774	1.24754	.781	-4.4117	2.0569
	6 to 10 years	5 years or less	-.5655	1.23728	.968	-3.7732	2.6422
		11 to 15 years	-1.6639	1.44840	.660	-5.4189	2.0911
		16 or more years	-1.7429	1.41878	.610	-5.4212	1.9353
	11 to 15 years	5 years or less	1.0983	1.28113	.827	-2.2230	4.4197
		6 to 10 years	1.6639	1.44840	.660	-2.0911	5.4189
		16 or more years	-.0791	1.45717	1.000	-3.8568	3.6987
	16 or more years	5 years or less	1.1774	1.24754	.781	-2.0569	4.4117
		6 to 10 years	1.7429	1.41878	.610	-1.9353	5.4212
		11 to 15 years	.0791	1.45717	1.000	-3.6987	3.8568
The Personal Science Teaching Efficacy sub-scale (PSTE) total	5 years or less	6 to 10 years	-.4459	1.09598	.977	-3.2873	2.3954
		11 to 15 years	-2.7237	1.13482	.081	-5.6658	.2183
		16 or more years	-3.2408*	1.10507	.020	-6.1057	-.3759
	6 to 10 years	5 years or less	.4459	1.09598	.977	-2.3954	3.2873
		11 to 15 years	-2.2778	1.28299	.288	-5.6040	1.0484
		16 or more years	-2.7949	1.25675	.121	-6.0530	.4633
	11 to 15 years	5 years or less	2.7237	1.13482	.081	-.2183	5.6658
		6 to 10 years	2.2778	1.28299	.288	-1.0484	5.6040
		16 or more years	-.5171	1.29076	.978	-3.8634	2.8292
	16 or more years	5 years or less	3.2408*	1.10507	.020	.3759	6.1057
		6 to 10 years	2.7949	1.25675	.121	-.4633	6.0530
		11 to 15 years	.5171	1.29076	.978	-2.8292	3.8634

It can be seen in Table 5.27 above that there was a significant difference in the PSTE sub-scale scores between teachers who had at most five years' teaching experience, and those who had at least 16 years' teaching experience. This means that teachers with five years and those with 16 years' teaching experience had significantly higher scores of PSTE than other teachers in other categories of teaching experience. Table 5.28 further shows that teachers with at least 16 years' teaching experience obtained significantly higher scores on the PSTE sub-scale (Mean = 54.79), than those with at most five years' teaching experience (Mean = 51.55).

Table 5.28: Mean PSTE by teaching experience

	Teaching_experience_recode			
	5 years or less	6 to 10 years	11 to 15 years	16 or more years
	Mean	Mean	Mean	Mean
PSTE sub-scale total	51.55	52.00	54.28	54.79

Therefore, MANOVA was conducted to assess the teaching experience differences on two STEBI-A sub-scales, namely, the PSTE and the STOE sub-scales. A non-significant Box's M test ($p = 0.464$) indicates homogeneity of covariance matrices of the dependent variables across the levels of teaching experience. The multivariate effect was significant by teaching experience, $F(6.000,368.000) = 2.238$, $p = 0.039$, $\eta^2 = 0.035$. Univariate tests showed that there were significant differences across the teaching experience on PSTE, $F(3,185) = 3.998$, $p < 0.01$, $\eta^2 = 0.061$. In conclusion, there was a significant difference in the PSTE sub-scale scores between teachers who had at most five years' teaching experience, and those who had at least 16 years' teaching experience ($p = 0.02$).

5.5.4 Relating the STEBI-A to educational background

The relationship between the teachers' educational background and their PSTE and STOE scores is shown in Figure 5.9.

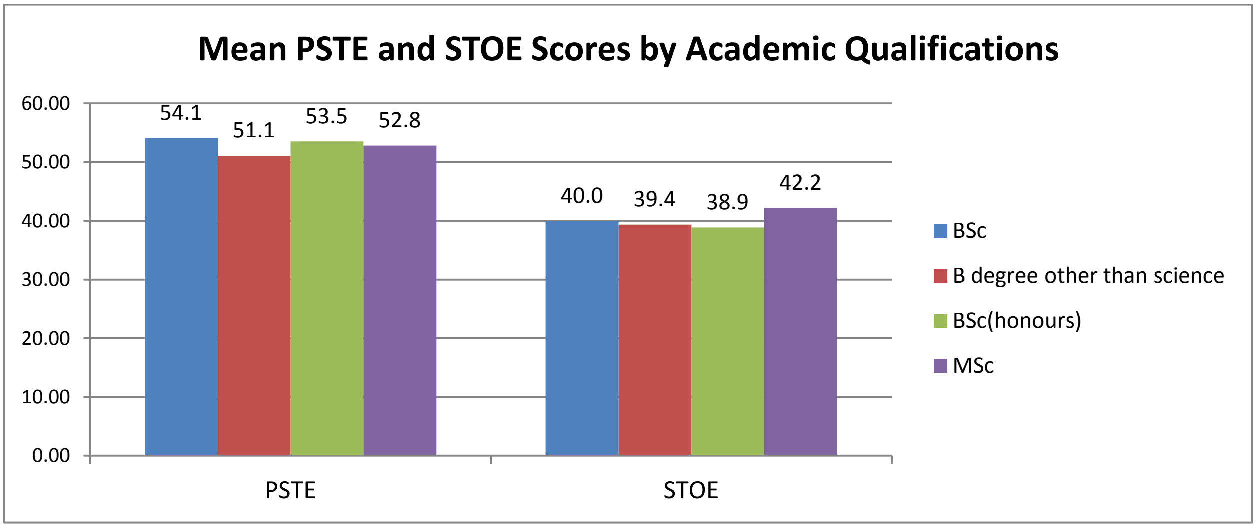


Figure 5.9: Mean PSTE and STOE scores by academic qualifications

It is important to note that the respondents in possession of a Bachelor's degree, other than Science, had the lowest PSTE (51.1) score, and those with an MSc scored the highest on STOE (42.2). The respondents who were not in possession of any academic qualification scored the highest on PSTE, and yet the lowest on STOE. For the purpose of this study, an academic qualification is any qualification that does not have any specialisation in the field of Education.

The next section looks at the respondents' professional qualifications against PSTE and STOE.

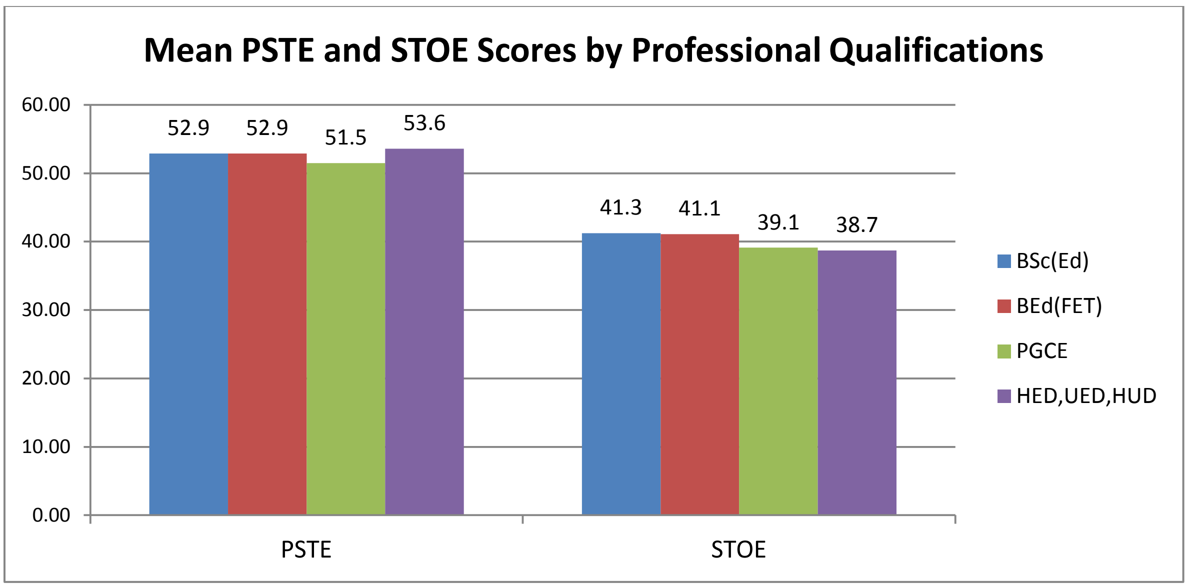


Figure 5.10: Mean PSTE and STOE scores by professional qualifications

As shown in Figure 5.10, respondents who are in possession of PGCE tend to have the lowest PSTE (51.5), and the lowest STOE of 38.7 is scored by respondents with national diplomas. The high PSTE and STOE scores are observed in the B.Sc (Ed), B.Ed (FET) and national diplomas in education.

MANOVA was conducted to determine if there was a difference in teaching efficacy beliefs (PSTE and STOE sub-scales) between teachers with different educational backgrounds. Figures 5.9 and 5.10 present the relevant descriptive statistics. All the MANOVA assumptions were tested and the following results were found:

Testing for univariate outliers

There was only one extreme univariate outlier in the data. Since this outlier probably represents an actual data point, it was decided not to delete this case.

Testing for multivariate normality

Table 5.29(a): Tests of Normality for academic qualification

Respondent's specific academic qualification		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
The Science Teaching Outcome Expectancy sub-scale total	BSc	.082	53	.200*	.981	53	.570
	B degree other than Science	.161	27	.069	.942	27	.139
	BSc (honours)	.182	14	.200*	.932	14	.320
	MSc	.276	5	.200*	.905	5	.437
The Personal Science Teaching Efficacy sub-scale (PSTE) total	BSc	.075	53	.200*	.976	53	.359
	B degree other than Science	.098	27	.200*	.958	27	.326
	BSc (honours)	.164	14	.200*	.951	14	.584
	MSc	.225	5	.200*	.909	5	.464

Table 5.29(b): Tests of Normality for professional qualification

Respondent's specific professional qualification in education		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
The Science Teaching Outcome Expectancy sub-scale total	BSc (Ed)	.125	23	.200*	.944	23	.224
	BEd (FET)	.160	34	.027	.961	34	.262
	PGCE	.097	27	.200*	.974	27	.712
	HED,UED,HUD	.111	57	.079	.966	57	.108
The Personal Science Teaching Efficacy sub-scale (PSTE) total	BSc (Ed)	.093	23	.200*	.977	23	.842
	BEd (FET)	.100	34	.200*	.980	34	.772
	PGCE	.115	27	.200*	.965	27	.467
	HED,UED,HUD	.058	57	.200*	.982	57	.534

Both dependent variables were normally distributed for every level of both independent variables.

Table 5.29(c): Testing for multicollinearity

Correlations

		PSTE sub-scale total	STOE sub-scale total
Personal Science Teaching Efficacy sub-scale total	Pearson Correlation	1	.084
	Sig. (2-tailed)		.248
	N	190	190
Science Teaching Outcome Expectancy sub-scale total	Pearson Correlation	.084	1
	Sig. (2-tailed)	.248	
	N	190	190

There was no indication of multicollinearity in the data, since the correlation between the two dependent variables were smaller than 0.9.

Testing for linearity

There was no indication of non-linear relationships in the data.

Testing for multivariate outliers

There was only one multivariate outlier in the data, as assessed by Mahalanabois distance. Since MANOVA is fairly robust against multivariate outliers, it was decided not to delete this case.

Testing for homogeneity of variance-covariance matrices

Table 5.29(d): Box's Test of Equality of Covariance Matrices[a]

Box's M	21.783
F	.687
df1	24
df2	806.876
Sig.	.868

There was homogeneity of variance-covariance matrices as assessed by Box's M test since p>0.001.

The results of MANOVA determining the difference in teaching efficacy between teachers with different educational backgrounds are presented in Table 5.30 below.

Table 5.30: MANOVA results for educational background

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.982	1858.412[b]	2.000	67.000	.000	.982
	Wilks' Lambda	.018	1858.412[b]	2.000	67.000	.000	.982
	Hotelling's Trace	55.475	1858.412[b]	2.000	67.000	.000	.982
	Roy's Largest Root	55.475	1858.412[b]	2.000	67.000	.000	.982
Academic_ qualification	Pillai's Trace	.201	2.532	6.000	136.000	.023	.100
	Wilks' Lambda	.802	2.610[b]	6.000	134.000	.020	.105
	Hotelling's Trace	.244	2.684	6.000	132.000	.017	.109
	Roy's Largest Root	.229	5.200[c]	3.000	68.000	.003	.187
Professional_ qualification	Pillai's Trace	.221	2.811	6.000	136.000	.013	.110
	Wilks' Lambda	.787	2.849[b]	6.000	134.000	.012	.113
	Hotelling's Trace	.262	2.884	6.000	132.000	.011	.116
	Roy's Largest Root	.220	4.996[c]	3.000	68.000	.003	.181
Academic_ qualification * Professional_ qualification	Pillai's Trace	.127	.767	12.000	136.000	.684	.063
	Wilks' Lambda	.875	.770[b]	12.000	134.000	.681	.064
	Hotelling's Trace	.140	.772	12.000	132.000	.678	.066
	Roy's Largest Root	.123	1.391[c]	6.000	68.000	.231	.109

As can be seen in the highlighted rows in Table 5.30 above, there were significant differences on the combined dependent variable for both teachers with different academic qualifications (F=2.610; p=0.020), and teachers with different professional qualifications in education (F=2.849; p=0.012). There was, however, no significant interaction effect between academic and professional qualifications (F=0.770; p=0.681). To determine which of the two sub-scales of teaching efficacy differed between the different professional and academic qualifications, further analysis were done. The results of these can be seen in Table 5.31 that follows.

Table 5.31: Tests of Between-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	STOE total	547.342[a]	12	45.612	1.057	.410	.157
	PSTE total	698.322[b]	12	58.193	2.004	.037	.261
Intercept	STOE total	49380.893	1	49380.893	1144.068	.000	.944
	PSTE total	80721.045	1	80721.045	2779.935	.000	.976
Academic_ qualification	STOE total	86.032	3	28.677	.664	.577	.028
	PSTE total	413.615	3	137.872	4.748	.005	.173
Professional_ qualification	STOE total	399.914	3	133.305	3.088	.033	.120
	PSTE total	232.941	3	77.647	2.674	.054	.106
Academic_ qualification * Professional_ qualification	STOE total	53.932	6	8.989	.208	.973	.018
	PSTE total	239.087	6	39.848	1.372	.238	.108
Error	STOE total	2935.054	68	43.163			
	PSTE total	1974.518	68	29.037			
Total	STOE total	133643.000	81				
	PSTE total	231901.000	81				
Corrected Total	STOE total	3482.395	80				
	PSTE total	2672.840	80				

As can be seen in the rows highlighted in blue in Table 5.31 above, teachers with different academic qualifications differed in terms of their PSTE scores only (F=4.748; p=0.005). In contrast, teachers with different professional teaching qualifications differed in terms of their STOE scores only (F=3.088; p=0.033).

In order to determine exactly which of the qualification categories differed in terms of PSTE scores and STOE scores, post hoc analysis were conducted. The results of these can be seen in the tables that follow. The first one, Table 5.32 looks at the academic qualifications and the PSTE scores.

Table 5.32: Multiple comparisons on the academic qualifications and PSTE scores
Tukey HSD

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
The Science Teaching Outcome Expectancy (STOE) sub-scale total	BSc	B degree other than Science	-1.1051	1.70912	.916	-5.6064	3.3963
		BSc (honours)	-.3778	2.20976	.998	-6.1977	5.4421
		MSc	-3.0444	3.91748	.865	-13.3620	7.2731
	B degree other than Science	BSc	1.1051	1.70912	.916	-3.3963	5.6064
		BSc (honours)	.7273	2.42607	.991	-5.6623	7.1168
		MSc	-1.9394	4.04345	.963	-12.5887	8.7099
	BSc (honours)	BSc	.3778	2.20976	.998	-5.4421	6.1977
		B degree other than Science	-.7273	2.42607	.991	-7.1168	5.6623
		MSc	-2.6667	4.27918	.924	-13.9368	8.6035
	MSc	BSc	3.0444	3.91748	.865	-7.2731	13.3620
		B degree other than Science	1.9394	4.04345	.963	-8.7099	12.5887
		BSc (honours)	2.6667	4.27918	.924	-8.6035	13.9368
The Personal Science Teaching Efficacy sub-scale (PSTE) total	BSc	B degree other than Science	2.7273	1.40183	.219	-.9648	6.4193
		BSc (honours)	-.4545	1.81246	.994	-5.2280	4.3190
		MSc	3.3333	3.21314	.728	-5.1292	11.7958
	B degree other than Science	BSc	-2.7273	1.40183	.219	-6.4193	.9648
		BSc (honours)	-3.1818	1.98987	.386	-8.4226	2.0589
		MSc	.6061	3.31645	.998	-8.1285	9.3407
	BSc (honours)	BSc	.4545	1.81246	.994	-4.3190	5.2280
		B degree other than Science	3.1818	1.98987	.386	-2.0589	8.4226
		MSc	3.7879	3.50981	.703	-5.4560	13.0317
	MSc	BSc	-3.3333	3.21314	.728	-11.7958	5.1292
		B degree other than Science	-.6061	3.31645	.998	-9.3407	8.1285
		BSc (honours)	-3.7879	3.50981	.703	-13.0317	5.4560

As can be seen in the Table 5.32 above, even though the significant ANOVA result showed that there are probably differences in the PSTE scores between the different academic qualification groups, no significant differences could be detected with the post-hoc analysis. Due to the sensitivity of the ANOVA test statistic, it is possible to sometimes detect significant differences in the ANOVA, but not in the follow-up post-hoc analysis. Thus, it is difficult to draw a conclusion as to which of the academic qualifications the teachers differed in the PSTE scores.

The next multiple comparisons test looks at the professional qualification and the differences in STOE sub-scale scores.

Table 5.33: Multiple comparisons on the professional qualification and the differences in STOE sub-scale scores

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Science Teaching Outcome Expectancy (STOE) sub-scale total	BSc (Ed)	BEd (FET)	3.3833	2.81303	.627	-4.0254	10.7921
		PGCE	6.4538*	2.44466	.049	.0153	12.8924
		HED,UED,HUD	6.4818*	2.37154	.039	.2358	12.7278
	BEd (FET)	BSc (Ed)	-3.3833	2.81303	.627	-10.7921	4.0254
		PGCE	3.0705	2.29281	.542	-2.9681	9.1091
		HED,UED,HUD	3.0985	2.21469	.504	-2.7344	8.9313
	PGCE	BSc (Ed)	-6.4538*	2.44466	.049	-12.8924	-.0153
		BEd (FET)	-3.0705	2.29281	.542	-9.1091	2.9681
		HED,UED,HUD	.0280	1.72280	1.00	-4.5094	4.5654
	HED,UED, HUD	BSc (Ed)	-6.4818*	2.37154	.039	-12.7278	-.2358
		BEd (FET)	-3.0985	2.21469	.504	-8.9313	2.7344
		PGCE	-.0280	1.72280	1.00	-4.5654	4.5094
Personal Science Teaching Efficacy (PSTE) sub-scale total	BSc (Ed)	BEd (FET)	.3167	2.30726	.999	-5.7600	6.3933
		PGCE	.8231	2.00512	.976	-4.4578	6.1040
		HED,UED,HUD	-2.7212	1.94515	.504	-7.8442	2.4018
	BEd (FET)	BSc (Ed)	-.3167	2.30726	.999	-6.3933	5.7600
		PGCE	.5064	1.88057	.993	-4.4465	5.4593
		HED,UED,HUD	-3.0379	1.81650	.346	-7.8220	1.7463
	PGCE	BSc (Ed)	-.8231	2.00512	.976	-6.1040	4.4578
		BEd (FET)	-.5064	1.88057	.993	-5.4593	4.4465
		HED,UED,HUD	-3.5443	1.41305	.068	-7.2659	.1773
	HED,UED, HUD	BSc (Ed)	2.7212	1.94515	.504	-2.4018	7.8442
		BEd (FET)	3.0379	1.81650	.346	-1.7463	7.8220
		PGCE	3.5443	1.41305	.068	-.1773	7.2659

In Table 5.33, it can be seen that there are significant differences in STOE sub-scale scores between teachers with a BSc (Ed) degree, and individuals with a PGCE certificate (p=0.049). There were also significant differences in STOE scores between teachers with an HED, UED, HUD in education, and teachers with a BSc (Ed) degree (p=0.039). In each instance, teachers with a BSc (Ed) degree obtained significantly higher STOE sub-scale scores. The means can be seen in Table 5.34.

Table 5.34: Respondents' professional qualification on STOE

	Respondents' specific professional qualification in education			
	BSc(Ed)	BEd(FET)	PGCE	HED,UED,HUD
	Mean	Mean	Mean	Mean
STOE sub-scale total	41.26	41.12	39.11	38.72

Therefore, MANOVA was conducted to assess the educational background differences on two STEBI-A sub-scales, namely, the PSTE and the STOE sub-scales. A non-significant Box's M test ($p = 0.868$) indicates homogeneity of covariance matrices of the dependent variables across the different educational background. The multivariate effect was significant by academic qualification, $F(6.000,134.000) = 2.610$, $p = 0.020$, $\eta^2 = 0.105$ and professional qualification, $F(6.000,134.000) = 2.849$, $p = 0.012$, $\eta^2 = 0.113$. Univariate tests showed that there were significant differences across academic qualifications on PSTE, $F(3,185) = 4.748$, $p < 0.01$, $\eta^2 = 0.173$, and professional qualifications on STOE, $F(3,185) = 3.088$, $p < 0.1$, $\eta^2 = 0.120$.

5.5.5 Relating the STEBI-A to grades taught by teachers

The PSTE and STOE scores against the different grades (Grade 10, 11 and 12) that teachers taught are shown in Figure 5.11.

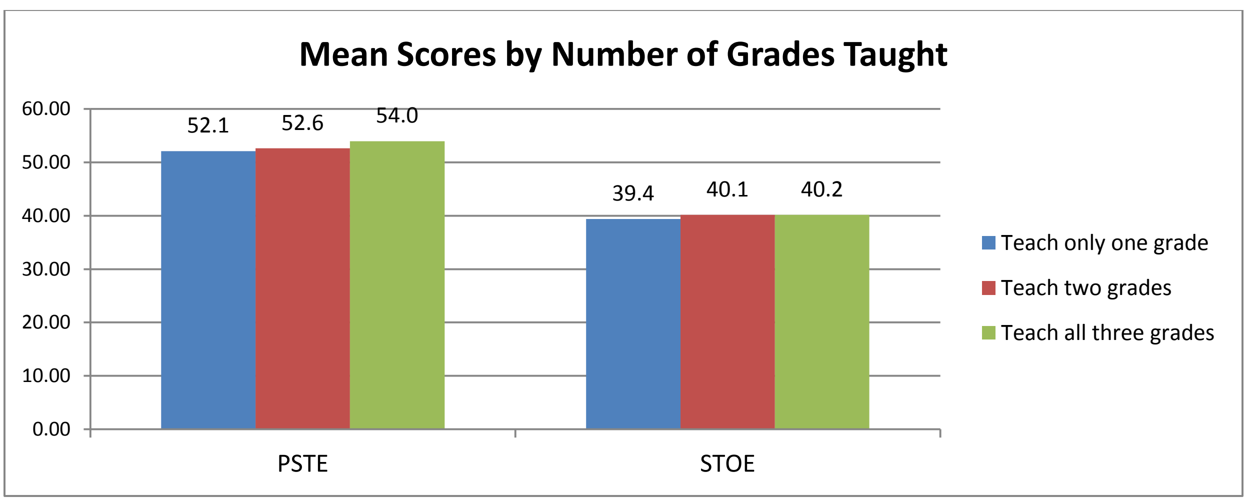


Figure 5.11: Mean PSTE and STOE scores by grades taught

It can be seen from Figure 5.11 that both the PSTE and STOE scores increase with an increase in the number of grades that the teachers taught.

MANOVA was then conducted to determine if there was a difference in teaching efficacy beliefs (PSTE and STOE sub-scales) between teachers who teach one, two or three grades. Table 5.9 presents the relevant descriptive statistics. All the MANOVA assumptions were tested and the following results were found:

Testing for univariate outliers

There were no extreme univariate outliers in the data.

Testing for multivariate normality

Table 5.35(a): Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Grade_recode2		Statistic	df	Sig.	Statistic	df	Sig.
STOE total	Teach only one grade	.090	63	.200*	.988	63	.782
	Teach two grades	.128	57	.021	.966	57	.110
	Teach all three grades	.085	62	.200*	.985	62	.667
PSTE total	Teach only one grade	.074	63	.200*	.982	63	.462
	Teach two grades	.089	57	.200*	.980	57	.467
	Teach all three grades	.086	62	.200*	.968	62	.105

STOE and PSTE scores were normally distributed for each level of "number of grades taught".

Testing for multicollinearity

Table 5.35(b): Test for multicollinearity

		PSTE sub-scale total	STOE sub-scale total
PSTE sub-scale total	Pearson Correlation	1	.084
	Sig. (2-tailed)		.248
	N	190	190
STOE sub-scale total	Pearson Correlation	.084	1
	Sig. (2-tailed)	.248	
	N	190	190

There was no indication of multicollinearity in the data, since the correlation between the two dependent variables were not highly correlated with each other.

Testing for linearity

There was no indication of a non-linear relationship between STOE and PSTE, for each level of the "number of grades taught".

Testing for multivariate outliers

There was only one multivariate outlier in the data, as assessed by Mahalanabois distance. Since MANOVA is fairly robust against multivariate outliers, it was decided not to delete this case.

Testing for homogeneity of variance-covariance matrices

Table 5.35(c): Box's Test of Equality of Covariance Matrices[a]

Box's M	3.793
F	.622
df1	6
df2	758505.981
Sig.	.713

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.
a. Design: Intercept + Grade_recode2

There was homogeneity of variance-covariance matrices, as assessed by Box's M test as p>0.001. The assumption was then not violated.

The results of MANOVA determining the difference in teaching efficacy between teachers who teach one, two or three grades are presented in Table 5.36.

Table 5.36: MANOVA results for different grades taught by teachers

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.992	10435.752[b]	2.000	178.000	.000	.992
	Wilks' Lambda	.008	10435.752[b]	2.000	178.000	.000	.992
	Hotelling's Trace	117.256	10435.752[b]	2.000	178.000	.000	.992
	Roy's Largest Root	117.256	10435.752[b]	2.000	178.000	.000	.992
Grade_recode2	Pillai's Trace	.022	1.000	4.000	358.000	.407	.011
	Wilks' Lambda	.978	.999[b]	4.000	356.000	.408	.011
	Hotelling's Trace	.023	.998	4.000	354.000	.409	.011
	Roy's Largest Root	.021	1.890[c]	2.000	179.000	.154	.021

There was no significant difference in the combined dependent variable between teachers who teach different numbers of grades (F=0.999; p=0.408), as seen in Table

5.36. Thus, teachers who taught one, two or all three grades did not differ in either the STOE sub-scale or the PSTE sub-scale scores.

5.5.6 Relating the STEBI-A to different districts where schools are located

The relationship between the educational districts where the schools are located against the PSTE and STOE scores is shown in Figure 5.12.

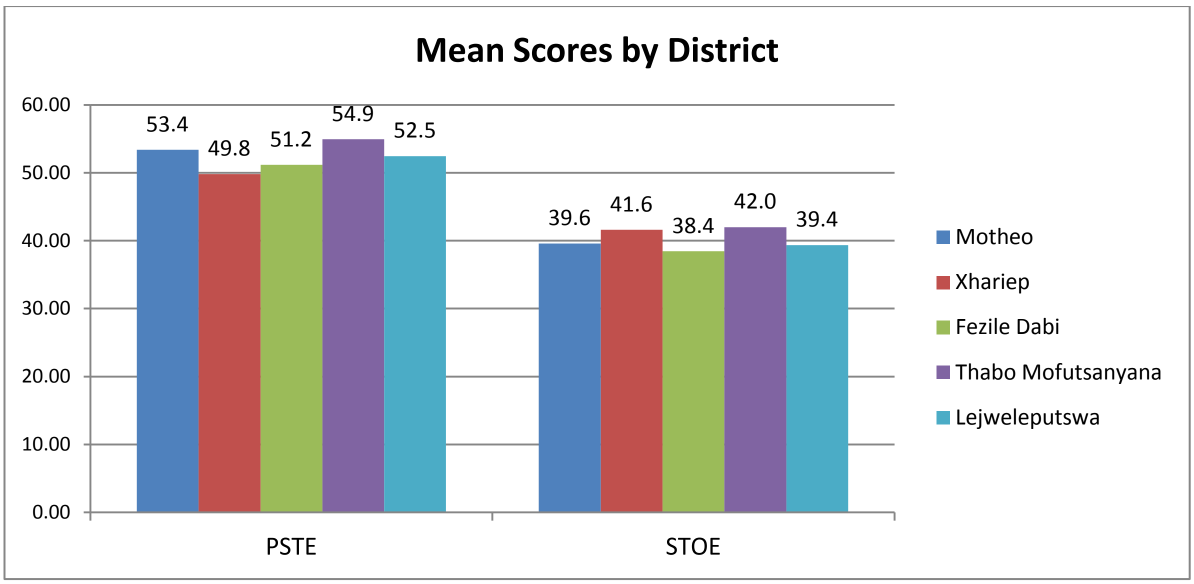


Figure 5.12: Mean PSTE and STOE Scores by District

It can be seen from Figure 5.12 that PSTE scores are more than STOE scores for all the districts, with Thabo Mofutsanyana leading in the scores of both the sub-scales, and Xhariep with the lowest PSTE and Fezile Dabi with the lowest STOE score.

MANOVA was then conducted to determine if there was a difference in teaching efficacy beliefs between teachers who teach in different educational districts. All the MANOVA assumptions were tested and the following results were found:

Testing for univariate outliers

There were no extreme univariate outliers in the data.

Testing for multivariate normality

Table 5.37(a): Tests of Normality

Respondent's district		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
The Science Teaching Outcome Expectancy sub-scale total	Motheo	.077	92	.200*	.985	92	.370
	Xhariep	.220	16	.037	.939	16	.332
	Fezile Dabi	.235	18	.010	.905	18	.071
	Thabo Mofutsanyana	.132	19	.200*	.959	19	.547
	Lejweleputswa	.139	45	.029	.944	45	.030
The Personal Science Teaching Efficacy sub-scale total	Motheo	.064	92	.200*	.983	92	.277
	Xhariep	.133	16	.200*	.966	16	.765
	Fezile Dabi	.107	18	.200*	.944	18	.332
	Thabo Mofutsanyana	.160	19	.200*	.959	19	.549
	Lejweleputswa	.104	45	.200*	.978	45	.556

There was some evidence of violation of the assumption of multivariate normality, but only for the independent variable "PSTE", and only within one school district. Since MANOVA is fairly robust to violations in this assumption, the test will be run anyway.

Table 5.37(b): Testing for multicollinearity

Correlations

		PSTE total	STOE total
PSTE total	Pearson Correlation	1	.084
	Sig. (2-tailed)		.248
	N	190	190
STOE total	Pearson Correlation	.084	1
	Sig. (2-tailed)	.248	
	N	190	190

There was no indication of multicollinearity in the data, since the correlation between the two dependent variables were smaller than 0.9.

Testing for linearity

There was no indication of a non-linear relationship between STOE and PSTE, for each of the districts.

Testing for multivariate outliers

There was only one multivariate outlier in the data, as assessed by Mahalanobis distance. Since MANOVA is fairly robust against multivariate outliers, this case was not deleted.

Testing for homogeneity of variance-covariance matrices

Table 5.37(c):Box's Test of Equality of Covariance Matrices[a]

Box's M	10.846
F	.869
df1	12
df2	27760.586
Sig.	.578

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + District

There was homogeneity of variance-covariance matrices, as assessed by Box's M test as p>0.001.

The results of MANOVA determining the difference in teaching efficacy between teachers who teach in different educational districts are presented in Table 5.38 below.

Table 5.38: MANOVA results for educational districts

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.987	7264.792[b]	2.000	184.000	.000	.987
	Wilks' Lambda	.013	7264.792[b]	2.000	184.000	.000	.987
	Hotelling's Trace	78.965	7264.792[b]	2.000	184.000	.000	.987
	Roy's Largest Root	78.965	7264.792[b]	2.000	184.000	.000	.987
District	Pillai's Trace	.076	1.838	8.000	370.000	.069	.038
	Wilks' Lambda	.925	1.833[b]	8.000	368.000	.070	.038
	Hotelling's Trace	.080	1.827	8.000	366.000	.071	.038
	Roy's Largest Root	.054	2.513[c]	4.000	185.000	.043	.052

There was no significant difference in the combined dependent variable between teachers who teach in different districts (F=1.833; p=0.070), as shown in Table 5.38. Thus, teachers from different districts did not differ in either the STOE sub-scale or the PSTE sub-scale scores.

In Section C of the questionnaire, respondents were requested to rate their confidence in Physical Science content knowledge. The results are presented in the next section.

5.6 Relationship between teachers' subject knowledge and their teaching efficacy

Respondents' level of preparedness with respect to subject knowledge is another variable that is under investigation and how it influences teaching efficacy. This section presents data on the respondents' confidence in teaching various concepts of Physical Science.

Teachers' confidence levels in different aspects of teaching Physical Science

This section presents data emanating from section C of the questionnaire. This is aimed at investigating the confidence that teachers have in teaching different concepts of Physical Science. Physical Science in the FET Phase comprises paper 1 and paper 2, which are Physics and Chemistry, respectively. This section is two-fold; it focuses first on theory, and secondly on practical work. It must be noted that the Lejweleputswa district was exempted from this section of the study because it was the first district where the questionnaire was administered, and during that time the Department of Education was in the process of finalising a policy document called the Curriculum and Assessment Policy Statement (CAPS), which is the amended version of the National Curriculum Statement (NCS). A single comprehensive CAPS document was developed for each subject to replace Subject Statements, Learning Programme Guidelines, and Subject Assessment Guidelines in Grade R to 12 in order to improve the implementation of the NCS (DoE, 2012).

The analysis of the pilot study provides a means of checking the relevance of the questions and offers an idea of the data that is likely to emerge from the main study. Hence, most of the questions on the NCS were later removed in the final questionnaire in order to fit in the aspects specified within the CAPS document. Soon afterwards, the CAPS document was approved and the Physical Science concepts addressed in this study had to be changed to match the prescribed concepts according to the CAPS document.

5.6.1 Chemistry

Chemistry forms part of the second paper in the National Senior Certificate (NSC) examinations. A deep understanding of Chemistry involves being able to link what one observes in the laboratory (the macroscopic level) to what one imagines is happening to substances at the invisible molecular or particulate level. Only then can these ideas be communicated meaningfully using abstract chemical symbolism, terminology and Mathematics (the symbolic level). Table 5.39 presents data on the mean scores of the Chemistry content knowledge of the teachers. This table summarises the comparison of the four districts. The respondents were requested to rate their confidence to teach the selected Chemistry concepts according to the three-point Likert scale: 1 = not confident, 2 = slightly confident, 3 = confident.

Table 5.39: Chemistry content knowledge of the four districts (N=190)

Concept	Xhariep		Motheo		Thabo Mofut-sanyana		Fezile Dabi	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Chemical bonding	2.75	0.56	2.91	0.28	2.89	0.31	2.88	0.32
Gas laws	2.69	0.58	2.85	0.42	2.74	0.55	2.88	0.32
Nomenclature of Organic compounds	2.70	0.70	2.63	0.61	2.74	0.55	2.76	0.54
Reactions of organic compounds	2.80	0.40	2.73	0.54	2.68	0.47	2.50	0.71
Balancing chemical reactions	3.00	0.00	2.96	0.21	3.00	0.00	2.76	0.55
Energy changes in chemical reactions	2.94	0.24	2.85	0.42	2.89	0.31	2.88	0.33
Redox reactions	2.80	0.50	2.76	0.52	2.89	0.31	2.41	0.77
Rate of chemical reactions	2.94	0.24	2.71	0.58	2.89	0.31	2.63	0.48
Acids and bases	3.00	0.00	2.87	0.37	2.79	0.41	2.76	0.42
Chemical equilibrium	2.90	0.30	2.69	0.53	2.79	0.41	2.63	0.48
Exploiting the lithosphere	2.38	0.60	2.22	0.64	2.21	0.83	2.24	0.64
The atmosphere	2.63	0.48	2.29	0.67	2.32	0.73	2.29	0.57
Chemical industry	2.56	0.50	2.53	0.64	2.47	0.68	2.35	0.68
Average mean	2.76	0.22	2.72	0.27	2.72	0.26	2.59	0.36

In general, teachers show a high level of confidence in teaching the selected concepts mentioned above. Exploiting the lithosphere was ranked the lowest in confidence, whereas balancing of chemical equations was ranked high in the three districts, as shown in the summary Table 5.39(b).

Table 5.39 (b): Summary on the Chemistry content knowledge

District	Highest score	Lowest score	Range	Skewness
Xhariep	3.00	2.38	0.68	-1.22
Motheo	2.96	2.22	0.74	-0.93
Thabo Mofutsanyana	3.00	2.21	0.79	-0.81
Fezile Dabi	2.88	2.24	0.64	-1.15

Respondents' confidence in teaching selected Chemistry concepts

As shown in Table 5.40, the Physical Science teachers in the Free State province were mostly confident that they are competent to teach Chemistry concepts selected from the CAPS document.

Table 5.40: Teacher Confidence in Teaching Selected Chemistry Concepts (N=190)

Knowledge Area	Concept	Mean	SD	Rank Order	Regular Curriculum concept (Yes/No)
Matter and materials	Chemical bonding	2.89	0.34	2	Yes
	Gas laws	2.83	0.43	5	Yes
Chemical systems	Nomenclature of organic compounds	2.70	0.58	9	Yes
	Reactions of organic compounds	2.73	0.49	8	Yes
	Exploiting the lithosphere	2.25	0.66	12	No
	The atmosphere	2.36	0.65	11	No
	Chemical industry	2.52	0.63	10	Yes
Chemical change	Balancing of chemical reactions	2.94	0.27	1	Yes
	Energy changes in chemical reactions	2.88	0.35	3	Yes
	Redox reactions	2.75	0.54	7	Yes
	Rate of chemical reactions	2.80	0.47	6	Yes
	Acids and bases	2.86	0.37	4	Yes
	Chemical equilibrium	2.73	0.47	8	Yes

Table 5.40 shows that the teachers were highly confident to teach matter and materials, and chemical changes (regular curriculum concepts), ranked 1 to 9, and least confident on the chemical systems, which include the lithosphere and the atmosphere (industrial concepts).

Influences of academic qualifications on subject knowledge towards teaching efficacy

A significant association between the respondents' academic qualifications and confidence to teach was observed for the following concepts:

- gas laws, $X^2(6, N = 82) = 17.51$, p=0.008
- energy changes in chemical reactions $X^2(3, N = 81) = 12.28$, p=0.006

The respondents with Science majors had higher confidence and self-efficacy to teach these concepts than those with different qualifications.

A significant association between the respondents' professional qualifications and confidence to teach was observed for the following concepts:

- Chemical equilibrium $X^2(8, N = 109) = 118.23$, p=0.000.
- Acids and bases $X^2(4, N = 110) = 12.73$, p=0.013
- Rate of chemical reactions $X^2(8, N = 106) = 56.60$, p=0.000
- Energy changes in chemical reactions $X^2(4, N = 108) = 13.58$, p=0.009
- Reactions of organic compounds $X^2(8, N = 107) = 57.40$, p=0.000
- Nomenclature of organic compounds $X^2(8, N =107) = 17.87$, p=0.022.

In addition, professional qualification was significantly related to their confidence in teaching chemical industry, $X^2(8, N = 110) = 18.58$, p= 0.017 in that 60% of the 142 respondents with professional qualifications were confident to teach this concept.

5.6.2 Physics

Physics forms paper 1 of the Physical Science examination of the NSC. A number of concepts were selected from CAPS and the respondents rated their confidence in teaching those concepts according to the Likert scale: 1 = not confident, 2 = slightly confident, 3 = confident. Table 5.41 shows the content knowledge levels of the respondents.

Table 5.41: Physics content knowledge of the four districts (N=190)

Concept	Xhariep		Motheo		Thabo Mofut-sanyana		Fezile Dabi	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Vectors in two dimensions	2.69	0.58	2.73	0.59	2.61	0.68	2.76	0.54
Newton's laws and application	2.94	0.24	2.92	0.29	2.94	0.23	2.82	0.51
Momentum and impulse	2.94	0.24	2.94	0.32	3.00	0,00	2.94	0.24
Vertical projectile motion in 1D	2.88	0.33	2.82	0.49	2.79	0.41	2.71	0.46
Work, energy and power	2.81	0.39	2.77	0.55	2.74	0.44	2.88	0.32
Geometrical optics	2.81	0.39	2.53	0.68	2.47	0.68	2.53	0.49
2D wavefronts	2.69	0.39	2.61	0.55	2.68	0.46	2.71	0.46
3D wavefronts	2.63	0.46	2.44	0.57	2.26	0.64	2.53	0.49
Doppler effect	2.75	0.56	2.69	0.62	2.79	0.52	2.81	0.39
Electrostatics	2.93	0.24	2.91	0.32	2.95	0.22	2.94	0.24
Electromagnetism	2.88	0.33	2.71	0.48	2.79	0.41	2.65	0.48
Electric circuits	2.88	0.48	2.86	0.37	2.74	0.44	2.94	0.24
Average mean and SD	2.82	0.17	2.74	0.24	2.73	0.21	2.77	0.20

It is evident from Table 5.41 that teachers revealed a very high level of confidence in all the concepts of the Physics section. 3D wavefronts ranked the lowest in the four districts, whilst momentum and impulse ranked the highest, as shown in summary table 5.41(b).

Table 5.41(b): Summary on the Physics content knowledge

District	Highest score	Lowest score	Range	Skewness
Xhariep	2.94	2.63	0.31	-0.51
Motheo	2.94	2.44	0.50	-0.57
Thabo Mofutsanyana	3.00	2.26	0.74	-0.98
Fezile Dabi	2.94	2.53	0.41	-0.54

Respondents showed high confidence in the outlined Physics concepts in Table 5.41 above. Comparing the two tables (5.40 and 5.41) above, it is worth noting (as shown in Figure 5.13) that in all the districts respondents had higher overall confidence in the Physics concepts than they did in the Chemistry concepts. It is also important to note that in both the Physics and Chemistry components of Physical Science, the Xhariep district had the highest confidence levels.

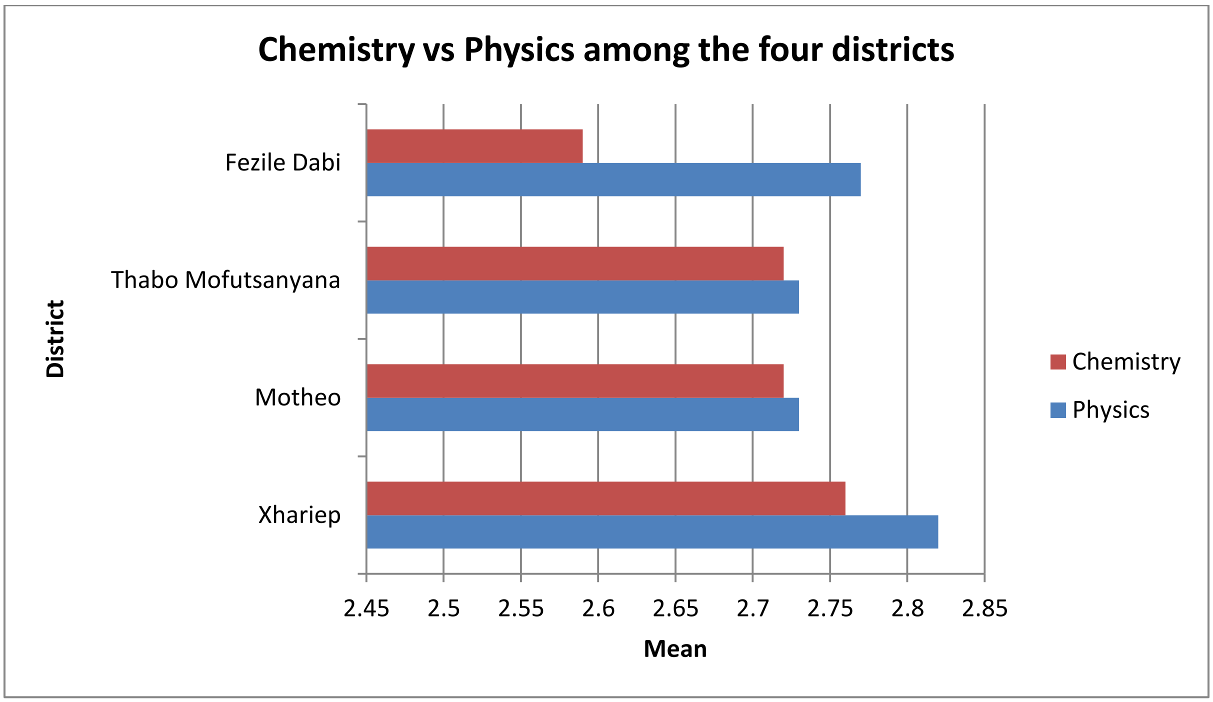


Figure 5.13: Comparison of the Physics and Chemistry content knowledge (N=190)

Respondents' confidence in teaching selected Physics concepts

Table 5.42 provides information on the teachers' confidence levels in teaching the selected Physics concepts, according to the three knowledge areas out of six of Physical Science in terms of CAPS.

Table 5.42: Teacher Confidence in Teaching Selected Physics Concepts (N=190)

Knowledge Area	Concept	Mean	SD	Rank order	Regular curriculum concept (Yes/No)
Mechanics	Vectors in two dimensions	2.69	0.58	5	Yes
	Newton's laws and their application	2.94	0.24	1	Yes
	Momentum and impulse	2.94	0.24	1	Yes
	Vertical projectile motion in one dimension	2.88	0.33	2	Yes
	Work, energy and power	2.81	0.39	3	Yes
Waves, sound and light	Geometrical optics	2.81	0.39	3	Yes
	2D wavefronts	2.69	0.46	5	No
	3D wavefronts	2.63	0.48	6	No
	Doppler effect	2.75	0.56	4	Yes
Electricity and magnetism	Electrostatics	2.94	0.24	1	Yes
	Electromagnetism	2.88	0.33	2	Yes
	Electric circuits	2.88	0.48	2	Yes

A significant association between the respondents' professional qualifications and confidence to teach was observed for the following concepts:

- vertical projectile motion in one dimension, $X^2(8, N = 107) = 25.01$, p=0.002
- geometrical optics $X^2(8, N = 108) = 30.71$, p=0.000
- 2D wavefronts $X^2(8, N = 108) = 37.80$, p=0.000
- 3D wavefronts $X^2(8, N = 108) = 26.53$, p=0.01
- Doppler effect $X^2(8, N = 107) = 29.38$, p=0.000

A significant association between the respondents' academic qualifications and confidence to teach was observed for vertical projectile motion in one dimension, $X^2(3, N = 80) = 12.62$, p=0.006 since 66% of the 80 respondents were confident to teach this concept.

The next section presents the results on subject content knowledge and teaching efficacy beliefs.

MANOVA was conducted to determine if there was a relationship between the teachers' subject content knowledge and teaching efficacy beliefs (PSTE and STOE sub-scales). Table 5.15 to Table 5.18 present the relevant descriptive statistics. The results of MANOVA determining this relationship in teaching efficacy and Chemistry content knowledge are presented in Tables 5.43 and Table 5.44, and Physics content knowledge are presented in Tables 5.45 and Table 5.46, respectively.

Table 5.43: Correlations on Chemistry content knowledge and PSTE sub-scale

Correlations

		Total of Chemistry Content Knowledge	Personal Science Teaching Efficacy sub-scale total
Total of Chemistry Content Knowledge	Pearson Correlation	1	.383**
	Sig. (2-tailed)		.000
	N	143	143
The Personal Science Teaching Efficacy sub-scale (PSTE) total	Pearson Correlation	.383**	1
	Sig. (2-tailed)	.000	
	N	143	190

**. Correlation is significant at the 0.01 level (2-tailed).

There was a significant positive correlation between Chemistry content knowledge and the PSTE sub-scale (r=0.383; p=0.000). This means that the higher the teachers' content knowledge of Chemistry, the higher their scores on the PSTE sub-scale.

Table 5.44: Correlations on Chemistry content knowledge and STOE sub-scale

Correlations

		Total of Chemistry Content Knowledge	Science Teaching Outcome Expectancy total
Total of Chemistry Content Knowledge	Pearson Correlation	1	.152
	Sig. (2-tailed)		.069
	N	143	143
STOE sub-scale total	Pearson Correlation	.152	1
	Sig. (2-tailed)	.069	
	N	143	190

There was no significant relationship between Chemistry content knowledge and the STOE sub-scale (r=0.152; p=0.069). This meant that irrespective of their high confidence levels in Chemistry content knowledge, teachers doubted that their knowledge could influence their learners' outcome.

The next section focuses on teachers' Physics content knowledge.

Table 5.45: Correlations on Physics content knowledge and PSTE sub-scale

Correlations

		Personal Science Teaching Efficacy sub-scale (PSTE) total	Total of Physics Content Knowledge
Personal Science Teaching Efficacy sub-scale total	Pearson Correlation	1	.380**
	Sig. (2-tailed)		.000
	N	190	144
Total of Physics Content Knowledge	Pearson Correlation	.380**	1
	Sig. (2-tailed)	.000	
	N	144	144

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.45 shows that there was a significant positive correlation between Physics content knowledge and the PSTE sub-scale (r=0.380; p=0.000). This means that the higher the teachers' content knowledge of Physics, the higher their score on the PSTE sub-scale.

Table 5.46: Correlations on Physics content knowledge and STOE sub-scale

Correlations

		Total of Physics Content Knowledge	Science Teaching Outcome Expectancy total
Total of Physics Content Knowledge	Pearson Correlation	1	.113
	Sig. (2-tailed)		.177
	N	144	144
Science Teaching Outcome Expectancy total	Pearson Correlation	.113	1
	Sig. (2-tailed)	.177	
	N	144	190

There was no significant relationship between Physics content knowledge and the STOE sub-scale (r=0.113; p=0.177). As with Chemistry, teachers' high confidence levels in Physics content knowledge did not influence their STOE.

Influence of teaching efficacy beliefs

This section reports on the influence of the respondents' academic and professional qualifications on their teaching efficacy beliefs. As shown in Table 5.47, the teachers' Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) were reported per academic and professional qualifications.

Table 5.47: Respondents' PSTE and STOE per Academic and Professional Qualification

Academic qualification	PSTE	STOE
Bachelor of Science (N = 53)	54.1	40.00
Bachelor's degree other than Science (N = 27)	51.1	39.40
Bachelor of Science (Hon) (N = 14)	53.5	38.9
Master of Science (N = 5)	52.8	42.2
Professional qualification		
Bachelor of Science in Education (N = 23)	52.9	41.3
Bachelor of Education in Further Education and Training (N = 34)	52.9	41.1
Diploma in education (N = 57)	53.6	38.7
Certificates in education (N = 28)	51.5	39.1

It must be noted from Table 5.47 that STOE was somewhat lower than PSTE for both professional and academic qualifications.

When the PSTE and STOE are related to teachers' qualifications to determine their effect on content knowledge, it can be further established that teachers with professional qualifications had higher STOE than those with academic qualifications.

5.6.3 Physical Science knowledge areas

As discussed in Chapter 2, Physical Science has six knowledge areas. Tables 5.40 and 5.42 present data on the six knowledge areas, the different concepts that fall under each knowledge area, and the mean to indicate the teachers' confidence levels in teaching those selected Physical Science concepts. It is important to note that in most schools, a teacher teaches both Chemistry and Physics and most of them are qualified more in Physics than they are in Chemistry, so they end up focusing more on Physics than they do on Chemistry. Also, they choose to start with Physics and spend more time on Physics than they do on Chemistry.

Figure 5.14 gives a schematic representation of the respondents' level of confidence to teach the six knowledge areas of Physical Science, as prescribed by CAPS. It is evident that the respondents' lowest confidence level is in chemical systems, which form part of Chemistry.

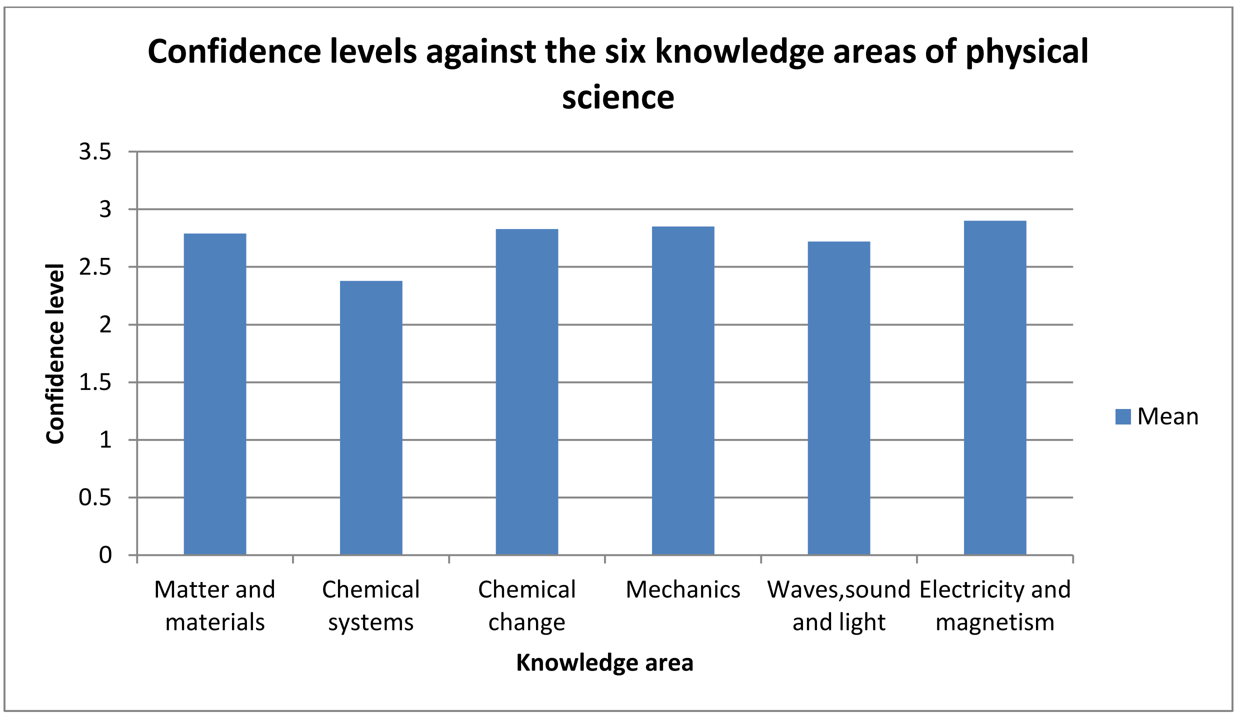


Figure 5.14: Respondents' confidence levels of Physical Science knowledge areas

Research has shown that teachers' efficacy influences learners' performance (Holden, Judy, Bloom & Weinburgh, 2011). The results of the 2012 National Senior Certificate (Grade 12) are outlined per district in Table 5.48 below to give an indication of the teachers' confidence levels and its impact on learners' learning.

Table 5.48: 2012 Grade 12 Physical Science results per district (DBE,2012)

District	Percentage achieved at 30% and above
Xhariep	25.19%
Motheo	48.28%
Thabo Mofutsanyana	70.80%
Fezile Dabi	64.21%
Lejweleputswa	76.8%

Lejweleputswa district had the highest pass percentage in Physical Science in 2012, followed by Thabo Mofutsanyana, Fezile Dabi, Motheo, and lastly, Xhariep. A 2011 Grade 12 Free State province Physical Science moderator's report (DBE, 2011) indicated that there was no improvement in the learners' performance, even though the teachers seemed to be confident in their content knowledge. Wheatley (2005) proposed that many pre-service and in-service teachers like to appear more confident in themselves than they really are. Hence, the results obtained need to be interpreted with caution. These findings are similar to the overall STEBI-A score where teachers rated their confidence very high (Table 5.10) and yet produced a low pass percentage in the 2012 Grade 12 results. However, these findings are contrary to the results of the teachers' confidence to teach the selected Physical Science concepts (Tables 5.39 and 3.40), where the teachers showed high confidence levels. A limitation of this study is that the teachers did not write any tests on the Physical Science concepts. They self-reported on their personal confidence and efficacy in teaching the selected concepts. Moreover, pedagogic knowledge was not considered. Pedagogic content knowledge includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that learners of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (Shulman, 1986, 1987). Teachers with lower pedagogic knowledge may have lower teaching confidence and self-efficacy.

The next section focuses on the practical aspect of teachers' level of preparedness to teach Science.

5.7 Relationship between practical work and teaching efficacy

Practical work in the laboratory contributes towards making Science relevant. This section of the questionnaire sought information on the extent to which practical work was conducted in classrooms; it also probed the level of the teachers' confidence in conducting the selected examinable experiments, in line with the CAPS document specifications.

5.7.1 Extent to which respondents conduct practical work

The results in Table 5.49 below are a representation of the extent to which practical work was conducted in classrooms. The teachers were requested to use the following ranking: Never = 1, Rarely = 2, Occasionally = 3 and Often = 4.

Table 5.49: The extent to which practical work is conducted

	Xhariep		Motheo		Thabo Mofut-sanyana		Fezile Dabi	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I perform a demonstration using bought apparatus.	2.94	0.90	2.89	0.97	3.25	1.59	2.81	0.88
I perform a demonstration using improvised apparatus.	2.6	0.99	2.94	0.89	2.75	0.53	2.81	1.03
I perform demonstrations, but with learner participation, and these demonstrations promote inquiry thinking rather than just illustrate concepts.	2.69	0.85	2.89	0.79	3.38	0.27	3.19	0.66
Learners use data from demonstrations to construct their own graphs and tables.	3.19	0.95	3.21	0.79	3.5	0.35	3.44	0.63
Learners perform practical work in groups using apparatus and are told what to do, either by me or a worksheet.	3.06	1.03	2.87	0.99	2.56	1.02	2.75	0.82
Learners perform practical work in groups using apparatus. They are given a problem or question and they design their own experiment to ensure that their data is accurate.	2.75	0.97	2.44	1.05	2.06	0.75	2.25	1.03

It is evident from Table 5.49 above that practical activities were performed from a range of rarely to occasionally. Table 5.49(b) shows the summary of the extent to which practical work was conducted in secondary schools in terms of the highest and the lowest ranked approaches per district.

Table 5.49(b): Summary on the extent to which practical work is conducted

District	Highest score	Lowest score	Range	Skewness
Xhariep	3.19	2.60	0.59	-1.37
Motheo	3.21	2.44	0.77	-1.02
Thabo Mofutsanyana	3.50	2.06	1.44	1.09
Fezile Dabi	3.44	2.25	1.19	0.17

Table 5.49 (b) shows that the extent to which practical work was conducted in the four districts are mostly through learners using data from demonstrations to construct their own graphs and tables. The least used method in the three districts was whereby learners actually perform practical work in groups using apparatus and they were given a problem or question to design their own experiment to ensure that their data was accurate. Xhariep was the only district whereby the option where a teacher performed a demonstration using improvised apparatus was rated the lowest.

From the above results it must be noted that inquiry learning was not encouraged because most of the practical work was done through the use of step-wise guidelines in which learners perform practical work in groups using apparatus and were told what to do, either by the teacher or a worksheet. Learners were not given a problem or question and had to design their own experiment to ensure that their data was accurate

In the next section, the respondents were expected to indicate how confident they were in conducting the experiments from a list compiled from the CAPS document for assessment for Grade 10 to Grade 12.

5.7.2 Confidence to conduct selected CAPS experiments

Respondents were requested to rank their confidence to conduct Physical Science experiments according to the ranking:

Fully confident = 4, Confident with a little guidance = 3, I can manage but depend on advice from others = 2, I need help to develop my knowledge and skills = 1.

Table 5.50: Confidence levels to conduct experiments

Experiment number and name	Xhariep		Motheo		Thabo Mofutsanyana		Fezile Dabi	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. Heating and cooling curve of water.	3.19	1.01	3.26	0.85	3.19	0.57	3.25	0.99
2. Electric circuits with resistors in series and parallel-measuring potential difference and current.	3.25	1.15	3.48	0.97	3.56	0.31	3.63	0.62
3. The effects of intermolecular forces: boiling points, melting points, surface tension, solubility, capillarity.	3.06	1.03	3.03	0.99	3.31	0.22	3.13	0.97
4. Investigating the relationship between force and acceleration (Verification of Newton's second law).	3.00	1.17	3.31	0.88	3.25	0.53	3.38	0.84
5. Preparation of esters.	2.81	1.18	2.82	0.98	2.63	1.15	2.19	1.09
6. How do you use the titration of oxalic acid against sodium hydroxide to determine the concentration of the sodium hydroxide?	2.75	1.25	3.09	1.14	3.06	1.45	2.69	1.09
7. Conservation of linear momentum.	3.13	1.17	3.25	0.93	3.44	0.39	3.25	1.06
8. Determining the internal resistance of a battery.	3.31	1.1	3.07	0.78	3.25	0.88	3.44	0.63
9. Setting up a series-parallel network with known resistor. Determine the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value.	3.25	1.15	3.13	1.04	3.19	0.57	3.69	0.61

Generally, teachers needed some kind of support to perform experiments; they battled to survive on their own when it came to practical work. They were mostly confident with a little guidance, as their score ranged between 2.19 and 3.69.

Table 5.50(b) presents a summary on the respondents' level of confidence to conduct the selected experiments.

Table 5.50(b): Summary on the level of confidence to conduct the selected experiments.

District	Highest score	Lowest score	Range	Skewness
Xhariep	3.31	2.75	0.56	0.10
Motheo	3.48	2.82	0.66	-1.96
Thabo Mofutsanyana	3.56	2.63	0.93	-0.49
Fezile Dabi	3.69	2.19	1.5	1.12

Experiment 5 (Preparation of esters) was the experiment in which teachers from the three districts had the lowest confidence in, apart from Xhariep in which the lowest confidence was found in experiment 6 (How do you use the titration of oxalic acid against sodium hydroxide to determine the concentration of the sodium hydroxide?). For all the four districts, teachers showed the highest confidence levels in performing Physics experiments, two districts in experiment 2 (Electric circuits with resistors in series and parallel–measuring potential difference and current), and the other two in experiment 8 (Determining the internal resistance of a battery), and 9 (Setting up a series-parallel network with known resistor and determining the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value) for Xhariep and Fezile Dabi, respectively.

The average mean confidence for the entire province is illustrated in Figure 5.15.

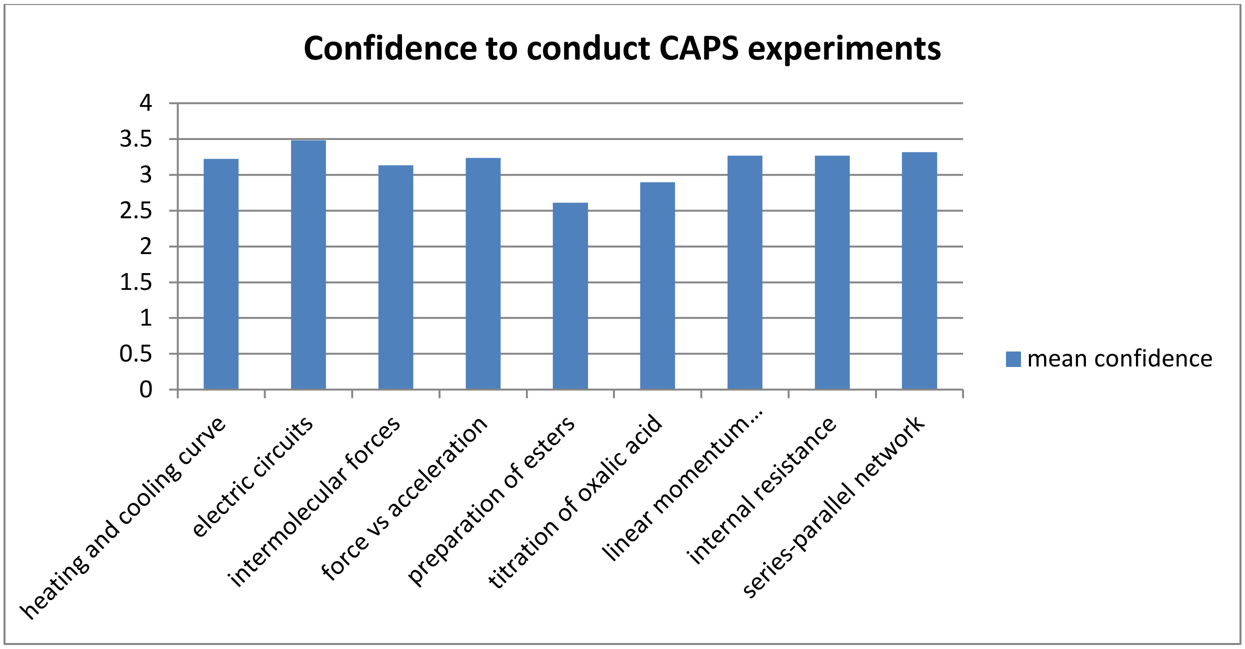


Figure 5.15: Average mean confidence to conduct examinable CAPS experiments

The next section provides the result of the relationship between practical work frequency and teachers' confidence in conducting experiments and teaching efficacy.

The results of MANOVA determining the relationship between practical work frequency and teachers' confidence in conducting experiments and teaching efficacy are presented in Table 5.51 below.

Table 5.51: Practical work frequency and PSTE sub-scale

Correlations

		PSTE total	Extent of practical work total
PSTE sub-scale total	Pearson Correlation	1	.192**
	Sig. (2-tailed)		.008
	N	190	189
Extent of practical work total	Pearson Correlation	.192**	1
	Sig. (2-tailed)	.008	
	N	189	189

**. Correlation is significant at the 0.01 level (2-tailed).

There was a significant positive correlation between the frequency of practical work and scores on the PSTE sub-scale (r=0.192; p=0.008). This means that the higher the frequency of practical work conducted, the higher the teachers' scores on the PSTE sub-scale.

The next relationship explored was between the practical work frequency and the STOE sub-scale scores.

Table 5.52: Practical work frequency and STOE sub-scale

Correlations

		Extent of practical work total	STOE sub-scale total
Extent of practical work total	Pearson Correlation	1	.158*
	Sig. (2-tailed)		.030
	N	189	189
STOE sub-scale total	Pearson Correlation	.158*	1
	Sig. (2-tailed)	.030	
	N	189	190

*. Correlation is significant at the 0.05 level (2-tailed)

After Bonferroni adjustment for multiple correlations, there was a significant correlation between the frequency of practical work and the STOE sub-scale (r=0.158; p=0.030). Even though p<0.05, it was still not a significant result since multiple correlations were done; the significance level was also adjusted. There was no meaningful relationship between the frequency of practical work conducted and the teachers' scores on the STOE sub-scales.

Table 5.53: Teachers' confidence in conducting experiments and PSTE

Correlations

		Total of Practical Work Confidence	PSTE sub-scale total
Total of Practical Work Confidence	Pearson Correlation	1	.284**
	Sig. (2-tailed)		.000
	N	189	189
The Personal Science Teaching Efficacy total	Pearson Correlation	.284**	1
	Sig. (2-tailed)	.000	
	N	189	190

**. Correlation is significant at the 0.01 level (2-tailed).

There was a significant positive correlation between the confidence of teachers in conducting experiments and scores on the PSTE sub-scale (r=0.284; p=0.000). This means that the higher the teachers' confidence in conducting experiments, the higher their scores on the PSTE sub-scale.

The next section focuses on teachers' confidence in conducting experiments and their STOE scores.

Table 5.54: Teacher's confidence in conducting experiments and STOE

Correlations

		Total of Practical Work Confidence	Science Teaching Outcome Expectancy sub-scale total
Total of Practical Work Confidence	Pearson Correlation	1	-.005
	Sig. (2-tailed)		.942
	N	189	189
Science Teaching Outcome Expectancy total	Pearson Correlation	-.005	1
	Sig. (2-tailed)	.942	
	N	189	190

There was no significant relationship between teachers' confidence in conducting experiments and scores on the STOE sub-scale (r=-0.005; p=0.942). Once again, it seems that teachers' confidence in conducting experiments and the frequency of practical work had an influence on scores on the PSTE sub-scale, but not on STOE sub-scale scores.

From these results, we can see that the teachers rated themselves more confident in conducting Physics experiments than in Chemistry experiments. The interviews further found that teachers rated themselves more confident in conducting Physics experiments because they felt that Physics experiments were easy to execute and they were not exposed to hazardous materials, as in Chemistry. They further indicated that they were afraid of getting wrong calculations that would impact on their findings in Chemistry.

5.8 Relationship between assessment skills and teaching efficacy

Dougherty (in Mchunu, 2009) defines assessment as a process of collecting data about what learners understand and can do, evaluating that data, and making decisions based on that evaluation (Mchunu, 2009). This clearly represents the impact of the STOE sub-scale, because STOE involves teachers' capability to influence learners' outcomes. It is further stated that "if, however, teachers use assessment data only to inform learners, their parents, or the school administration of what learners know, then much of the power of assessment as a learning tool is lost" (Mchunu, 2009).

The assessment strategies are used in this study for different methods, types or tools of assessment. Clark (1996:336) argues that "strategies are conceived at the level of organization and structure", while "tasks are conceived at the level of activities". Maree and Fraser (2004 in Mchunu) offer examples of assessment strategies as well-known traditional assessment instruments or tools such as portfolios, journals, and activity checklists (Mchunu, 2009).

The respondents were requested to rate how they used the assessment strategies outlined according to the following grid: 1 = never, 2 = rarely, 3 = occasionally, 4 = often.

Table 5.55: Rate at which assessment strategies are used per district

In assessing learners, I pay attention to the following:	Xhariep		Motheo		Thabo Mofut-sanyana		Fezile Dabi	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Written theory tests	3.64	0.21	3.64	0.56	3.89	0.31	3.69	0.42
Examinations	3.73	0.15	3.58	0.54	3.61	0.49	3.75	0.42
Assignments	3.80	0.12	3.68	0.53	3.61	0.76	3.47	0.49
Projects	3.47	0.31	3.05	0.80	2.56	0.83	3.00	0.78
Practical work (hands-on)	3.21	0.45	3.10	0.81	3.22	0.71	3.44	0.72
Practical tests	3.43	0.33	3.30	0.73	3.06	0.78	3.31	0.58
Quizzes	2.07	0.04	2.34	1.00	2.18	0.92	2.56	1.20
Oral presentations	2.43	0.80	2.68	1.05	2.22	0.79	2.53	1.05

Table 5.55 shows the assessment strategies used in the districts of the Free State province. Generally, the first four modes of assessment (written theory tests,

examinations, assignments and projects) are utilised more than the last four. Quizzes are the least utilised method of assessment, as shown in Figure 5.16.

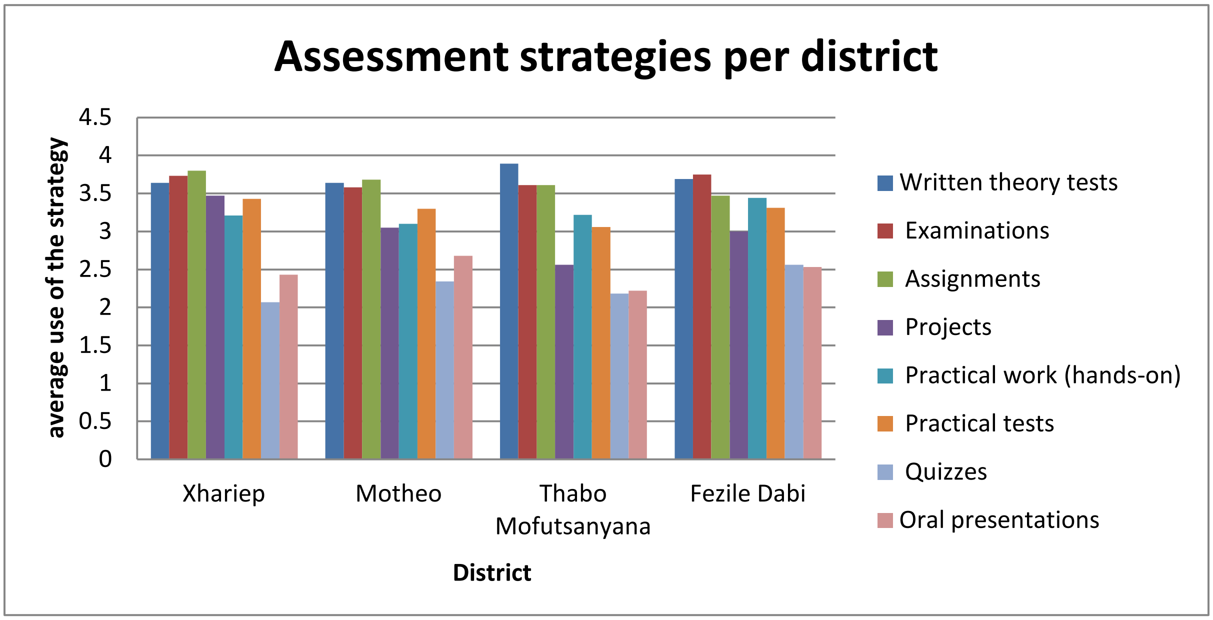


Figure 5.16: Assessment strategies per district

Assessment practices and PSTE

The results of MANOVA determining the relationship between teaching efficacy and teachers' confidence in assessment practices are presented in Table 5.56 below.

The first relationship tested was on the teachers' confidence in assessment practices and scores on the PSTE sub-scale.

Table 5.56: Assessment practices and PSTE

Correlations

		Mean of Assessment Practices	PSTE sub-scale total
Mean of Assessment Practices	Pearson Correlation	1	.142
	Sig. (2-tailed)		.091
	N	143	143
Personal Science Teaching Efficacy sub-scale total	Pearson Correlation	.142	1
	Sig. (2-tailed)	.091	
	N	143	190

There was no significant relationship between teachers' confidence in assessment practices, and scores on the PSTE sub-scale (r=0.142; p=0.091). Thus, there was no meaningful relationship between confidence in assessment practices and the PSTE sub-scale.

The next section looks at the relationship between confidence in assessment practices and STOE scores.

Table 5.57: Assessment practices and STOE

Correlations

		Mean of Assessment Practices	STOE sub-scale total
Mean of Assessment Practices	Pearson Correlation	1	.046
	Sig. (2-tailed)		.581
	N	143	143
Science Teaching Outcome Expectancy sub-scale total	Pearson Correlation	.046	1
	Sig. (2-tailed)	.581	
	N	143	190

Table 5.57 shows that there was no significant relationship between teachers' confidence in assessment practices and STOE sub-scale scores (r=0.046; p=0.581). Thus, there was no meaningful relationship between confidence in assessment practices and the STOE sub-scale.

Teaching, learning and assessment are like the two sides of the same coin. Therefore, it is imperative for teachers to use the assessment strategies that influence the achievement of the learning outcomes.

The next section presents the aspects on open-ended questions where respondents were required to indicate any other problems that they encounter in their Science classrooms.

5.9 General problems encountered by Physical Science teachers

Participants were given the opportunity to express themselves freely in responding to the four open-ended items in the questionnaire. The researcher endeavoured to get an idea of the problems encountered by the participants in teaching Physical Science and what they perceived as challenges towards the teaching, learning, practical work and assessment of Science in secondary schools.

The verbatim responses were coded and categorised. Comments were mainly made on lack of resources and support material, overcrowding, workload, and learners' poor knowledge of Physical Science in secondary schools. Respondents identified problems relating to assessment, included large numbers of learners to be assessed, limited time for assessments, excessive amounts of administrative work, and unclear guidelines and lack of knowledge on the use of rubrics.

Even though most of the participants did not respond to the open-ended questions to write commentary statements, a number of common factors were identified from those who responded. Problems teachers encountered in the teaching of Science, as identified by them, included:

- Lack of resources
- Poor learner motivation and lack of parental involvement
- Learners' poor Chemistry basic principles content knowledge
- Learners poor Mathematics knowledge
- Learners' choice of relevant equations, especially with work, energy and power
- Introduction of new concepts
- Overcrowding
- Language difficulty

Problems Science teachers encounter in conducting practical work:

- Lack of resources
- Overcrowding
- Insufficient time

Problems encountered by teachers in the assessment of Physical Science:

- Use of rubrics and unclear guidelines
- Not enough time for assessment
- Teachers' work overload and excessive paperwork
- Large numbers of learners to be assessed

5.10 Conclusion

The research findings presented in this chapter identified the various factors that impact on Science teachers' efficacy in the five districts of the Free State province of South Africa. The demographic factors, as well as teachers' level of preparedness to teach Science, were investigated in relation to teachers' self-efficacy beliefs.

CHAPTER 6

QUALITATIVE DATA PRESENTATION AND ANALYSIS

6.1 Introduction

This chapter presents data gathered through the semi-structured interviews (see Appendix F) conducted with 17 respondents, out of the 20 chosen to participate. This is a follow-up account of a descriptive study of Science teaching efficacy of Physical Science teachers of secondary schools in the Free State province. This is to provide a data source to develop a deeper understanding about Science teachers' confidence, the relationship between the major subjects teachers they took during their pre-service training and the subjects they are teaching at the moment, the general problems they encounter in teaching Physical Science, the type of support they receive from their principals and learning facilitators, the type of training and workshops they undergo, what boosts their confidence and what frustrates them regarding the teaching of Science.

6.2 Findings

Five category headings were generated from the data and under these all the data were accounted for. Different themes emerged from these categories. These themes mostly address the factors that influence the teaching efficacy of secondary school teachers of the Free State province, as presented in the next section.

6.2.1 What teachers like about teaching Science that boosts confidence?

The respondents like teaching Science for various reasons. These reasons range from Science being a practical subject that links the classroom situation with real-life, to Science making them aware of the world and the environment and giving them exposure to real-life. The respondents said Science was one of the most exciting subjects to teach; it had the ability to spark curiosity from learners. They also indicated that teaching Science boosts one's dignity and respect in the teaching and learning fraternity. One opined that:

> "When you teach Science, the community takes you seriously. Remember, Science was always perceived to be a difficult subject. And as a woman like myself, it gives me even more credit".

Another respondent noted that for one to be able to cope with a subject, it was important to have self-love:

> "Uhm… I don't know, I feel that there is something very important to add on. Liking something begins with self-love, love yourself then your learners and the feeling is going to be mutual towards the subjects. Learners will realise that you teach something that you really enjoy, and this will be instilled in the learners and they will have a state of mind that is ready to and willing to learn; this will thus boost their participation in the subject".

The respondents emphasised that there were a number of factors that made some teachers more confident in teaching Physical Science than other teachers. These factors contributed to teachers' confidence. One respondent stated the following:

> "These teachers have empowered themselves in this subject because of their qualifications and training. They like the subject and they feel free to relate the Science that we experience in our daily lives to the Science that we teach in the classrooms; I believe this is basically what Science is all about".

Moreover, the way learners responded to the methods that teachers used gave them confidence in the classroom as teacher-learner interaction took place. Their ability to solve complicated and higher order problems also boosted the teachers' confidence because they were in a position to rate their own teaching, based on the learners' performance. Teaching and learning is a two-way process - for teaching to take place, learning must also take place, and vice versa.

The themes that emerged from this category are:

- Proper planning, and
- Support from principals and subject advisors.

6.2.2 What frustrates the teachers regarding the teaching of Science?

The respondents elaborated on their confidence in teaching Physical Science and re-affirmed that they were confident to teach most of the concepts. They further said that proper planning and instructional support from the HODs and principals boosted their confidence more. However, lack of integration between theory and practicals affected their confidence, as one teacher said:

> "I like the subject, but it is frustrating to find that some concepts become very difficult for learners if no or few practicals are done".

Amongst the challenges highlighted by the respondents was teaching learners who were not prepared to learn. Learners were of the opinion that it was easy for them to pass Science because they needed only 30 percent to pass. In addition, learners had lost interest in the subject and this affected their readiness and willingness to learn. The respondents expressed concern about the pass percentage of 30. One respondent verbalised this sentiment as follows:

> "Most learners take a pass level as low as level 2 to guarantee them exit. This 30% pass percentage has limited the learners from broadening their horizons and doing their best. Passing is no longer about getting the best grades to allow one entry into university like it used to be in the past".

The same sentiments were shared by Dr Mamphele Ramphele in her inaugural lecture "Educating the 21st Century" at the University of the Free State on 25 October 2012:

> "The irony of our situation is that the freedom we enjoy today was fought for by young people: university, high school and civil society groups with quality education as the rallying cry. How did we lose the plot? How have we become so tolerant of mediocrity in our education system that we can have people

> defining themselves as education specialists and former activists, saying that 30% is good enough as a pass mark for matriculating students? Would they get into a car being driven by a person with 30% knowledge of the rules of the road? Would they tolerate this low level of ambition if their relatives' children were being subjected to an education process that fails to teach them 70% of what they need to know?"

The other burning issue raised by the respondents was lack of parental involvement in their children's learning, as expressed by a respondent:

> "Learners who choose to do Science and are not 'Science material' make it difficult for us as teachers because parents force their kids to do Science and yet they do not support them. Learners pass at low levels and their pass rate is also low".

If parents are not fully involved in their children's learning, commitment and discipline become almost unattainable. This was confirmed in Chapter 3 through a study by Smith & Schalekamp (in Letlhoko, Heystek & Maree, 2001) that showed that learners' lack of motivation to learn and their ability to concentrate in class; language skills; self-discipline and punctuality are some of the factors that have a negative influence on the learning environment.

Grade 10 teachers also expressed frustration at learners from Grade 9 who were not well-prepared and ready to grasp Grade 10 work. One respondent expressed it as follows:

> "There is a huge gap between GET and FET; this gap needs to be bridged to allow progression. Our school is a combined school but we are still struggling; the problem becomes even worse when we get learners from other schools to join us in Grade 10".

Even though the Grade 9 syllabus for Natural Science involves a number of Physical Science concepts, most teachers experienced problems with learners' subject knowledge foundation on basic principles.

Amongst other factors, lack of resources, equipment and laboratories were also mentioned. Generally, most of the schools that participated in the research had infrastructural challenges, apart from a few, including the Dinaledi School. Even though this school is well-resourced, the teacher interviewed stated that more training was required in order to fully utilise the resources. According to a respondent:

> "INSET must be brought back; we need to be empowered from time to time in order to meet the day-to-day challenges of Science teaching …".

This respondent then referred to the researcher:

> "… I still need you to come and assist me with the equipment that was sponsored; there needs to be an interaction with the varsity people".

Thus, it is important for the sponsors to ensure that equipment is not just delivered to schools; there must be a system in place to ensure that teachers are given support and training in the use of the equipment, thus ensuring that laboratory equipment is fully utilised. According to the Education and Social Policy Department of the World Bank (1993) in Musar (1993), teacher training has been highlighted as one of the possible reasons why equipment supply projects fail whereby proper in-service training is often not available when new equipment is supplied to schools. Although well-prepared manuals and teachers guides may be supplied, they are frequently not enough to ensure efficient use of the equipment. In-service training was essential, especially when new equipment was accompanied by changes in the curriculum (Musar, 1993).

Professional development is another area that needs more attention. A majority of the teachers felt that their confidence and effectiveness in teaching Physical Science could be enhanced by more training and workshops to assist them specifically on how to conduct experiments. They were also in need of content knowledge workshops that lasted longer than a few days. The excerpts below are representative of the teachers' discontent:

> "We get one-day workshops where they train us for content knowledge skill and these workshops are far apart."
>
> "Yes, we do attend workshops, especially when there is a change in the education system, first it was OBE, NCS and now CAPS. The CAPS workshop lasts for three to five days."

This seems to be a recurring problem (as confirmed by similar findings by Ramokgopa) to determine the significance of teacher in-service training regarding NCS implementation, as it was found that most participants did not receive in-service training on the principles of integration, organised by the Department of Education. Participants who had undergone training viewed it as insufficient as it was held over a few days, or over a few hours after school. Participants were, therefore, dissatisfied with the type of training they had received (Ramokgopa, 2013). It is imperative that the DoE pays attention to professional development because effective professional development can have a long-term effect on how teachers view their self-efficacy (Watson, 2006)

The themes that emerged from this category are:

- Lack of integration between theory and practicals,
- Learner unpreparedness,
- Lack of parental support,
- Thirty percent minimum pass percentage,
- Lack of resources, and
- Lack of in-service training.

6.2.3 Pre-service preparation

The tertiary education experience of most of the teachers interviewed was similar, apart from one respondent who did not have a professional qualification in Education. They completed coursework in specific content knowledge and general education modules, as well as subject-specific didactics that catered for pedagogic knowledge. The respondents reported high levels of satisfaction in terms of their content knowledge. Similarly, the findings of a previous study indicated that teachers who were prepared in teacher education programmes felt significantly better prepared across most dimensions of teaching than those who entered teaching through alternative programmes or without preparation (Darling-Hammond, Chung & Frelow, 2002)

In regards to pre-service training, the respondents indicated that their pre-service training has prepared them adequately to teach secondary school Science. One respondent said the following:

> "I trained at a well-equipped institution; the lecturers there made me become a better teacher I am today".

However, not all the teachers felt as confident. One respondent observed:

> "I don't have any problem about methodology classes, but they must train us in laboratory work".

Due to the changes in the educational system and curriculum, teachers are faced with new concepts they have to teach. This is highlighted by this excerpt from one of the respondents:

> "I think I need more knowledge because there are some topics that are not easy for me to teach; I did not get any training in these topics. What shall I do? I learn as I teach my learners; that is why we give these topics to learners as self-study".

The themes that emerged from this category are:

- Teachers' lack of training in laboratory work; and
- Curriculum change.

6.2.4 Relationship between major subjects and subjects currently taught by the teachers

Physical Science comprises Physics as paper 1 and Chemistry as paper 2 in terms of the NSC. Even though this is treated as one subject at secondary school level, it requires expertise in both sections for effective teaching and learning to take place. At the former colleges of education, pre-service teacher training in the secondary phase would automatically be provided to teach Physical Science, but in the current qualifications through universities and universities of technology, these two components are treated as separate subjects.

Even though all the teachers interviewed taught both Physics and Chemistry, only 50 percent of the respondents took Physics and Chemistry as their major subjects during their pre-service training. Sixty percent of the respondents indicated that they were more confident in Physics than in Chemistry, and that if given an opportunity to choose between Physics and Chemistry, the majority would choose Physics because it was much easier to teach. One of the respondents expressed this desire as follows:

> “I'll definitely choose to teach Physics; it is so easy to teach, very straightforward so that it can be taught even if there is no laboratory”.

When asked why Physics is chosen over Chemistry, one respondent said:

> “Chemistry is more practical and I'm fearful of getting calculations wrong; just imagine if the molar mass is wrong, the mass will then be wrong, then the experiment fails”.

Many of the respondents indicated that there were no Physics concepts they did not like; but many indicated that there were various Chemistry concepts that they disliked teaching, especially new topics that they did not do during their training, such as lithospheres and fertilisers. This explains why the teachers rated their confidence levels lowest in these concepts in the questionnaires. They added that they disliked chemical systems in the Grade 10 content because it was based on theory and the history of Science. This is in agreement with the finding of the questionnaires whereby out of the six knowledge areas of Physical Science, chemical systems were rated the lowest (see Figure 5.14).

The themes that emerged from this category are:

- Non-specialisation in subject of expertise, and
- Physics is favoured above chemistry.

6.2.5 Type of support teachers receive from principals and learning facilitators

For the effective implementation of Physical Science, a good communication network needs to be established between teachers, the head of department, principals, learning facilitators, suppliers of equipment and materials, and all other stakeholders responsible for the teaching and learning of Science. As stated in Chapter 2, the principal plays a major role as an instructional coach to ensure that the vision of the school is achieved. Jones (2010) asserts that instructional leadership involves developing a common vision of good instruction; building relationships; and empowering staff to innovate in instruction, give one another feedback, and share best practices (Jones, 2010)

Most of the participants stated that their experiences with their principals and learning facilitators were positive. However, there were defiant voices that held opposite views. Although some voiced negative comments on the support from their principals and learning facilitators, these voices also spoke volumes about the significance of the involvement of the principals and learning facilitators in their teaching of Science.

One teacher stated the following:

> "Even though my principal is not a Science person, he always ensures that we as the Science family, (yes, we are a family because we share Physical Science and work effectively together) we get the support that we need. He is a father figure to us, ensures that we get money for transport when we come for extra classes, organises food for the learners so that they do not go hungry, and most importantly, we are allowed to attend workshops and conferences. I attended South African Association of Science and Technology Educators (SAASTE) last

year and now I am confident that I can present next year. When other schools require our assistance in some concepts, he allows us to share our expertise with our fellow colleagues from other schools. He encourages team-teaching".

This statement can ascertain that teachers in this particular school are highly efficacious and motivated to do their work. Similarly, Ryan (2007) found out in his study that examined the relationship between teacher efficacy and teachers' perceptions of their principals' leadership behaviours. According to the outcomes of the study, total respondent data indicates a generally positive relationship between these two variables. Teachers with strong efficacy reported strategies that foster teacher efficacy, make teachers feel good about teaching (cf. Chapter 2). However, the situation might be different in other schools.

Two teachers from different schools had this to say about their principals' support:

"No support, we share nothing with the principal," and, "There was no guidance from the principal at all in my first year of teaching; now I'm in my third year".

The theme that emerged from this category is:

- Supportive and unsupportive principals and Learning Facilitators.

6.3 General problems in teaching Physical Science

This section presents the general problems the teachers encountered in content knowledge, practical work and assessment.

6.3.1 Content knowledge

Teachers were of the opinion that they had to deal with abstract concepts, but whilst practical work was important, due to a lack of resources they could not relate theory to practical work. Science as a subject required them to study and do research; find information and gain technology experience. At the same time, some teachers felt that the content framework kept on changing, but they did not receive sufficient training. They also indicated that there were insufficient exercises for homework purposes.

A substantial number of respondents related their content knowledge to learners' poor background knowledge and foundations on basic principles and laws. Learners leave the GET phase without any knowledge of Physical Science. In grade 9, they are taught Natural Sciences that deal more with Life Sciences and Geography than Physical Science. Unlike in the FET Phase, there is no content document in the GET Phase. Hence, when learners enter Grade 10 they perceive Physical Science as a difficult subject. FET Phase teachers emphasise that there has to be progression of Physical Science between the GET and FET Phases.

As a follow-up from the findings of the questionnaire to determine their confidence in teaching Science, a majority of teachers indicated that they would choose to teach Physics over Chemistry, if given the chance. This agreed with the findings of the questionnaire that indicated that teachers had higher confidence levels in their content knowledge of Physics, than Chemistry (see Figure 5.13).

6.3.2 Practical work

Most of the respondents were of the opinion that their confidence in teaching Science was compromised by their lack of skills to conduct experiments. When asked which section of Physics and Chemistry they were more confident in, the majority of the teachers said none, while some said Physics, and very few chose Chemistry. The reasons for their incompetence in conducting Chemistry experiments ranged from lack of apparatus and chemicals, to fear of dealing with hazardous materials that might put the lives of learners at risk. Those who chose Physics indicated that most of the material was available, making it easy to execute, and that the results were more specific and to the point. They also indicated that improvisation was explored, but emphasised that it was not always feasible.

Teachers revealed a higher confidence in conducting Physics experiments, than Chemistry experiments, whereby learners used data from their teachers' demonstrations to construct their own graphs and tables (see Table 5.49).

To confirm the above findings that teachers prefer Physics to Chemistry, the findings of the questionnaires showed that of the nine Physical Science experiments prescribed by CAPS for Grade 10 to 12 classes, teachers rated themselves the highest in Physics, compared to Chemistry (see Figure 5.15 and Table 5.50). The five Physics experiments were rated the top five, while the four Chemistry experiments were rated the lowest.

To confirm the findings of the questionnaires that overcrowding, lack of resources and insufficient time are major inhibitors to practical work, the interviews further probed that teachers do demonstrations for the learners due to lack of equipment, and where there is some, it is usually not enough for the whole class due to large numbers of learners per class. To attest to the issue of lack of time, one teacher said:

> "Practical work takes too much time, lots of preparation in advance and needs people who are not in any rush".

6.3.3 Assessment

Most teachers did not have any problems with assessment; their main challenge was the amount of administration work they had to do and marking the work of large groups of learners in different learning areas. An important factor raised by one teacher was based on how to prepare and set a question paper for a test or examination:

> "I did not know how to set good standardised papers in terms of lower order and high order; I'm grateful to my mentor because with her assistance, I can now set a proper test. I am now able to evaluate poorly set tests and separate good standard from poor standard".

The teachers also indicated that they encounter problems when they have to assess practical work because learners mostly find the practical section difficult. Since experiments were mostly conducted through teachers' demonstrations or, in some instances, laboratory work was learner-centred depending on the nature and type of experiment where the teacher guided the learners. Some teachers added that there was no hands-on experience for the learners. Because of lack of apparatus, there were demonstrations or no experiment at all. This approach did not promote inquiry learning, thus, it will have implications for the 2014 first CAPS output, and a can of worms might be opened. To tie up with this, the questionnaire data showed that practical tests and hands-on practical work assessment formed part of the four least used methods of assessment (see Table 5.55 and Figure 5.16). The other two were quizzes and oral presentations.

6.4 INTEGRATION OF PHASES 1 AND 2

Both quantitative and qualitative data were gathered and analysed separately. In this section, the researcher integrated the results from the analysis of both sets of data to show how the results from both phases of the study support each other. Thus, the direct comparison of the data provided information on data sources and enabled the integration process. The process of integrating the two phases of the research study is illustrated in Figure 6.1:

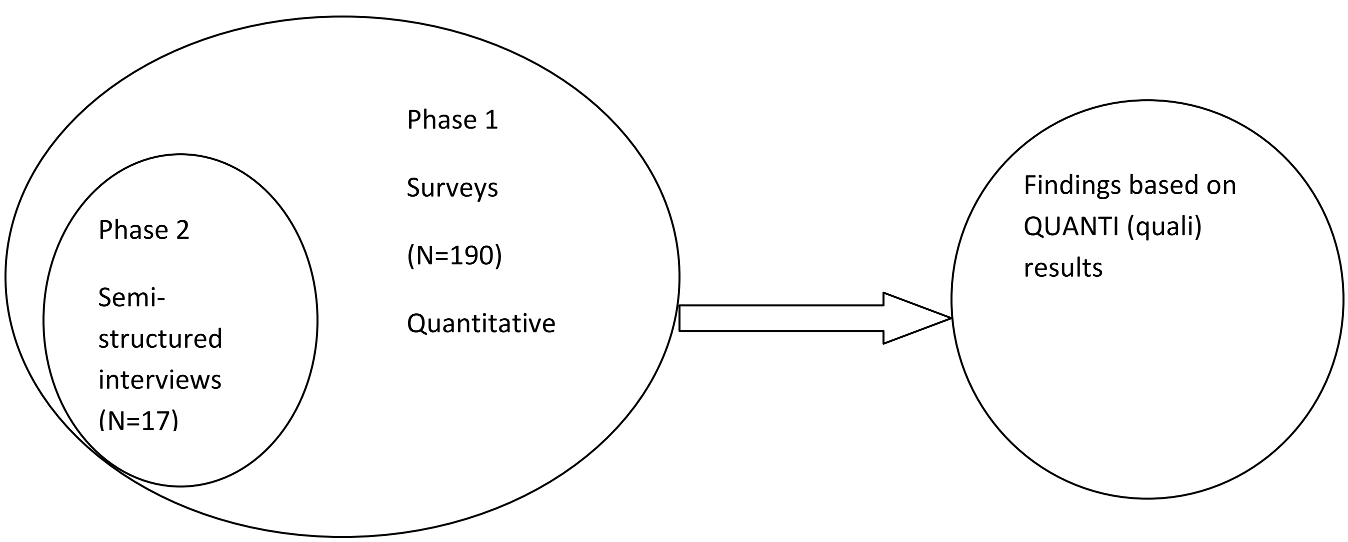


Figure 6.1: Integration of quantitative and qualitative data (Creswell & Clark, 2007:76).

6.4.1 Discussion of integrated data

Integration of the quantitative and the qualitative findings confirmed the initial supposition of the thesis that professional qualification, as one of the demographic factors, does influence the secondary school teachers' teaching efficacy in that most teachers teach Physical Science, even though they did not major in both Physics and Chemistry during their pre-service training. The results of the interviews confirmed those of the questionnaires in that most teachers were more comfortable to teach Physics than they did Chemistry. Even though most of the teachers opined that they would produce better results if they were given an opportunity to focus on their area of expertise, a few held a different position:

> "It is going to be very difficult to share a subject with somebody else; what if the person cannot stick to the deadlines? What is going to happen when marks are due and this person is not done with his or her marking? You don't want to know, some teachers can be difficult sometimes".

Another teacher had the following to say:

> "It is sometimes because of positions; if I don't see eye to eye with my HOD, especially because I am not happy with the appointment, I just can't cooperate".

The above-mentioned excerpts are a result of a lack of discipline and the inability to work as a team amongst other teachers. A sense of responsibility has to be instilled in teachers to ensure that healthy work ethic. The following excerpt indicates a commendable attitude:

> "My colleague and I share concepts all the time, depending on our areas of expertise; even though I teach Physical Science, I am more into Chemistry and he is into Physics, then it becomes easy for us to practice team-teaching".

Furthermore, analyses of the level of preparedness in conducting practical work indicated respondents were more confident to conduct Physics experiments, than they were in Chemistry experiments. Two examples follow:

> "Physics experiments are easy to execute and one can even do without a laboratory," and,
>
> "In Physics, one is not exposed to hazardous materials like in Chemistry".

The respondents also indicated that they were afraid of wrong calculations, which would impact on their findings in Chemistry.

Integration of the data supported the findings of the quantitative and the qualitative findings; confirming that teachers revealed a higher confidence in conducting Physics experiments than Chemistry experiments. Analysis of MANOVA proved that there was a statistical significance in teachers' PSTE scores in the frequency of practical work and in their confidence to conduct experiments. Teachers confirmed that even though Chemistry experiments were more fun for the learners, they doubted themselves and lacked the confidence to handle chemical reagents. They indicated that even though they felt that they were adequately trained to handle such cases, the unavailability of resources made them lose touch with the real Science, that is, the practical work. Thus, the STOE scores proved to have no statistical significance.

6.5 Conclusion

This chapter presented the results of the qualitative study and offered the teachers' insight into various factors influencing their Science teaching efficacy; ranging from their pre-service training to the support that they received from their principals and their learning facilitators. The illustration in the next page represents a summary of the integrated findings from qualitative and quantitative data.

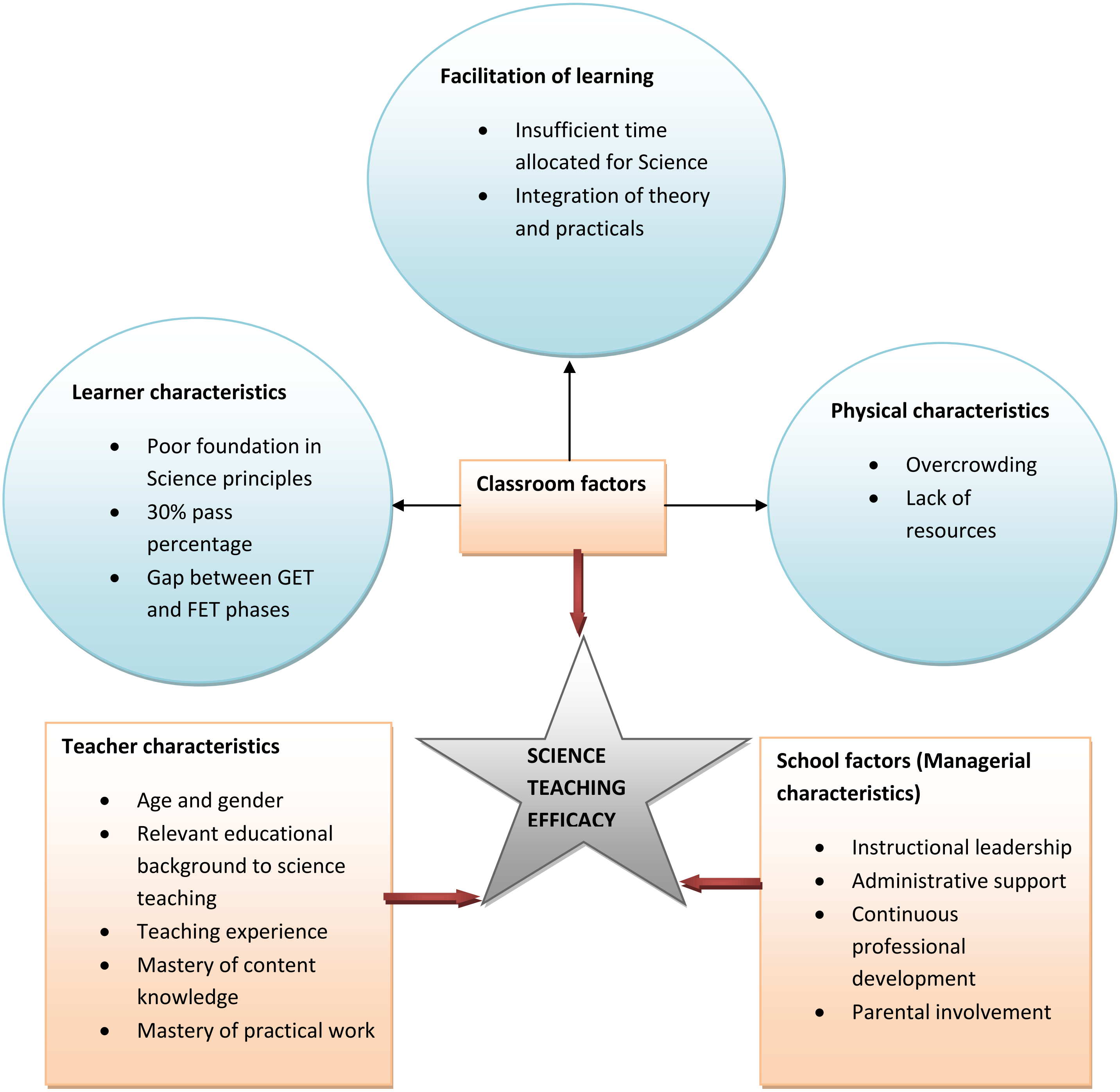


Figure 6.2: Summary on integrated findings from qualitative and quantitative data.

The next chapter provides a summary of the findings and conclusions on Science teaching efficacy, as well as recommendations for further research.

CHAPTER 7

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

In an effort to positively inform Science teaching and learning, the purpose of this study was to assess the Science teaching efficacy beliefs of secondary school Science teachers in the Free State province. Specifically, the study investigated the context specific, as well as subject specific, problems that secondary school Science teachers encountered in their schools. The study is to suggest possible solutions to the problems in order to assist the Department of Basic Education and Training by making departmental officials and secondary school principals aware of the situation. Data was collected on the demographic information and specific characteristics of efficacy and the relationships between Science and Science teaching were analysed. STEBI-A was administered to in-service secondary school Science teachers in order to determine 1) their self-efficacy beliefs about Science teaching; 2) whether there is a significant difference between their Science teaching self-efficacy beliefs; and, 3) their level of preparedness to teach Science, Moreover, semi-structured interviews relating to Science teaching efficacy beliefs scores were carried out with seventeen participants who were selected in a purposeful way.

The research questions of this study were:

1. What is the general teaching efficacy level of Science teachers in secondary schools in the Free State province?
2. Are there differences in the teaching efficacy of Science teachers in terms of demographic characteristics such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels?
3. To what extent does teachers' subject content knowledge affect their teaching efficacy?
4. To what extent does practical work knowledge affect their teaching efficacy?
5. To what extent do teachers' assessment skills affect their teaching efficacy?

To be in a position to respond to these questions, it was imperative to review related literature in Chapters 2 and 3. Chapter 2 focused on the problems facing the teaching and learning of Science and how these problems hampered the teaching and learning of Science. The general school factors that have a negative influence on the learning environment, and factors outside the school setting affecting the teaching and learning of Science, were examined. In Chapter 3, relevant literature on self-efficacy, perceived Science teaching, and Science teaching efficacy was explored.

The following section reports on the conclusions drawn from the results presented in Chapters 5 and 6. Following these conclusions, implications for these findings and future recommendations for continued research will be discussed.

This final chapter discusses the findings of the study to answer the five research questions that were translated into the following hypotheses:

1. The general teaching efficacy level of Science teachers in the Free State province is high.
2. There are differences in the teaching efficacy of Science teachers differentiated by demographic characteristics such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels.
3. Lack of proper subject content knowledge among teachers negatively influences Science teaching efficacy.
4. Lack of exposure/practical knowledge negatively affects Science teachers' efficacy.
5. Lack of proper assessment skills among teachers negatively affect Science teaching efficacy.

7.2 Findings

The five research questions addressed the relationships among Science teaching efficacy, Science teachers' level of preparedness to teach in relation to content knowledge, practical work and assessment, as well as the influence of teachers' demographic factors such as age, gender, educational qualifications, and teaching experience on the constructs of PSTE and STOE. Specifically, the researcher sought to understand the Science teaching efficacy of the secondary school teachers of the Free State province. The researcher also explored whether these demographic factors, assessment skills and Science content knowledge would predict Science teaching efficacy. This study makes a unique contribution to understanding teaching efficacy of secondary school in-service Science teachers in the South African context. This contribution is made in the knowledge that most of the studies in the literature nationally, and to a certain extent internationally, on Science teaching and learning, specifically on self-efficacy beliefs, are on pre-service teachers and primary (elementary) school Science teachers. A discussion of the findings from the five quantitative questions is presented below, along with a comparison to the existing literature.

7.3 Discussion of findings

The discussion of the findings is organised in line with the research questions and the corresponding hypotheses.

7.3.1 What is the general teaching efficacy level of Science teachers in secondary schools in the Free State province?

The hypothesis corresponding to this research question was that:

The general teaching efficacy level of Science teachers in the Free State province is high.

General Science teaching efficacy

The general Science teaching efficacy of Science teachers in secondary schools in the five districts of the Free State province was found to be high, indicating that they feel "very competent" about general teaching situations. The overall STEBI-A scores ranged from 83.25 (66.6%) to 97.45 (77.96%) (see Table 5.13). These findings are not dissimilar from those in Slovakia, which show that an above-average level of perceived self-efficacy of teachers is characteristic of the majority of in-service teachers (Gavora, 2011). Most studies have indicated that PSTE is usually higher than STOE. Similar findings were confirmed by the districts of the Free State province. It was also found by Cerit (2007) that primary teachers' sense of efficacy was high (M =3.75), based on the results obtained from the application of the five-point Likert TSES.

Conclusion

The mean PSTE for Science teachers is 52.82 and STOE is 39.85. Thus, it can be concluded that the hypothesis, the general teaching efficacy level of Science teachers in the Free State province is high, can be accepted.

7.3.2 Are there differences in the teaching efficacy of Science teachers in terms of demographic characteristics such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels?

The hypothesis corresponding to this research question was that:

> *There are differences in the teaching efficacy of Science teachers differentiated by demographic characteristics such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels.*

7.3.2.1 Gender

The results of this study showed that male respondents were more efficacious than the female respondents. The male respondents reported high PSTE (see Figure 5.2) and STOE values (see Figure 5.3). This finding is in agreement with similar findings by Enochs and Riggs (1990), and Cantrell and Young (2003). It can be generalised that the male Physical Science teachers have a higher PSTE than the females. Contrary to this finding, a study conducted by Gavora (2011) showed that female teachers scored higher than their male counterparts in both dimensions of teaching efficacy. However, a study by Mulholland, Doman and Odgers (2004) on pre-service elementary teachers showed that gender had no significant effect on either PSTE or STOE.

Furthermore, the results of this study showed that the combined dependent variable was significantly different between males and females, and that there was a significant difference between males and females in STOE, but not in PSTE. Similarly, Kiviet and Mji (2003) found significant mean sex differences on the personal sub-scale, but not on the general sub-scale of elementary Science teachers in the Eastern Cape province of South Africa. Conversely, the findings of a study by Sarikaya (2004) showed that there was no statistically significant difference between the mean scores of male and female pre-service elementary teachers with regard to their attitude towards Science teaching. Additionally, Hassan and Tairab (2012) found no significant effect of gender on PSTE; however, gender did have an effect on STOE of secondary school Science teachers. Sridar and Badiei (2008) found a statistical difference between male and female teachers of two different countries (Iran and India) in terms of personal teaching efficacy of higher primary school teachers.

This study also showed that there was no statistical significance for age on the combined dependent variable. Finally, there was no statistical significant interaction effect between age and gender.

Conclusion

The average mean of 53.1 and 52.7 in PSTE, and 40.9 and 38.7 in STOE for males compared to their female counterparts indicates that Physical Science remains male dominated. This might be due to the cultural and societal stereotypes influenced by historical mindset that Science is meant for the boy child. Therefore, the hypothesis that there are differences in the teaching efficacy, specifically with PSTE, of Science teachers of the Free State province differentiated by gender can be accepted.

7.3.2.2 Age

Another variable that determined the respondents' teaching efficacy was age. Cantrell and Young showed in Chapter 3 that male elementary teachers expressed higher self-efficacy for teaching Mathematics and Science than female teachers in both in-service and pre-service situations (Cantrell & Young, 2003). In this study, the youngest (less than 30 years) and oldest respondents (older than 45 years) had the highest PSTE (see Table 5.18), whereas STOE tended to decrease with an increase in age (see Table 5.19). This finding is similar to Joseph's whereby older pre-service students had a significantly higher PSTE and lower STOE, which might relate to their life experiences contributing to lower expectations of a teachers' ability to make a difference in the classroom (Joseph, 2010).

The high PSTE scores for younger respondents is an indication that they are still ambitious, confident and believe that they are capable to teach Science. As they reach their peak years in the teaching profession, they might have experienced many challenges which might have had a negative effect on their confidence. In addition, they are at a stage where the rate of attrition is high. Nonetheless, the older respondents show high levels of PSTE because they have gained extensive experience through their years of teaching. In contrast to PSTE scores, STOE scores tend to decrease with an increase in age. This finding shows that even though the older teachers have been in the teaching profession for a longer period, they do not believe that they can influence their learners' outcomes. As shown in Chapter 3, Riggs (1991) reported higher scores for males on self-efficacy for Science teaching in both the in-service and pre-service samples but no significant differences obtained for outcome expectancy scores.

Conclusion

Thus, the hypothesis that there are differences in the teaching efficacy of Science teachers of the Free State province, differentiated by age, can be accepted. There was, however, no significant main effect for age (F=0.509; p=0.850) in the combined dependent variable. This means that people in the different age categories did not differ in the combined dependent variable.

7.3.2.3 Qualifications

Research (cf Chapter 2) has shown that academic and professional qualification influences teacher competence (Gopal & Stears 2007, Ogunleye 2008, Omolara 2008). In a study by Udeani and Ejikeme (2011), teachers indicated that the Education courses they took at university or college prepared them adequately to handle their classes; in this study, though, as seen in Figure 5.9, the respondents in possession of a Bachelor's degree, other than Science, had the lowest PSTE (51.1) score, and STOE score (39.4). However, respondents with professional qualifications in Science (e.g. a B.Sc (Ed), B.Ed (FET) and national diplomas) had higher PSTE and STOE scores, as seen in Figure 5.10.

A striking finding is that the respondents in possession of a PGCE qualification scored the lowest in both PSTE and STOE (Figure 5.10). Moreover, there were significant differences in STOE sub-scale scores between teachers with a BSc (Ed) degree, and individuals with a PGCE qualification (p=0.049). There were also significant differences in STOE scores between teachers with an HED, UED or HUD in education, and teachers with a BSc (Ed) degree (p=0.039). In each instance, teachers with a BSc (Ed) degree obtained significantly higher STOE sub-scale scores. Similarly, studies by Gassert, Shroyen and Staver (in Sünger, 2007) and Tarik (2000) showed that PSTE correlated positively with variables, such as educational degree level and self-rated effectiveness in Science teaching. These researchers further probed the possibility that the relation between PSTE and educational degree level was linked with teachers' beliefs to continue learning Science with the purpose of teaching Science effectively. Cripe (2009) however found that there was no relationship between self-efficacy and teacher qualification status in Science.

It is evident that the respondents, whose qualifications are not in the Sciences, believe that they can make an impact on learners' outcomes because of their higher STOE scores. How can these teachers be confident about bringing about desired change in learners' outcomes if they do not believe in their capabilities to teach Science? It is worth noting that the respondents with no academic qualification in Science have the highest PSTE score, relative to their lowest STOE (see Figures 5.9 and 5.10). There is a possibility that these teachers have some professional qualifications in Science, even though they strongly believe in their capability to teach Science, they still cannot commit themselves towards producing desired results on the learners' outcomes.

Respondents who were in possession of a PGCE qualification tended to have the lowest PSTE (49.82) and lowest STOE (36.80). It is not surprising that their STOE score is this low as one year is inadequate to undergo a four-year programme that prepares a teacher in the various disciplines of Education and subject methodologies. These are the respondents for whom teaching was not their first choice as a career.

Conclusion

It can be concluded that there are differences in the teaching efficacy of Science teachers in the Free State province, differentiated by educational background; therefore, the hypothesis can be accepted.

7.3.2.4 Teaching experience

Teachers' years of experience showed nonlinear relationships with the two sub-scales (PSTE and STOE) of the STEBI-A, increasing from early career to mid-career, and then falling afterwards (as shown in Figure 5.8). This finding is in agreement with a similar finding by Ross *et al.* (1996) and Klaasen and Chiu (2010). However, a one-way analysis of variance showed a statistically significant relationship between the respondents' teaching experience and the full-scale STEBI-A (Klassen & Chiu, 2010). On the contrary, as shown in Chapter 3, Aydin and Boz (2010), Furner (2007), Liaw (2009), Liu, Jack and Houn-Lin (2007), Tschannen-Moran and Woolfolk-Hoy (2007), Woolfolk and Spero (2005) pointed out that highly experienced teachers were more efficacious than less experienced teachers.

MANOVA revealed a significant multivariate main effect for region, Wilks' $\lambda = .465$, F (6, 368.000) = 0.039, $p < 0.001$, partial eta squared = .035. Univariate tests showed that there were significant differences across the teaching experience on PSTE, $F(3,185) = 3.998$, $p < 0.01$, $\eta^2 = 0.061$. In conclusion, there was a significant difference in the PSTE sub-scale scores between teachers who had at most five years' teaching experience, and those who had at least 16 years' teaching experience ($p = 0.02$). Similarly, Gavora showed that the teachers with above five years of practice scored significantly higher in personal teaching efficacy than the teachers with one to five years of practice (Gavora, 2011). However, teaching experience was found to be important, but not necessarily enough to increase teachers' outcome expectancy beliefs (Desouza, Boone, & Yilmaz, 2004), which is also the case with the findings of this study since there was no significant difference found in the STOE sub-scale scores and teaching experience.

Conclusion

From this finding, it thus can be concluded that there are differences in the teaching efficacy of Science teachers of the Free State province differentiated by teaching experience, and the hypothesis can be accepted.

7.3.2.5 Major subjects taken during pre-service training

Results have also shown that most of the teachers are more qualified to teach Physics than Chemistry. It can be seen from Table 5.7 that 74.7% of the respondents majored in Chemistry; whereas it is taught by 95.5% of the respondents (see Table 5.8). In a study by Mustafa, STOE was positively and significantly correlated with the number of college Science courses taken during training (Mustafa, 2007).

In a study that was aimed to gain insight into the effect of Science coursework and teacher certification, Joseph (2010) found that the pre-service teachers with Science majors had a significantly higher PSTE, but their STOE was not different from their non-Science counterparts (Joseph, 2010). On the contrary, studies by Cantrell *et al.* (2003) have shown that the more science courses the teacher took resulted in increased STOE (cf Chapter 3).

Results have also shown that most of the teachers are more qualified to teach Physics than Chemistry. These teachers tend to devote most of their time to Physics because they know and master the concepts better. The way the textbooks are structured also favour Physics because the first part is Physics, and then Chemistry. It is only logical to start the book from the left to the right and only focus on Chemistry when time is no longer available. This filters down to the learners because they take Chemistry to be more difficult than Physics since their teachers did not do justice to the Chemistry part. This is in support of the findings of a study conducted by Mji and Makgato (2006) (cf Chapter 3, section 3.6). At the university level, the two areas of Physical Science are treated as separate majors. Not all teachers who teach Physical Science have majored in both Chemistry and Physics. This situation can be remedied by having Chemistry and Physics allocated independently on the timetable, and ensuring that each has a qualified teacher.

Conclusion

It can be concluded that the hypothesis that there are differences in the teaching efficacy of Science teachers of the Free State province, differentiated by major subjects taken during pre-service training, can be accepted.

7.3.3 To what extent does teachers' subject knowledge affect their teaching efficacy?

The hypothesis corresponding to this research question was that:

> *Lack of proper subject knowledge among teachers negatively influences Science teaching efficacy.*

Confidence in content knowledge

Mastery experiences happen when the teacher has reached the point where they understand the content knowledge enough to perform a task or master the task. It happens if the teacher goes in to sufficient depth on material he or she is trying to teach the learners. It happens with adequate prior exposure to the content. At some stage the teachers are able to interpret the results of their actions and use those results to develop their own capability to engage in future actions or tasks. They are able to participate in tasks on a first hand basis with little or no assistance from outside influences. Bandura confirmed in Chapter 3 that mastery experiences help to increase efficacy beliefs (Bandura, 1997).

Respondents showed high confidence levels in the outlined Physics concepts. In all the districts, respondents had higher overall confidence levels in the Physics concepts than they did in the Chemistry concepts (see Tables 5.39 and 5.40, and Figure 5.13). It is important to note than in both the Physics and Chemistry components of Physical Science, Xhariep district had the highest confidence levels. Evidence was given in Chapter 3 by Ogunleye (2008), Wan (2010) and Wu & Chang (2006) that teachers' efficacy beliefs are influenced by their content knowledge. Similar studies (Udeani and Ejikeme, 2011) showed that teachers perceived that they were adequately prepared to teach the Science concepts and conduct practical classes in their subject areas at the secondary level (Udeani & Ejikeme, 2011). In a similar study, Rubeck and Enochs (1991) showed that Physics teaching efficacy was significantly different from and higher than the Chemistry teaching efficacy.

Conclusion

It can therefore be concluded that the hypothesis: lack of proper subject knowledge among teachers negatively influences Science teaching efficacy can be accepted.

7.3.4 To what extent does teachers' practical knowledge influence their teaching efficacy?

The hypothesis corresponding to this research question was that:

> *Lack of exposure/practical knowledge negatively affects Science teachers' efficacy.*

Practical work

Effective pedagogy is at the heart of improving the quality of practical work in Science. When well-planned and effectively implemented, practical work stimulates and engages learners' learning at varying levels of inquiry, challenging them both mentally and physically in ways that are not possible through other Science education experiences (SCORE, 2008).

Even though the results of this study show that practical work is conducted to some degree in some schools, the results are still not satisfactory. Since the first group of the Grade 12s to write the CAPS examinations will be in 2014, and practical examinations on prescribed experiments is going to be emphasised, a can of worms will be opened regarding the status of practical work in schools. Ngema (2011) conducted a study to explore how the Physical Science teachers used practical work in their teaching. The exploration sought to ascertain whether there was any relationship between teachers' perceptions of the purpose of practical work and their use of practical work. The findings showed that teachers value using practical work in the teaching of Physical Science. Qualitative data analysis enables recommendation to be made for the improvement of the use of inquiry-based practical work in the teaching of Physical Science. The teachers held the view that the most important aim of practical work was to promote conceptual understanding. During their teaching, teachers used practical work to verify theory through non-inquiry practical instructional practices and strategies (Ngema, 2011).

Teachers revealed a higher confidence in conducting Physics experiments than Chemistry experiments (see Figure 5.15), whereby learners used data from their teachers' demonstrations to construct their own graphs and tables.

The findings of this study showed that even though the teachers felt confident about practical work, the situation in their schools was not favourable to conduct practical work due to a lack of facilities, and they ended up losing interest in this practical activity. This is in agreement with the findings of Ogunleye (2008) that a significant number of teachers experienced difficulties in teaching many of the topics of the Science curriculum depending on their adequate knowledge of the Science content of the curriculum and how often they carry out the practical activities specified in the curriculum. Thus, it is imperative that teachers embark on continuous professional development that involves sharpening their skills on laboratory management and the actual execution of experiments. This, in turn, will enhance their confidence in practical work as per SCORE recommendations (cf Chapter 2).

The results of this study showed that teachers' confidence in conducting experiments and the frequency of practical work had an influence on scores on the PSTE sub-scale, but not on STOE sub-scale scores.

Conclusion

It therefore can be concluded that the hypothesis, lack of proper practical work skills among teachers influences Science teaching efficacy negatively, can be accepted.

7.3.5 To what extent do teachers' assessment skills affect their teaching efficacy?

The hypothesis corresponding to this research question was that:

> *Lack of proper assessment skills among teachers negatively affect their Science teaching efficacy.*

Assessment

As seen in Table 5.55, generally, out of the eight assessment strategies used in the districts of the Free State province, the four modes of assessment (written theory tests, examinations, assignments and projects) were utilised more than the practical work, practical tests, quizzes and oral presentations. Quizzes were the least utilised method of assessment.

It is important to emphasise that even though teachers did not label assessment as a problematic area, it is not as obvious as it seems. Proper and adequate questioning techniques have to be maintained in order to meet the requirements as set by CAPS.

Onwuakpa and Nweke (2000) advised that Science teachers should give assignments, projects and tests to their learners and discuss the results of these with them. This is because knowledge of learners' performance in tests and assignments helps to identify their areas of weakness and strength (Abuseji, 2007). Thus, the methods teachers use to assess learners' competencies can reinforce a way of thinking about Science.

This study showed there was no significant relationship between teachers' confidence in assessment practices and PSTE (r=0.142; p=0.091) and STOE (r=0.046; p=0.581) sub-scale scores. Thus, there is no meaningful relationship between confidence in assessment practices and PSTE and STOE sub-scale scores.

Conclusion

It can therefore be concluded that the hypothesis: lack of proper assessment skills among teachers negatively affect their Science teaching efficacy can be accepted.

7.4 GENERAL RECOMMENDATIONS

1. **Time**

   The findings of this study indicated that time is an inhibitory factor towards effective and efficient Science teaching, practical work and assessment; thus, it is recommended that officials of the Department of Basic Education reconsider the teaching time allocated to Physical Science and not treat it like other Group B subjects that do not have practical work. Theory and practical work have to be indicated separately on the timetable and time should be allocated to both these components.

2. **Qualifications**

   The Department of Education must be applauded for the initiatives to offer bursaries to students pursuing a qualification in Education. However, for the profession to maintain its dignity, academically-deserving prospective students should only be awarded bursaries on merit, and only on condition that they have qualified and have been admitted to study Education at their prospective institutions of higher learning.

Students do not have to apply to be admitted to Education only because they have been awarded bursaries. It is a common practice for prospective students to apply after they have been awarded a bursary, only to find that their Grade 12 results do not qualify them to be admitted to their preferred field of study.

PGCE is one of the qualifications meant to upgrade a teacher with a non-education qualification, thus qualifying him or her to teach. For teaching to be taken seriously as a profession it is recommended that PGCE only be offered to individuals who are already in the teaching profession, but who do not have a teaching qualification; this should only be applicable to qualifications that do not have any specialisation in Education, such as Marketing, Human Resource Management and Public Management. It should be discouraged for people with pure Science qualifications because they could have opted to take the education route in the first place, but were now using PGCE as a stepping stone to education, which they did not choose as a career in the first place. If this is not discouraged, teaching as a profession will continue to absorb poor passes, while the cream of the crop continues to chase their ambition in other Science-related fields, only to bounce back to education when they do not find employment by using PGCE as a shortcut.

3. **Pre-service training**

Teacher training institutions should review curriculum timeously to ensure that they are on par with the changes in the educational system and the curriculum. The findings of this study indicate that various factors influence PSTE positively, but not STOE, therefore, teacher education programmes should be designed in such a way that pre-service teachers' STOE beliefs are highly encouraged for them to be in a position to be positive that they are capable of bringing about the desired results in their learners' learning.

4. **Major subjects**

Even though Physics and Chemistry form part of Physical Science, not all teachers who have majored in Physics have taken Chemistry as a major, and vice versa, during their pre-service training. Thus, it is recommended that Physics and Chemistry be plotted independently on the timetable and each be allocated to teachers with relevant majors so that they can excel in their areas of expertise.

5. **Practical work**

   It is recommended that practical work be explicitly indicated on the timetable and be given the time it deserves, according to the weights as stipulated by CAPS. Since the findings of this study have shown that teachers feel less confident in conducting experiments, it is recommended that the Department of Basic Education offers workshops on practical work. Ideally, the starting point should be Grade 10 to Grade 12 experiments, prescribed by CAPS, and to offer science kits on these experiments to ensure that they are performed in schools. This could then be rolled over to other experiments and eventually the entire scope of the practical work will be covered. Since practical work requires apparatus to be set up, and most of the respondents raised time as an inhibitory factor, it is recommended that laboratory technicians be appointed to assist in setting up the experiments and ensuring that the laboratory is properly maintained at all times.

6. **Assessment**

   Assessment is an integral part of teaching and learning. For this reason assessment should be part of every lesson and teachers should plan assessment activities to complement learning activities.

7.5 Policy implications and recommendations

This study has brought to light a number of issues that affect and influence teaching efficacy, including the role of the Department of Basic Education in enhancing the teaching and learning of Science. For as long as the Department of Education, teacher training institutions and schools operate in silos, the same situation will recur whereby problems are not resolved; this culminates in those involved shifting the blame.

All subject advisors should be required to form part of, and actively participate in, the advisory boards of the Departments of Science Education at institutions of higher learning. In so doing, all stakeholders involved in teacher education will meaningfully contribute towards the improvement of the teaching and learning of Science.

To combat the problem of lack of equipment, the Department of Basic Education should have a service level agreement with officials who are involved in curriculum design and implementation to develop low-cost equipment that is aligned and relevant to the curriculum. They will be expected to prepare experiments and manuals for the use of the equipment. Teachers will also be trained by the same people on how to utilise the equipment. Teachers will then be in the position to take the knowledge gained back to their classrooms.

One of the findings of this study was the issue of teachers teaching subjects that they did not take as majors during their pre-service training. In-service teachers' qualifications have to be audited per school to confirm that each school has teachers qualified to teach both Physics and Chemistry, since most schools have more than one teacher responsible for Physical Science. As long as the advertised posts in the vacancy lists of the Government Gazette continue to be placed as "Physical Science", teachers will teach both Physics and Chemistry, even if they are not qualified to teach both. Thus, it is recommended that the advertisements should explicitly state the area of expertise that is required in the advertised posts.

Physical Science is regarded as a Group B subject, according to the NCS. It forms part of the elective school subjects, whereby an FET learner is expected to have at least three subjects in this group. Most of the subjects in this group are “non-science” and do not have a practical aspect. It is important that Physical Science should not be given four hours per week, like the other subjects in this group in the FET Phase. It is recommended that an extra hour be allocated to Physical Science so that it can be utilised for the purpose of practical work.

The way in which the position and roles of a Head of Department (HOD) at a school is designed is such that he or she is not only responsible for Physical Science, but also for other Science-related subjects, such as Life Sciences and Mathematics. The Department of Basic Education should consider introducing the post of subject heads so that the role of the HODs can be modified so that subject experts are responsible for their subjects of expertise. The subject head will be a member of staff responsible for instructional leadership, mainly through coordinating the curriculum implementation of a subject. In addition, the subject head will take the lead in facilitating and creating team building and continuous professional development in order to improve the teaching competence of teachers involved in the specific subject. As in the Namibian Ministry of Education, the role of the subject head can be performed by the principal, the vice-principal, the HOD or a senior teacher (Namibian National Subject Policy Guide for Physical Science Grades 8-12, 2009).

Most novice teachers feel isolated; they find it difficult to adjust to their new environment for various reasons, ranging from lack of self-confidence to unruly learners, and lack of mentorship and supervisory support. Therefore, early career support has to be greatly improved whereby pre-service preparation has to be combined with induction support to ensure that novice teachers settle into the system with ease. “Adopt a school” or “Adopt a novice teacher” can be an approach used by teacher educators working together with teacher mentors and learning facilitators to improve the quality of mentoring and induction in schools. This can improve and enhance the novice teachers’ self-efficacy beliefs; thus, reducing the rate of teacher attrition.

7.6 Implications

In light of the research findings, some implications for practice are put forward in this section. The literature has shown data supporting that teacher efficacy is an important factor contributing towards the effective teaching of Science and the improved performance of learners. In order to enhance the teaching and learning of Science, the results of this study support the idea that:

- It must be emphasised that Physical Science is not just Physics, as perceived by many people, but it involves another section, Chemistry. Therefore, the Department of Basic Education should consider having Physics and Chemistry taught independently as part of Physical Science to avoid one part of the subject suffering because of the other and to allow the teachers to excel in their areas of expertise for the benefit of the learners and the progressive development of Science education in the country.

- The time of the year during which a concept is taught influences the outcome. Those concepts that teachers experience most difficulty in are treated towards the end of the year. To confirm that lack of enough time is a barrier to effective teaching, the concepts taught late in the year are the ones that teachers rated their confidence the lowest in, and these were mostly Chemistry concepts.

- Learners' low level of knowledge in basic principles of Physical Science shows that they are introduced to Chemistry and Physics at a later stage of their school lives. If these can be introduced at levels as low as the GET phase so that they can know the difference between Chemistry and Physics at an early age, they will develop and start building a firm foundation of these principles.

- For teachers to have confidence in themselves, but not be that confident to bring about the desired outcome in learners' performance, shows that they are confident in content knowledge but not in pedagogical knowledge, thus PCK is partially addressed. Therefore, Continuous Professional Development (CPD) has to be encouraged in order to attend to the teachers' confidence on how to teach the different concepts of the subject. In addition, teacher training programmes need to have the concept of efficacy-belief integrated into the methodology courses to enhance their efficacy through experience.

- The task of creating environments conducive to learning rests heavily on the talents and self-efficacy of teachers. Evidence indicates that the atmosphere in a classroom is partly determined by a teacher's belief in his or her instructional efficacy. Teachers who believe strongly in their instructional efficacy create mastery experiences for their learners (Bandura, 1997:19). Thus, one way for principals to improve learners' performance may be by working to raise the collective efficacy of their schools. When the teachers believe that they are members of a school that is both competent and able to overcome the detrimental effects of the environment, the learners in their own classrooms and school have higher performance and achievement scores than learners from schools with lower levels of collective efficacy. If the level of collective efficacy is higher, this filters down to the individual teaching efficacy of teachers, and better performance in their respective subjects.

It is imperative to indicate that the Department of Basic Education, the teacher training institutions of higher learning, and in-service teachers cannot operate in isolation. They should work together for teacher training institutions to be able to meet the demands of the Department in producing well-prepared and confident teachers.

7.7 Recommendations for further study

In this section, recommendations for further research are put forward.

Further research might involve the aspect of pedagogy as part of the instrument. There should also be a test in content knowledge, so that teachers can be assessed to confirm their confidence in content knowledge, rather than allowing them to rate themselves without the actual test. Moreover, qualitative studies may be conducted to support teachers' self-report measures, such as classroom observations in order to gain in-depth data about teachers' efficacy beliefs. A more intense year-long study can be conducted with a number of teachers whereby they self-rate their efficacy beliefs and confidence levels in the selected concepts at the beginning of the year, and then their PSTE can be measured against STOE, with reference to the performance of the learners, at the end of the year. This will give a clear picture on the influence that teachers have on learners' future choice of subjects.

Even though the teachers in this study showed high levels of Science teaching efficacy, it is important that further study involves observation of teachers' actual classroom practices in order to confirm if there is a positive relationship between their efficacy scores and how they actually conduct their lessons. This can lead to further qualitative evidence with respect to the findings of this study.

In order to achieve the intended results through implementation of good teaching practices and strategies that boost teachers' efficacy, the assessment of teachers' practices and beliefs in Science teaching should be a continuous process, and not a once-off activity.

It would also be interesting to study the influence and relevance of PGCE on teaching efficacy; whether it is appropriate for university graduates who did not plan to become teachers as their first career choice and followed pure Science qualifications, but later obtained a one-year certificate that qualified them to teach, whereas other graduates studied for four years to qualify as a teacher.

7.8 Conclusion

Dealing with the role of demographic factors on teachers' level of preparedness to teach Science, this study is intended to make officials of the Department of Basic Education and school principals aware of the context specific, as well as subject specific, problems that teachers encounter in schools, and to suggest possible solutions. This contribution is made in the knowledge that most of the studies in the literature conducted nationally and internationally on Science teaching and learning, specifically on self-efficacy beliefs, are about pre-service teachers and primary (elementary) Science teachers. This study was aimed at bridging the gap of secondary school Science teaching efficacy, which has been overlooked. If more research is conducted on self-efficacy beliefs of in-service Science teachers at secondary school level, the curriculum of teacher training programmes can be further developed and structured, and there will be a deeper level of understanding of what pre-service teachers face. In addition, such research will help to understand how to motivate teachers to teach Science.

The most effective way of creating a strong sense of efficacy is through mastery experiences. They provide the most authentic evidence of whether one can master whatever it takes to succeed. Successes build a robust belief in one's personal efficacy. Failures undermine it, especially if failures occur before a sense of efficacy is firmly established. Developing a sense of efficacy through mastery experiences is not a matter of adopting ready-made habits. Rather it involves acquiring the cognitive, behavioural and self-regulatory tools for creating and executing appropriate courses of action to manage ever-changing life circumstances. After people become convinced that they have what it takes to succeed, they persevere in the face of adversity and quickly rebound from setbacks. By sticking it out through tough times, they emerge stronger from adversity (Bandura, 1997:3). Thus, teachers have to deal with the stereotype that a teacher's need to learn is seen as a sign of incompetence. Instead, it should motivate them to achieve better results.

In order to address the need for confident Science teachers, positive aspects of teaching need to be revisited. The goal of Science is to create scientifically-literate individuals who can function in a contemporary technological society, and ultimately, prepare more learners for science-related careers.

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APPENDIX A

LETTER REQUESTING PERMISSION FROM THE DEPARTMENT OF EDUCATION

Central University of Technology, Free State

Faculty of Humanities

School of Teacher Education

Bloemfontein

14 March 2011

The Regional Chief Director
Free State Department of Education

Private Bag

BLOEMFONTEIN

9300

Dear Sir

REQUEST FOR PERMISION TO CONDUCT A FIELD STUDY IN SOME SELECTED SCHOOLS IN THE FREE STATE PROVINCE

I am a doctoral student at the Central University of Technology, Free State. I hereby kindly request permission to conduct research in some schools in the province. The title of my research is "Assessing the self-efficacy of science teachers in secondary schools of the Free State province. The aims of this research are to assess:

- the general teaching efficacy of the science teachers in secondary schools in the Free State province;
- the impact of the demographic factors such as age, gender, educational background, teaching experience, geographical location of the school, and grade levels on science teaching efficacy, and
- the impact of the teachers' level of preparedness regarding content knowledge, facilitation skills and assessment on teaching efficacy.

I believe that the results of this study will contribute to the knowledge about problems experienced by science teachers in secondary schools. The findings of this study will be made available to you, should you request for them.

Thank you.

Yours faithfully

Mrs Motshidisi Anna Lekhu

APPENDIX B

RESPONSE FROM THE DEPARTMENT OF EDUCATION

education
Department of Education
FREE STATE PROVINCE

Enquiries: Khatite M
Reference: 16/4/1/08 - 2011
Tel: 051 404 9275
Fax: 051 404 9274
E-mail: research@edu.fs.gov.za

2011 – 05 – 06

MRS M. A. LEKHU
18 Moncherie
Anna Needling Street
Langenhoven Park
BLOEMFONTEIN
9301

Dear Mrs Lekhu

REGISTRATION OF RESEARCH PROJECT

1. This letter is in reply to your application for the registration of your research project.
2. Research topic: **Assessing the self-efficacy of science teachers in secondary schools in the Free State Province.**
3 Your research project has been registered with the Free State Education Department.
4. Approval is granted under the following conditions:-

4.1 The name of participants involved remains confidential.

4.2 The questionnaires are completed and the **interviews are conducted outside normal tuition time.**

4.3 This letter is shown to all participating persons.

4.4 A bound copy of the report and a summary on a computer disc on this study is donated to the Free State Department of Education.

4.5 Findings and recommendations are presented to relevant officials in the Department.

5. The costs relating to all the conditions mentioned above are your own responsibility.
6. **You are requested to confirm acceptance of the above conditions in writing to:**

DIRECTOR: STRATEGIC PLANNING, POLICY AND RESEARCH,
CNA Building, Maitland Street - Private Bag X20565, BLOEMFONTEIN, 9301

We wish you every success with your research.

Yours sincerely

RR SELLO
DIRECTOR: STRATEGIC PLANNING, POLICY AND RESEARCH

Directorate: Strategic Planning, Policy & Research – Private Bag X20565, Bloemfontein, 9300 – Room 301, Old CNA building, Maitland Street, Bloemfontein 9300 – Tel: 051 404 9287/ Fax: 051 4049274 E-mail: quality@edu.fs.gov.za

education
Department of Education
FREE STATE PROVINCE

Tel: 051 404 9275
Fax: 051 404 9274

Enquiries: MC Khatite
Reference no. : 16/4/1/06 - 2011

2011-05- 06

Mr M.J. Mothebe
Director: Motheo Education District
Room413
9570

Dear Mr Mothebe

NOTIFICATION OF A RESEARCH PROJECT IN YOUR DISTRICT

Please find attached copy of the letter giving **Mrs Lekhu** permission to conduct research in sampled schools in the Motheo Education District. Mrs Lekhu is a lecturer and is studying for PhD Education with the Central University of Technology.

Yours sincerely

FR SELLO
DIRECTOR: STRATEGIC PLANNING, POLICY AND RESEARCH

Directorate: Strategic Planning, Policy & Research; Old CNA Building, Maitland Street, Private Bag X20565, Bloemfontein, 9300 – Tel: 051 404 9287 / 9275; Fax: 051 404 9274 – E-mail: research@edu.fs.gov.za
www.fs.gov.za

education
Department of Education
FREE STATE PROVINCE
Tel: 051 404 9275
Fax: 051 404 927488
E-mail: khatitem@edu.fs.gov.za

Enquiries: KHATITE MC
Reference: 16/4/1/06 - 2011

2011 – 05 – 06

MRS M. A. LEKHU REQUEST PERMISSION TO CONDUCT RESEARCH IN THE DEPARTMENT OF EDUCATION, FREE STATE PROVINCE.

1. PURPOSE

To request permission to conduct a research project with principals, educators and learners in the public, primary schools sampled in the Education Districts.

2. BACKGROUND

- Mrs Lekhu is a lecturer and is studying for PhD Education with the Central University of Technology.
- The title of the research project is: **Assessing the self-efficacy of science teachers in secondary schools in the Free State Province.**
- The research will provide valuable information to the Education Department regarding assessment of general teaching efficacy of the science teachers, and the impact of their level of preparedness regarding content knowledge and facilitation skills.

3. SELECTION OF A TARGET

- Schools
- Grade 10 to 12 Physical Science Educators across the Province

4. DISCUSSION

- Since all the documentation is in order, there is no apparent reason to withhold permission to conduct research.
- The request should be granted under the conditions as stipulated under recommendations.

5. FINANCIAL IMPLICATIONS

None.

6. PERSONNEL IMPLICATIONS

None.

7. LEGAL IMPLICATIONS

None.

8. PARTIES CONSULTED

None.

9. RECOMMENDATION

10.1 It is recommended that:

10.1.1 Permission be granted to **MRS LEKHU** under the following conditions:

10.1.2 A report on this study is donated to the Free State Department of Education after completion of the project.

10.1.3 The researcher donates a copy of the summary of the report on a computer disc when the hard copy is given to the Department.

10.1.4 The researcher addresses a letter to the Superintendent General: Education accepting the conditions as laid down.

9.2 The enclosed letter to the applicant is signed.

Recommended / Recommended as amended / Not Recommended

Comments:

....

....

....

Mmaleka DATE: 09/05/2011

MVM MALEKA
ASSISTANT DIRECTOR: STRATEGIC PLANNING, POLICY & RESEARCH

Approved / Approved ~~as amended~~ / Not ~~approved~~

Comments:

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....

....

DATE: 09/05/2011

FR SELLO
DIRECTOR: STRATEGIC PLANNING, POLICY & RESEARCH

APPENDIX C

LETTER TO PRINCIPALS

Central University of Technology, Free State

Faculty of Humanities

School of Teacher Education

BLOEMFONTEIN

10 May 2011

The Principal

…………………

…………………

…………………

Dear Sir/ Madam

RE: REQUEST FOR PERMISSION TO VISIT YOUR SCHOOL FOR RESEARCH PURPOSES

The above subject bears reference:

My name is Motshidisi Lekhu, a PhD in science education student at the Central University of Technology, Free State. I am undertaking a study aimed at assessing the self-efficacy of science teachers in secondary schools in the Free State province.

I hereby request to be granted permission to visit your school to conduct research amongst science teachers.

It is hoped that the findings of the study will shed light on the teaching efficacy of science teachers in the Free State province; and make departmental officials and school principals aware of the context specific as well as subject specific problems that teachers encounter in their schools and possible solutions towards these problems will be recommended.

Yours sincerely

………………………………

Mrs Motshidisi Anna Lekhu (MSc in Chemistry)
School of Teacher Education
Central University of Technology, FS

APPENDIX D

LETTER TO THE RESPONDENTS

Central University of Technology, Free State

Faculty of Humanities

School of Teacher Education

BLOEMFONTEIN

Dear Respondent

I am Ms Motshidisi Lekhu, a doctoral student at the Central University of Technology, Free State. I have been granted permission by the Department of Education to conduct this study.

The aim of this questionnaire is firstly to assess the self-efficacy beliefs of science teachers in secondary schools of the Free State province, and secondly their confidence in handling certain sections of the physical science syllabus. Self-efficacy is defined as one's judgements, beliefs and confidence in one's abilities to perform a particular task. In the context of education and teaching, self-efficacy affects teacher efficacy to an extent to which the teacher believes and has confidence in himself/ herself to influence learners' learning, to bring about desired results even to those learners that are considered to be difficult and unmotivated.

You are kindly requested to complete this questionnaire as genuinely as possible. Your name is needed to make a follow-up study possible and the responses that you provide will be used solely for the research purpose. All responses will be treated with utmost confidentiality and anonymity.

The questionnaire is divided into sections. Please answer all questions in the different sections of the questionnaire as indicated.

Thanking you in anticipation.

MA Lekhu

APPENDIX E

QUESTIONNAIRE

QUESTIONNAIRE TO PHYSICAL SCIENCE TEACHERS

<u>SECTION A</u> (Demographic data)

Please provide your personal details below. Please complete the following by placing a cross (X) in the appropriate space.

1.	Your name										
2.	District	Motheo		Xhariep		Fezile Dabi					
		Thabo Mofutsanyana		Lejweleputswa							
3.	School name										
4.	Type of school	Independent		Public		Farm					
5.	Geographic location of school	Urban (town)		Semi-urban (location)		Rural (farm)					
6.	Your gender	Male		Female							
7.	Your age in years	< 24		25 to 30		31 to 35		36 to 40			
		41 to 45		46 to 50		51 to 55		56 +			
8.	Academic qualification	B.Sc		B degree other than science		B.Sc (honours)		M.Sc		Other ---------------	
9.	Professional qualification	B.Sc (Ed)		B.Ed (FET)		PGCE		UED, HED, HUD		Other ---------------	
10.	Major science subjects taken during training	Chemistry		Physics		Biology		Other --------------			
11.	Grade(s) currently teaching	Grade 10		Grade 11		Grade 12					
12.	Physical Science teaching experience in years	Less than 1 year		1 to 5 years		6 to 10 years		11 to 15 years			
		16 to 20 years		21 to 25 years		26 to 30 years		31 years and more			
13.	Section(s) of Physical Science currently teaching	Physics		Chemistry		Physics and Chemistry					

SECTION B (MEASUREMENT OFSELF-EFFICACY BELIEFS)

This part of the questionnaire measures your self-efficacy beliefs about teaching Physical Science. Please complete the following by placing a cross (X) in the appropriate space. Use the following key:

Strongly Agree =SA; Agree =A; Uncertain = U; Disagree=D; Strongly disagree =SD

	Statements	**SA**	**A**	**U**	**D**	**SD**
1.	When a student does better than usual in physical science, it is often because the teacher exerted a little extra effort					
2.	I am continually finding better ways to teach physical science.					
3.	Even when I try very hard, I don't teach science as well as I do most subjects.					
4.	When the science grades of learners improve, it is most often due to their teacher having found a more effective teaching approach.					
5.	I know the steps necessary to teach science concepts effectively.					
6.	I am not very effective in monitoring science experiments.					
7.	If learners are underachieving in science, it is most likely due to ineffective science teaching.					
8.	I do not teach science effectively.					
9.	The inadequacy of a learner's science background can be overcome by good teaching.					
10.	The low achievement of some learners in science cannot generally be blamed on their teachers					
11.	When a low achieving learner progresses in science, it is usually due to extra attention given by the teacher.					
12.	I understand science concepts well enough to be effective in teaching secondary (FET) science.					
13.	Increased effort in science teaching produces little change in some learners' science achievement.					
14.	The teacher is generally responsible for the achievement of learners in science.					
15.	Learners' achievement in science is directly related to their teacher's effectiveness in science teaching.					
16.	If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the learner's teacher.					
17.	I find it difficult to explain to learners why science experiments work.					
18.	I am typically able to answer learners' science questions.					
19.	I wonder if I have the necessary skills to teach science.					

	Statements	SA	A	U	D	SD
20.	Effectiveness in science teaching has little influence on the achievement of learners with low motivation.					
21.	Given a choice, I would not invite the principal to evaluate my science teaching.					
22.	When a learner has difficulty understanding a science concept, I am usually at a loss as to how to help the learner understand it better.					
23.	When teaching science, I usually welcome learners' questions					
24.	I don't know what to do to attract learners on to science.					
25.	Even teachers with good science teaching abilities cannot help some learners learn science.					

Adapted from Riggs, I. & Knochs, L. (1990). Towards the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*, 625 - 637.

PTO

SECTION C (Level of preparedness and confidence to teach physical science)

1. CONTENT KNOWLEDGE

This part of the questionnaire investigates the confidence you have in teaching different concepts in Physical Science. Please indicate how confident you feel about the following concepts by making a cross (X) in the appropriate space.

CHEMISTRY COMPONENT

		Confident	Slightly confident	Not confident
1.	Chemical bonding			
2.	Gas laws			
3.	Nomenclature of organic compounds			
4.	Reactions of organic compounds			
5.	Balancing of chemical reactions			
6.	Energy changes in chemical reactions			
7.	Redox reactions			
8.	Rate of chemical reactions			
9.	Acids and bases			
10.	Chemical equilibrium			
11.	Exploiting the lithosphere or earth's crust			
12.	The atmosphere			
13.	Chemical industry			

Are there any other problems encountered with chemistry content? Explain.

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PHYSICS COMPONENT

Please indicate how confident you feel about the following concepts by making a cross (X) in the appropriate space.

		Confident	Slightly confident	Not confident
1.	Vectors in two dimensions			
2.	Newton's laws and their application			
3.	Momentum and impulse			
4.	Vertical projectile motion in one dimension			
5.	Work, energy and power			
6.	Geometrical optics			
7.	2D wavefronts			
8.	3D wavefronts			
9.	Doppler effect			
10.	Electrostatics			
11.	Electromagnetism			
12.	Electric circuits			

Are there any other problems encountered with physics content? Explain.

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2. PRACTICAL WORK

Please rate the extent to which practical work is conducted in your classroom. Cross (X) the relevant box.

0 = never, 1 = rarely, 2 = occasionally, 3 = often

		0	1	2	3
1.	I perform a demonstration using bought apparatus				
2.	I perform a demonstration using improvised apparatus				
3.	I perform demonstrations, but with learner participation, and these demonstrations promote inquiry thinking rather than just illustrate concepts.				
4.	Learners use data from demonstrations to construct their own graphs and tables.				
5.	Learners perform practical work in groups using apparatus and are told what to do, either by me or a worksheet.				
6.	Learners perform practical work in groups using apparatus. They are given a problem or question and they design their own experiment to ensure that their data is accurate.				

How confident are you to conduct the following experiments? Cross the relevant box

1 = fully confident, 2 = Confident with a little guidance, 3 = I can manage but depend on advice from others, 4 = I need help to develop my knowledge and skills

		1	2	3	4
1.	Heating and cooling curve of water.				
2.	Electric circuits with resistors in series and parallel–measuring potential difference and current.				
3.	The effects of intermolecular forces: boiling points, melting points, surface tension, solubility, capillarity,...				
4.	Investigate the relationship between force and acceleration (Verification of Newton's second law).				
5.	Preparation of esters.				
6.	How do you use the titration of oxalic acid against sodium hydroxide to determine the concentration of the sodium hydroxide?				
7.	Conservation of linear momentum.				

8.	Determine the internal resistance of a battery.				
9.	Set up a series-parallel network with known resistor. Determine the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value.				

Are there any other problems encountered in science practical work? Explain.

____

____

3. ASSESSMENT

How do you assess your learners? Cross (X) the relevant box using the following keys:

0 = never, 1 = rarely, 2 = occasionally, 3 = often

In assessing learners, I pay attention to the following:

		0	**1**	**2**	**3**
1.	Written theory tests				
2.	Examinations				
3.	Assignments				
4.	Projects				
5.	Practical work (hands-on)				
6.	Practical tests				
7.	Quizzes				
8.	Oral presentations				

Are there any other problems encountered in the assessment of physical science? Explain.

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____

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Thank you for your co-operation

Ms Motshidisi Lekhu

APPENDIX F

INTERVIEW PROTOCOL AND QUESTIONS

My name is Motshidisi Lekhu. I am a PhD candidate at the Central University of Technology, Free State. I am currently working on a study assessing the science teaching efficacy beliefs of science teachers across the Free State Province. You'll remember that some time ago, you filled in a questionnaire seeking information on your science teaching efficacy beliefs, as well as your level of preparedness and confidence to teach physical science concepts. Thank you very much for your contribution. This interview is a follow up from the responses of the questionnaire, and based on the findings, your name was nominated for the interviews. It will take about thirty minutes.
(Permission will be asked to record the interview and confidentiality of the responses will be assured.)

Interview questions:

1. What it is that you like the most about teaching physical science?
2. Could you share anything you do not like about teaching physical science? What frustrates you about teaching science?
3. What can you tell me about your own confidence in teaching science in the classroom? What boosts your confidence?
4. Why do you think some teachers have more confidence teaching physical science than other teachers?
5. Could you share your opinions of the guidance you have had from your principal regarding teaching physical science in your school?
6. What type of support do you get from your LF?
7. What forms of professional development in physical science have you received at your school during the last six months?
8. What type of training workshops do you get? How often and how long do they take?
9. Thinking back, how well do you think your pre-service training prepared you for teaching secondary school science?
   9.1 How do you feel about your physical science content and methodology classes during your training? Do you think that they adequately prepared you to teach science effectively?

10. What would you say is the most important thing that would make you feel more confident about teaching science in your classroom?
11. What is your professional qualification?
12. For how long have you been teaching physical science?
13. Do you teach either physics or chemistry, or do you teach both?
    13.1 During your pre-service training did you take them both as major subjects?
    13.2 If you were given a chance to choose between the two, which one will it be and why?
    Which one are you more confident in, physics or chemistry?
14. From the chemistry content, which topic do you like the most and why?
    Which one do you dislike the most and why?
15. From the physics content, which topic do you like the most and why?
    Which one do you dislike the most and why?
    In terms of practical work, which section are you more confident in, physics or chemistry? Why?
    How do you conduct the experiments? Demonstrations or learners are hands-on?
16. What are the general problems that you encounter in teaching physical science in terms of the following:
    - Content knowledge
    - Practical work
    - Assessment
17. What do you think needs to be done in order to increase teacher effectiveness and confidence?
18. Is there anything else you would like to add?

Thank you very much for your time and contribution.