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TEACHER DEVELOPMENT AND CHANGE IN THE CONTEXT OF TEACHING LARGE UNDER-RESOURCED SCIENCE CLASSES

By

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Submitted in partial fulfillment of the requirements for the degree
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APPROVAL

This research work has been examined and is approved as meeting the required standards of scholarship for partial fulfilment of the requirements for the degree of Master of Education at the University of Pretoria.

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DECLARATION STATEMENT

I hereby certify that this piece of work is entirely my own work. It is original except for the work of others and sources that have been acknowledged. The material contained in this report has not been submitted previously for assessment in any formal course of study.

STUDENT'S SIGNATURE: ________________________ DATE: _____________

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SUMMARY

Title:	Teacher development and change in the context of teaching large under-resourced science classes
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This is a biographical case study of science teachers who teach at schools that have consistently produced good results in the examinations despite disabling teaching conditions such as large, under-resourced classes.

The study analysed the life experiences, education, school- and community environment of the teachers in an attempt to identify the critical features that inspire and support their classroom commitment to hands-on / minds-on teaching.

Evidence was collected through semi-structured interviews with the teachers to get their stories, with groups of learners to assess how they perceived the teachers in the classrooms, and through informal discussions with the principals (school management) and colleagues, for a richer description. Questionnaires were administered to find out what the situations concerning resources were at the schools. Classroom interactions were observed and analysed for more information on the conduct of the teachers in the process of teaching and learning.

It was found that both case study teachers had adequate content knowledge and pedagogical content knowledge (PCK) and taught in a way that reflected their understanding and belief of the nature of science (NOS).

The view that the two participating teachers have of the nature of science was formed during their own formative school years and influenced the view of the nature of science they instill in their learners.

The inadequacy of resources at the schools although a frustration to the teachers, did not deter them from teaching science in an experimental way reflective of the nature of the subject matter.

The education implications of this study are discussed in relation to lessons that can be learnt from such inspiring teachers. The significance of the study is seen in the contribution it can make to the existing scholarship on effective science teaching and on teacher development programs including factors contributing to effective science teachers in the present South African climate of having large, under-resourced science classes.

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LIST OF TERMS

In this study the keywords will be operationalized as follows:

Large class	In this study a large class is defined as one where the majority of characteristics and conditions present themselves as inter-related and collective constraints, that impede meaningful teaching and learning (Onwu, 1999a: 126). This may include a high learner-to-teacher ratio of more than 45:1.
Under-resource:	In this study an '*under-resourced*' science class is one with certain features missing or only partly present: such as teaching and learning aids, inadequate teaching space, ill equipped laboratory, insufficient learning materials.
Effectiveness of teaching:	In this study effectiveness of teaching is used as a point of entry in selecting the teachers whose schools have had consistently good results in the Senior Certificate exam for a period of five years or more.
Nature of science:	In this study the nature of science is defined in terms of science as a human activity in the sense of "science is what scientists do"; in which scientific ideas change through time, and where the scientific ideas and the uses to which they are put are affected by the social and cultural contexts in which they are developed.
Pedagogical content knowledge:	In this study pedagogical content knowledge is defined as (i) content knowledge and (ii) the content specific methodology a teacher displays regarding an understanding of ways in which to present subject content that is accessible to learners. This includes an awareness of topics that learners have difficulty with, and a consciousness of misconceptions that learners hold or could develop and the taking of preventative action.
Teaching strategy(ies)	Teaching strategy refers to the specific method(s) of teaching to achieve a particular learning outcome. A successful teaching strategy would create a condition for learners to learn with meaningfulness so that they can relate their new learning to different contexts.
Teacher development:	Instances of teachers undergoing professional development for quality improvement.

Classroom management Classroom management is defined as the skill and competences that create and maintain an orderly and conducive learning environment.

Teacher formative experience: Teacher formative experience refers to identified factors in the background of a teacher, namely the teacher's (1) own schooling and academic achievements, (2) family background, (3) identification of persons who have been influential, (4) qualifications, and (5) identified emotional, social, professional and intellectual drives that influenced and sustain him/her in the teaching profession.

School culture: School culture describes the overall character of the school, its ethos and how policy and practice of the staff, learners, parents and community impact on the schools own unique performance.

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

“Basic education for all” is generally regarded as a fundamental right and a way of developing the human resources within a country (Budlender, 2003; Tomaševski, 2001). For the first time in the history of South Africa, basic education for all was given a prominent place when the Interim Constitution of the Republic (1994) was accepted. However, prior to the acceptance of the new constitution there had already been a great increase in the enrolment of learners at school in South Africa over the previous fifteen years (Perry and Arends, 2003). The growth of learner enrolment was partly due to businesses wanting a more skilled workforce but mainly as a result of the black youth demanding a better education (Taylor and Vinjevold, 1999). The growth rate has since slowed down as enrolment in public schools has stabilized. Statistics indicate a decrease in school-age population enrolment (6 to 18 year-olds) for the period 1997 to 2003 (Perry and Arends, 2003).

With the growth over the years in learner enrolment in schools there has been a corresponding increase in the number of learners in science classes. As Lewin (2000) has indicated, most developing countries, including South Africa, believe that an investment in science and technology will enhance economic development. The hope that increased access to science and technology education would help eliminate the shortage of qualified scientists has led to government initiatives having an emphasis on science education in many African countries (Onwu, 1999a). Such initiatives have radically altered the education climate and have led to a dramatic increase in the number of learners in science classes. These imperatives have resulted in large science classes; the consequent demands on the recruitment and training of teachers and the provision of suitable curriculum material, are central challenges that must be addressed (Watson, Crawford and Farley, 2003). The demand for science education has outstripped the present resources (Onwu, 1999a). The question arises of how science teachers are to cope with this continuing reality of large classes and insufficient resources.

1.2 Background to the problem

In South Africa before 1994 there were basically two types of government school: (i) the Model C schools which were predominantly white and were generally well-resourced in terms of teachers, materials, class-size and government funding, (ii) the township and rural schools which were mainly black and lacked infrastructure and resources, and had poorly-trained teachers and large classes. With the new political dispensation in 1994 a new education reform policy was adopted (RSA 1994:58). The Schools Register of Needs Survey was conducted in 1996 in order to determine the greatest needs in the education system and "to rid the country of the inequities of apartheid" (Kader Asmal, 2000). One of the areas identified was that of science and mathematics education. A great concern was the small percentage of school-leavers having academic results that could lead to a career in science or technology (Centre for Development and Enterprise (CDE) Research Report, 2004).

In the first decade after 1994 much was attempted in the education sector and, in particular, mathematics and science education, to change previous inequalities. Indeed the Government designed various policies to improve the mathematics, science and technology capacities of South Africa (DoE, 2000; DST, 2002). In 1997, the National Education Policy Act was introduced, with an emphasis on outcomes based education (OBE). This initiative, known as Curriculum 2005, was introduced in phases and the intention was to implement it in all grades by 2005 (DoE, 1997a). The curriculum prescribes a "learner-centred" approach to both teaching and learning. In science education, at any rate, there were new difficulties. Curriculum 2005 under-specified the content to be covered, while teachers, now having to emphasize activities of the learners, experienced a lack of structured resources and materials (Reddy, 2006). The policy also introduced new types and purposes of assessment. Teachers needed to devote a lot of careful thought, before the time, to implementing new and effective activities for the learners and to developing new instruments and methods for assessing their progress in knowledge, skills and attitudes. (Taylor and Vinjevold, 1999). As Taylor (1999: 128) pointed out, "the scheme for applying the curriculum in the classroom is quite bewildering in its complexity. It would seem likely that only the most dedicated, knowledgeable and skilled teachers are likely to achieve South Africa Qualifications Authority's (SAQA's) learning goals" using this curriculum. Not surprisingly, this curriculum was reviewed and revised, and by 2002 "The Revised National Curriculum Statement" was accepted, one that was more streamlined and gave more structure and guidance to teachers (DoE, 2000; DoE, 2002).

Another change in the education system brought about by the change in the curriculum is that of the Senior Certificate examination, a public examination that the learners write at the end of their grade 12 year. The intention of such an examination is to give learners a certificate giving them access to the job market or higher education institutions. In the past the examination system was based essentially on a record mark (from just a few tests) and then the final examination. With the implementation of The Revised National Curriculum Statement teachers are expected to deal with a system that includes a kind of continuous or formative assessment. The idea behind this is that teachers are then able to obtain immediate feedback on the strengths and weaknesses of their classroom practices. Teachers now have to organise learner activities (outcomes based activities) into portfolios that are externally moderated (Chrisholm, 2006). The marks for these portfolios then become part of a year mark. The year mark comprises an aggregate of scores obtained from classroom tests, homework, practical work and assignments (Pandor, 2005). For the first time (in 2001) in the examination the final marks of learners were calculated using the year mark (Pandor, 2005). However, very little has been done to train teachers to administer continuous assessment. The process is also not properly monitored and controlled and the different provinces do not show equal concern for the new process (CDE Research Report, 2004).

Until the end of 2007 learners also had the option of writing the Senior Certificate science examination on the higher grade or on the standard grade. When the Revised National Curriculum Statement is implemented in the Further Education and Training phase (FET) (starting with grade 10 in 2006), which is currently in force, only one grade will be offered and learners will not have the choice of taking science on either higher grade (HG) or standard grade (SG) (CDE Research Report, 2004). The system of taking HG or SG physical science is of great concern, since only learners with a HG pass in science and mathematics may pursue a degree in science at tertiary level (CDE Research Report, 2004). Over the twelve-year period from 1991 to 2003, as reported (CDE Research Report, 2004), there was only an increase of 12,80% in the number of higher grade passes in physical science and in 2002 only 14,06% of the higher grade passes in physical science came from black learners (CDE Research Report, 2004). As education experts point out, the slight increase in the number of passes might be attributable to incorporating the continuous assessment component in the final grade (CDE Research Report, 2004). However 2007 brought a noticeable and worrying decrease in the number of candidates passing physical science on the higher grade - only 28 122 as compared to 29 781 in 2006 (Pandor; 2007).

In order to address the situation, a national strategy to improve mathematics and science education was developed in June 2001. The intervention was named the Dinaledi project (DoE, 2001). In this project, schools that were successful in the mathematics and science fields (recognized by having a pass rate in the examination of 80% - 100%) were identified and invited to take part in the project with the aim of increasing the number of school leavers with a higher grade pass in science and mathematics. The 102 schools across South Africa that joined were then granted additional facilities, equipment and support (Reddy, 2006). In the report (published in 2004) reviewing the progress made by the Dinaledi project, concern was expressed that the programme did not significantly increase the number of learners with higher grade passes in science and mathematics as had been expected, and it was suggested that the project should be reconceptualised and expanded (CDE Research Report, 2004).

Other areas in education in which improvements occurred since 1994, have been to improve school buildings and basic facilities of schools in rural areas and to lower teacher-learner ratios on average (Van der Berg, 2001). Many teachers have upgraded their qualifications, often through distance education (Chrisholm, 2006: 213).

Despite these changes it seems that many teachers are unhappy in the profession. In a recently published report "Educator Supply and Demand in the South African Public Education System" (ELRC, 2005), in which the findings from various reports are integrated, more than half (54%) of the teachers of the nationally representative sample of teachers in the Educator School Survey indicated that they had thought about leaving the profession and about a third (29%) of the sample indicated that they had very often thought about leaving. Most of the teachers who indicated that they were thinking of leaving were in the fields of technology, natural sciences, economics and management (ELRC, 2005). In stating their intention to leave, more than half of them indicated that salary was an issue. Apart from low salaries, other reasons given were the low status of the profession, lack of career advancement, dissatisfying teaching conditions and high job stress. Other complaints mentioned were poor support for education by the government, by parents and by the community, and also the lack of discipline amongst learners (ELRC, 2005). In a related study (Rangraje, Van der Merwe, Urbani, Van der Walt, 2005), conducted in the Durban central district, 86% of the 280 teachers in the sample mentioned taking a huge work load home, 79% mentioned lack of teaching resources, and 78% mentioned large classes as additional reasons for job dissatisfaction (Rangraje et. al., 2005) Large classes could be at the root of most of these complaints, since the administration of learner information and the assessing of the activities and scripts of learners will increase in proportion to the number of learners present. More learners in a class could also increase the noise level and result in discipline problems. The shortage of resources could also be a result of just having too many learners in a class. Teachers play a crucial role in the education system (Kollapen, 2006) and one would hope to find that teachers, in general, are passionate, committed and hard working. However, many of the teachers in both of these samples felt demoralized and unenthusiastic and were not enjoying their profession at all.

Notwithstanding the improvements undertaken to overcome the legacy of apartheid, many schools are still without proper facilities and teaching materials to cope with the increase in learner numbers. As Jansen (2006) has pointed out, "despite significant investment in education, and the formal equalisation of education expenditure, educational outcomes are not only hugely unequal across schools, but also far below standard in comparison with other middle- or lower income countries". Large, under-resourced science classes is a phenomenon that is likely to remain with us in South Africa for a time, as is the case in other African countries (Onwu, 2005). The new Revised Curriculum is not likely to be adequately implemented when the teachers have not received sufficient training on how to implement the assessment properly (Kollapen, 2006; Rogan, 2004). The intensification of the workload teachers experience due to all the administration required by the new OBE curriculum that goes hand-in-hand with the number of learners in a class, including the assessment of the work of these learners, could be reasons for teacher morale being low (Stoffels, 2005).

However, there are teachers who teach large science classes and have few resources, yet have consistently produced students with good science results in the Senior Certificate examinations. These teachers have also produced passes on the higher grade in science. It would be interesting to know whether any such teachers were among those in the survey that were thinking of leaving the profession or whether only teachers struggling to cope with their situation of large, under-resourced classes were considering leaving. In a situation where science teachers are already struggling to produce competent learners that are interested in pursuing a career in science, it would be a pity to lose the effective teachers. It is important to know what teachers actually do, who have consistently produced good science results in the examination, while teaching under these circumstances.

The present study probes the relationship between OBE policy in the context of large, under-resourced science classes and teacher practices. What is the effective teacher's response to the new policy? How has the teacher adapted his or her science teaching? It is necessary to observe what an effective teacher does in the classroom. Are there any innovations in his/her teaching approaches? What teaching and learning strategies does he/she follow? Also the background of this teacher is important - where he/she comes from, the formative experiences from his/her own science class as a learner at school, qualifications and training, and how he/she developed into an effective science teacher. What kind of in-school support, if any, does this teacher have and what support does the school community give? To answer these questions it was decided to do a biographical case study of two teachers who were identified as effective teachers of large, under-resourced science classes.

The findings should be useful for teacher development in the current education reform agenda for both pre-service and in-service teachers. Basically the question is, to what extent can the lessons learned from such inspiring teachers be incorporated into teacher development programs to change science teaching in schools?

1.3 Purpose of the Study

The purpose of this study is to undertake a biographical case study of two teachers, who have been identified as being effective in the context of teaching large, under-resourced science classes. The findings could be helpful for in-service training of teachers and for training student teachers to cope with the demands expected of them.

1.4 Research Questions

- What does an effective science teacher do and have in the classroom while teaching large, under-resourced science classes and how and why do these actions bring about effectiveness?
- What formative experiences have influenced the behaviour of the teacher and how and why have they contributed to effectiveness?
- What in-school support does the effective teacher have that sustains the practice, and how and why does this support lead to continuing effectiveness?

1.5 Significance of Survey

Since the South African government has increased access to education and since there has been recognition of the importance of science and technology, there has been a drive to improve science and technology education. One consequence of this initiative has been an increase in learners studying science at secondary schools, which in turn has led to large science classes. Many of these schools are not adequately resourced for so many pupils. Some of the schools are not furnished with laboratories or the equipment for doing practical science experiments and many do not have adequate learning materials. Coupled with this are the low salaries of teachers, low status of the profession, lack of career advancement, dissatisfying teaching conditions and high job stress.

Notwithstanding these factors there are teachers who have persistently produced learners with good science results in the Senior Certificate Examinations despite teaching large classes and being under-resourced. Therefore it will be fruitful to study what such an effective teacher does at a school known for high performance, while teaching under these circumstances. A case study of two such teachers is conducted.

1.6 Overview of Chapters

Chapter one gives a background to the problem. The research questions are identified, the significance of the study is presented and an overview to the study is given.

Chapter two reviews the literature concerning large, under-resourced science classes, the present situation concerning resources at schools in South Africa and characteristics of effective teachers. The point is argued that although the teacher-learner ratio for the school is the usual way for characterizing class size in the literature, this is not necessarily an accurate reflection of the actual class size a teacher faces. Then, some strategies are identified, which have been developed to assist teachers of large classes. The situation at schools concerning resources, and also the different views regarding the importance of resources for teaching - in particular for science teaching - are discussed. Various ways in which effective teachers have been described over the years in the literature are briefly mentioned. The characteristics of effective science teachers, as found in the literature, are mentioned. Aspects of teaching that would describe an effective teacher and especially an effective science teacher in the South African context are identified. A framework for analysing the data gathered in the study is developed.

Chapter three presents the research procedure used in this study. The procedure for sampling the case-study teachers is described. A description of the different research instruments used in gathering data is given, including an account of the validation of the instruments. The gathering and analysis of the data, and their validity are presented. The chapter ends by mentioning ethical considerations.

Chapter four presents the two case studies. A narrative account of each case study, the observations in each and information from the various interviews are given.

Chapter five discusses the findings of the case studies using the framework developed in Chapter two. Three themes are identified in answer to the research questions.

Similarities and differences in the case studies are highlighted. The study concludes by referring to characteristics of effective teaching found in both case-studies of teachers who had large, under-resourced science classes and to those effects that need further development if they are to be effective. The study ends with recommendations for further research.

1.7 Chapter summary

This chapter gave some background to the study. The need to investigate effective science teachers teaching large, under-resourced classes is recognized. The research questions and the significance of the study are identified. The chapter ends with an overview of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter the whole concept of large classes will be discussed and the teaching strategies typically used in them. The notion of "under-resourced" teaching in the present South African situation will be considered. Various views on effective teachers will be surveyed. The characteristics of effective teaching, in general, and effective science teaching, in particular, will be considered.

2.2 The Concept of Large Classes

In 2000, the member states of the United Nations agreed upon eight Millennium Development Goals (United Nations, 2000). One of the goals was similar to that of a document adopted by the World Education Forum in Dakar in that year, requiring participants to commit themselves to increasing access to, and providing, complete, free, and compulsory primary education of good quality for all children, world-wide, by 2015. In attempting to achieve this goal, governments of sub-Saharan African countries have supported a steady growth in the enrolment of learners at school (Nilsson, 2003). As executed, the increased enrolment requires more teachers, more training and more curriculum material (Watson et al., 2003). However, the demands made on education in general and on science education in particular, have not necessarily been met by a corresponding increase in resources. In particular, one of the results of this shortfall has been larger science classes (Perry et al., 2003).

<u>Defining 'Large Classes'</u>

In the South African setting, a study was undertaken in which forty-one participants made up of researchers, curriculum developers, university science educators, teacher educators and students from the sub region, including Malawi, Zimbabwe and South Africa, addressed the concept of large classes and how to define them (Onwu, 1999a). Interestingly the participants had various conceptions of large classes. Some defined large classes according to the number of learners, while others preferred to describe the characteristics of large classes (Onwu, 1999a). A working definition derived from an African context defined "a large class as one where the majority of characteristics and conditions present themselves as inter-related and collective constraints, that impede meaningful teaching and learning" (Onwu, 1999a: 126).

The concept of large classes from an African perspective is not necessarily in accord with the expression "learner-to-teacher ratio" often used in the literature when reporting statistics on class sizes (World Bank, 1999). According to Nilsson (2003: 9), learner-to-teacher ratio is defined as "the average number of full-time study learners per full-time working educator". Based on this view, the whole school is considered when defining learner-to-teacher ratio (Nilsson, 2003). The definition is not necessarily meaningful in the context of this study where the focus is on the actual number of learners that a teacher faces in a classroom context.

Goldstein and Blatchford (1998), in agreement with the view of this study, argue that calculating class size or establishing learner-to-teacher ratios using Nilsson's definition, for example, is not a true reflection of actual class size. According to them, values of learner-to-teacher ratios are arrived at by including among the educators those, like the principal, whose posts are essentially managerial; in reality, there are fewer educators actually teaching in the classrooms. Thus the learner-to-teacher ratio is actually larger, and ought to be calculated using the number of teachers regularly teaching in the classroom. Goldstein and Blatchford also maintain that during any school year there is a migration of learners from one school to another so that the actual number of learners in a class at any given time may be different from the number used to calculate the learner-to-teacher ratio. On this view a study on large classes using learner-to-teacher ratios is not properly meaningful. Another complication arises when learners have a choice of subjects (of which Physical Science is one). Certain subjects are popular and many learners choose them, while other subjects have few learners. These very different situations are not reflected in the learner-to-teacher ratio.

Nevertheless, in comparisons of class size, the learner-to-teacher ratios as defined by Nilsson (2003) are generally used in the literature. Hence, at present, the issue of when to regard the learner-to-teacher ratio as "large", is relevant.

In 2001 the South African Department of Education agreed upon a learner-teacher ratio of 40:1 at all primary schools and 35:1 at all secondary schools (DoE, 2001a). However, in practice, this goal is not always reached - as is seen by an educator survey in which educators were asked to report on the average number of learners they had taught during the years 2001 to 2003. The average class size for urban primary schools was 45:1 and, for urban secondary schools 52:1. In rural schools the reported class sizes were even higher than these (ELRC, 2005). In a recent study undertaken by Onwu and Stoffels (2005) in the Limpopo Province of South Africa - to find out what actually happens in a science classroom in a secondary school - of the 53 senior science teachers who took part in the study, only 18 (34%) had classes where the learner-to-teacher ratio was less than 60:1; furthermore, there were 8 teachers (15%) who had classes for which the learner-to-teacher ratio was more than 110:1. In this study, a class is only considered large if it has a ratio of 45+ learners per teacher.

High learner-to-teacher ratios entail, or are accompanied, by a number of serious conditions that affect learning. As Onwu (1999a) has reported, large classes have an effect on the learners, the teachers, the physical circumstances and economic policies. Some of the restrictions learners experience are a lack of space to move in, fewer chances to participate actively, an increased noise level and more distractions, while teachers experience an increased workload, and insufficient resources and learning materials. Often the method of teaching is simply lecturing and the practical work is, at best, simply demonstrations by the teacher (Onwu and Stoffels, 2005; Onwu, 1999a). If large classes bring about such constraints, the question naturally arises of the extent to which class size influences the achievement of learners.

2.2.1 Class size and Achievement

Generally in the western world there has been an understandable tension between educators on the one hand and the economists/administrators on the other with regard to class size and achievement. For educators generally maintain that learners do better in smaller classes, while politicians generally favour fewer teachers (resulting in larger classes) because of budgetary constraints (Biddle and Berliner, 2002; Hanushek, 1998). Research has often been undertaken by one or other of these groups in the hope of substantiating their viewpoint. Educationists have wanted to show that the average achievement of learners improves in smaller classes while the economists/administrators have wanted to show that the alleged improvement in smaller classes was not really significant or that it was not actually due to the smaller size of the class (Hanushek, 1998). Several researchers (Krueger, 2002, quoted in Buckingham 2003; Hanushek, 1998) conducted meta-analyses of previous studies on the effects of class size, while other studies (Scudder, 2005; Buckingham, 2003; Biddle et al., 2002) conducted a literature review. However many of the studies undertaken by both the educationists and economists/administrators have been very limited and often, also, the methodology used is open to question (Biddle et al., 2002). Hence the results of most of these studies have been regarded as insignificant (Buckingham, 2003; Biddle et al., 2002). Nevertheless there have been some major studies conducted in the United States to establish the importance of class size on the achievement of learners. Two such studies were the Tennessee STAR project (Pate-Bain, 1992, quoted by Muijs and Reynolds, 2005) and the report of the Wisconsin Student Achievement Guarantee in Education (SAGE) during the period 1996/7 (Biddle et al, 2002). Also noteworthy have been the similar studies of Blatchford (Blatchford et al., 2006; Blatchford et al., 2003; Blatchford et al., 2002) in the United Kingdom. The results of these studies are discussed in more detail in the following paragraphs.

The Tennessee STAR project (Tennessee Student/Teacher Achievement Ratio), which started in 1985 in Tennessee, USA, followed the achievements of 11 600 learners in approximately 80 schools for an initial four-year period. The learners were divided into two types of classes: (1) small classes which had one teacher and about 15 learners and (2) standard classes which had one certified teacher and more than 20 learners (Biddle et al., 2002; Hanushek, 1998). (As indicated previously, even the larger classes here are small in comparison with those in the developing countries). Some of the findings showed that learners who had been in small classes in the early grades, generally had better achievements later on - in reading ability, word-study skills and mathematics. Furthermore, the longer the period that these learners had been in small classes the greater the gains. Learners from impoverished backgrounds showed the greatest gain after being put in smaller classes (Scudder, 2005). Follow-up studies on the learners in the original STAR program (to investigate whether these gains had a lasting effect) showed that, on average, those learners who had attended small classes in the lower grades were 4.1 months ahead in reading by the time they reached grade eight, 3.4 months ahead in mathematics, 4.3 months ahead in science and 4.8 months ahead in social science, compared with learners who had attended classes of standard size (Biddle et al., 2002). Hattie (2003) reported that Hanushek queried the results, implying that the STAR study might have been biased since those participating - school principals, teaching officials, parents and even learners - were aware of this study, and this would have made an unavoidable difference in the treatment of the group.

The Student Achievement Guarantee in Education (SAGE) (1999) program reported similar results to those of the STAR program. Learners form smaller classes experienced larger gains in achievement and, in the case of learners from poorer backgrounds, these gains were even greater (Biddle et al., 2002).

The findings of these studies should be relevant to the South African situation. In South Africa at present the most disadvantaged learners are the African learners in the rural areas. The rural communities are usually the poorest areas, and have the largest class sizes, according to reports (ELRC, 2005; Onwu and Stoffels, 2005). Are the large, under-resourced classes a reason for the poor academic achievement of the learners? As mentioned in section 1.1, some of the teachers who took part in the educator survey indicated as reasons for their wanting to leave the teaching profession, problems of discipline and a huge workload (ELRC, 2005). Are the problems they experience related to the large size of classes they teach? How, in fact, do teachers cope in the South African situation? Although small classes cannot, at present, be realized in the whole South African situation, there are nevertheless teachers who are considered effective in their teaching of large classes. How do they manage with these large, under-resourced science classes and still get good results?

Although the STAR and SAGE projects show that learners do better when the classes are smaller, both these studies focussed on learners in their early school years. A limited number of studies (Blatchford et al., 2006; Onwu and Stoffels, 2005; Betts & Shkolnik, 1999; Onwu, 1999a; Onwu, 1999b; Rice, 1999) have focused on the influence of class-size on learners later on in their school careers. Blatchford (2006) studied the effects of large classes on learners aged between seven and eleven years and found that learners in smaller classes had more individual attention, played a greater part in the activities in the classroom and had more chance of being successful. Although both Betts & Shkolnik (1999) and Rice (1999) investigated learners in the middle and high school years, they did not so much study the achievement of learners as the changes teachers were making to cope better with large classes. More research is needed to establish whether learners in smaller classes in secondary school will show similar gains in achievement to those shown by learners in early primary school.

Two questions that are being asked more and more frequently are (i) why learners in small classes in the early grades seem to be successful even in later years and, coupled with that, (ii) what in the pedagogy and classroom management changes when teachers have larger classes. Tentative theories have been put forward, but little has been done to verify them (Biddle et al., 2002). In this area, too, the literature is sparse.

2.2.2 Class size and Teaching

Although the intuitive feeling is that it is more difficult to teach large classes, few studies actually give statistical evidence of such findings. Some of the first studies on large classes in the United Kingdom (Blatchford and Martin, 1998; Bennett, 1996) tried to establish, through questionnaires and observations, what the perceptions on the teaching of large classes were, of head teachers, chairmen of boards of governors, teachers and parents. In these studies the size of small classes had, on average, 19 children and large classes had, on average, 33 children (Blatchford et al, 2003). The findings agreed with what was intuitively expected, that class size has an effect on the quality of teaching and learning, but did not answer the question, "What factors in the classroom management or the pedagogy make it more difficult to teach large classes?"

Having discerned the perception that large classes are more difficult to teach, researchers have probed for answers to the second question, "What changes in the pedagogy of teaching when the classes are large?" The study by Blatchford et al. (2002) gives a good review of the effect of large classes on teaching, including aspects such as allocation of teacher's time to various activities, conceptions of effectiveness of teaching, and cognitive components of teaching. In a follow-up study, Blatchford et al. (2003) tried to establish what classroom processes might be involved in the different educational performances of different class-sizes. They focused on two dimensions: attentiveness and peer relations, and they found that although there seems to be less aggressive and anti-social behaviour in large classes, there is more 'mucking about' and off-task engagements with peers, such as not listening to the teacher and not concentrating on one's own work, than in smaller classes.

The study by Betts and Shkolnik (1999) tried to establish how teachers changed their conduct in the classrooms when there is a variation in class size. This research involved 2170 maths classes (of learners in middle and high school) from a representative sample of American public schools. The researchers found that teachers react to the change in class size by re-allocating the time they spend on various activities in the lesson. For example, an increase in class size of 10 learners significantly increases the percentage of time the teacher spends on discipline and routine administration, while significantly reducing the percentage of time spent on review (or revision of concepts already explained). The surprising result was that in smaller classes, teachers tend to improve the learners' grasp through additional review rather than by covering new material, whereas in larger classes the teachers did more group work (thus maintaining time-on-task) and spent less time with individual learners and less time on review. It was also clear from the study that teachers of large classes did not alter the time they required for presenting new material.

Rice (1999) investigated how class size influenced the use of time spent (1) in instruction (e.g. working with small groups, using innovative instructional practices, leading whole group discussion, amount of homework assigned) and (2) in non-instructional activities (e.g. administration, discipline) in high school mathematics and science courses. The findings showed that class size influenced both instructional and non-instructional activities, but the effect varied by subject area, type of student and how well teachers had planned their activities. Most of the findings reviewed have been undertaken in European and American countries. Are the findings similar in the South African situation?

Onwu and Stoffels (2005) undertook a study to find out what actually happens in large, under-resourced science classrooms. At the end of a workshop, they handed out, to 53 teachers, questionnaires probing information on teaching methods and strategies in the classroom. The participating teachers all taught secondary science in the Limpopo Province of South Africa and they had average class sizes of 65 to 85 learners. The researchers found that some of the characteristics of large classes referred to by the teachers in the study were the increase in noise level, increase in discipline constraints and decreased motivation of learners due partly to resource constraints. The teachers indicated that they had very little opportunity to help individual learners by means of self-activity and inquiry. The teachers in the study also lamented the lack of laboratory equipment, the lack of teaching and learning materials (textbooks, teachers' guides, etc.), a shortage of space simply to move in, and the huge marking load required for assessing learners continuously and giving immediate feedback. However, when the teachers were asked to comment on their 'best lesson', the lessons most of them described were those in which they were facilitators and the learners were engaged in an inquiry activity (Onwu and Stoffels, 2005: 88).

These findings are in accordance with those reported by Blatchford et al. (1998 and 2003) in which they found that teachers experience more stress in larger classes with a consequent waning in their own morale and enthusiasm.

Johnson et al. (2000c), reporting on an intervention undertaken in the Western Cape Province of South Africa for training teachers in the use of Outcomes Based principles, commented on a possible reason for why teachers of large, crowded classes had difficulty in changing their customary method of "talk-and-chalk" to that of facilitator. They referred to the space near the blackboard as the peculiar domain of the teacher from which the teacher wields authority. (In some crowded classrooms it is almost impossible for the teacher to move around among the learners). When a teacher changes his method to that of facilitator he has to relinquish this "authority". Often the teachers are unwilling to make this change for fear of picking up more problems in discipline than they can cope with (Johnson, S., Monk, M., Watson, R., Hodges, M., Sadeck, M., Scholtz, Z., Botha, T., and Wilson, B., 2000c).

Although the studies mentioned focused on some classroom processes that might influence the effectiveness of teaching in large classes, the data is meagre and more research is needed. Nevertheless, these studies confirm the perception of most educators that it is more difficult to teach large classes, *ceteris paribus* (other aspects being equal). The interest in the present study is in determining what effective teachers actually do when teaching large, under-resourced science classes.

Some studies have emerged that suggest that learner-to-teacher ratios are not as important as generally believed. A study undertaken by Crouch and Mabogoane (1998) correlates data from four different data bases, viz. the matriculation exams database, the Education Management Information System (EMIS), the School Register of Needs (SRN) and a certain socio-economic database commissioned by the Department of Education. The purpose was to determine which factors among the categories, resource availability, management and the social environment, have an influence on performance as measured by the pass rate. They concluded that the learner-to-teacher ratios matter far less than the quality of the teachers (Crouch and Mobogoane, 1998). One could here, of course, respond that it is precisely those teachers that are well-trained and effective that adopt good strategies for teaching large classes; in their case the size of the class might not appear crucial, but such teachers are few and far between.

In the third plenary address at the ADEA 2006 Biennale, in reporting on the quality of education and some recent findings of international research into effective schools, Verspoor (2006a: 26) mentioned that the quality of teaching is not influenced by class size up to a certain number of learners, and also that class size, up to 60, does not affect the performance of the learners (Verspoor, 2006b: 3). Van der Berg (2006), in analysing results from a survey of SACMEQ II (Southern African Consortium on Monitoring Education Quality) – the purpose of which was to understand better the relationship between educational outcomes, socio-economic status, school resources and teacher inputs – reported, amongst other things, that the influence on learner-to-teacher ratios did not show statistical significance in any of the regressions (Van der Berg, 2006: 12).

Despite these studies suggesting that learner-to-teacher ratios are not as important as has been believed, the controversy on class size and learner performance continues. As Onwu (1998) has pointed out, a teacher could be empowered by in-service training workshops to use strategies that encourage learner involvement in classroom activities, to become effective in classroom management techniques and to use local resources effectively in the classroom. Do teachers who are effective in teaching large, under-resourced science classes make use of those teaching strategies that are generally favoured for large classes? How do teachers in the Southern African setting cope with the constraints of large, under-resourced classes and what are their strategies? Is it, for example, possible to create a "small class atmosphere" where individual learners receive attention, even in a large class? What teaching strategies can be used to achieve a small class atmosphere? In the next section some of the strategies for use in large classes will be reviewed.

2.2.3 Teaching strategies in large size classes

While it is commonly believed that, in general, small classes are better, the ***Center for Excellence in Learning and Teaching*** **(1992)** has pointed out that, just as reducing the number of students in a class does not necessarily improve the quality of instruction, so also, increasing class size need not necessarily worsen it. What is of importance is that good teaching should take place in either setting.

Onwu (1998: 127) has pointed out "that teachers of large science classes can be helped to: (1) adopt strategies that provide for more pupil involvement; (2) use classroom management techniques that maximize resource utilization; (3) recognize local resources; and (4) relate local resources to topics in their curriculum". In an article (Dolan, 1995) entitled "Teaching Large Classes Well: Solutions from Your Peers" the writer also mentions some strategies that have proved successful in dealing with large classes. The strategies could be summed up as (1) Creating a Small-Class Atmosphere in a Large Class Setting, (learn the names of learners, and move around the classroom), (2) Encouraging Class Participation, (dividing the class into groups, giving participation points and having students contribute material for the class) and (3) Promoting Active Learning, (using demonstrations and audio-visual aids, giving frequent assignments, and giving "think breaks"). Points one and two of this author are in agreement with point one of Onwu (1998), but he elaborates by means of examples.

Niadoo and Reddy (1994) report on a study undertaken at the University of Durban Westville which used a strategy of co-operative learning with a large science class of first-year pre-service science teachers. They pointed out that in the teaching of large classes, co-operative learning is the most helpful line in overcoming student-centred learning.

Johnson, Scholtz, Hodges, and Botha (2003) report on a project they undertook in the Western Cape Province of South Africa to assist teachers in implementing strategies for teaching large classes. In this project science teachers (mainly of grades 8 and 9) were introduced to the use of paper and pencil "Translation Activities" (worksheets where learners discuss information presented in one form e.g. texts, diagrams, tables or graphs, and then transform it into another form, (p. 87) in their classes.) Worksheets were developed in a collaborative writing workshop in which all the different stakeholders were involved. They found that teachers who implemented the Translation Activities were helped to "see and believe" that the new pedagogic strategy would help them; if schools were provided with the necessary duplicating facilities the teachers would have control over the resources and be able to sustain the practice (Johnson et al., 2003; 94).

2.3 Resource availability and Teaching Large Classes

In Africa, as mentioned before, large classes are, in general, the norm. Since most of the African countries are also "developing countries", resources for teaching are not often readily available. In this section an overview of the availability of various types of resources (human resources, resources in the school environment and resources in the classroom environment) in the present South African situation is presented. It is argued that the view science teachers hold on the nature of science plays a huge role in the importance they place on resources.

In 1994, the Government of South Africa, in accordance with the White Paper on Education (DoE, 1995), adopted a policy to address the issue of resources with the purpose of ensuring equity in opportunities for learning. The School Register of Needs Survey (SRNS) prepared a document in 1996, and in 2000, giving details on the exact location, physical facilities, condition of school buildings, services provided, and equipment and resource material available for every school in the country (Chrisholm, 2004: 8). It was noted that a huge disparity in resources exist between the so-called Model C schools and schools of the mainly black communities - especially those in rural areas (Chrisholm, 2004: 8). The government implemented some initiatives to rectify the inequality of resources. To what extent the policy is succeeding in making resources available will be reviewed in the following paragraphs.

In South Africa the increase in the number of learners at school and especially in the number of learners in science classes since the 1980's led not only to a shortage of qualified science teachers but also to a shortage of learning materials (Perry and Arends, 2003; Taylor and Vinjevold, 1999).

Naidoo and Lewin (1998: 739), however, have questioned the assumption that there is a shortage of qualified science teachers. They found, in a study conducted in the Kwazulu-Natal Province of South Africa, that there was not really a shortage of qualified science teachers – but the qualified science teachers were doing other things in the school than teaching science. Indeed, in 1994, of the 927 science teachers employed to teach science at the 564 secondary schools in the Province, 332 teachers (i.e. 34%) were not qualified to teach science. However, of the 1167 qualified science teachers registered in the departments of DEC and DET in Kwazulu-Natal at that time, 572 qualified science teachers (i.e. 62%) were not teaching science. Naidoo and Lewin (1998) also show that the learner-to-teacher ratios for physical science classes were low, (averaging 38:1 in grade eight and dropping to 23:1 in grade 12), because comparatively few learners chose the subject. They therefore question the investment made on procuring resources for such a small number of learners - if the teachers are not using them - suggesting that the deployment of staff with regard to the teaching of Physical Science is a drain on resources.

2.3.1 Human Resources

For ease of discussion, resources are put into the following categories: human resources, school environment and learning-support materials or resources needed in the classroom.

The lack of human resources in the teaching profession has been attributed to poor remuneration. It was noted by Van der Berg (2001: 409) that the salaries of teachers of white learners were on average 28% higher (in 1997) than those teaching mainly black learners. One reason for this is the fact that teachers of white learners are usually better qualified and have had more experience. Although for the period 1991 to 1997 spending per black pupil increased by 54%, there was only an increase of 17% in teacher resources per black pupil, since the bulk of the money went toward salary increases (Van der Berg, 2001). However, as Van der Berg pointed out - in comparing pass rates in the exams for the years 1994 to 1999 - these shifts in resources were poorly translated into educational outcomes, since there was a decline in the pass rate for those years (a pass rate of 58.0% in 1994 dropped to a pass rate of 47.4% in 1997 and 48.9% in 1999). One reason might be that the salary increases were not matched by the provision of material resources to cope with the increased learner population, or some other internal factors to do with classroom, learner or teacher. A recent study (CDE, 2004) suggests that there are three determinants of success in the School Certificate examinations in science and maths, namely, teacher qualification, language and the classroom environment.

Chrisholm (2004: 6), reports that, apart from increasing salaries of science teachers, another initiative undertaken by the government of South Africa to improve equity and quality was to redistribute teachers from better resourced (mainly white and Indian urban schools) to poorer-resourced black and mainly rural schools. By implementing this measure, the Department of Education wanted to lower the learner-to-teacher ratio to 40:1 for primary schools and 35:1 in all secondary schools. However, some of the richer schools (that were already well equipped) used additional school fees to appoint extra teachers in addition to those on the public payroll. This resulted in these schools having smaller learner-to-teacher ratios than those set by the Department of Education. Furthermore it seems that some of the schools in the deep rural areas have had difficulty in finding teachers for their posts, thereby increasing learner-to-teacher ratios (Van der Berg, 2001: 415).

Quality of teachers

A further aspect related to human resources is that of adequate training of teachers (De Feiter and Ncube, 1999). Johnson et al. (2003) reported that teachers who were confident in their teaching were more able and ready to implement new ideas in their classrooms - as would be necessary with the implementation of a new curriculum. Both Crouch and Mobogoane (1998) and Verspoor (2006a) indicated that better qualified teachers seem to cope better with teaching large classes. These researchers felt that reducing class size was not the real issue, but that teachers should rather improve their qualifications. Verspoor (2006a), in reporting on Transforming Resources into Results at School Level, mentioned, among other things, that the quality of teachers and activities in the classroom must improve if an improvement in education is to be expected. He acknowledged that overall learning levels remained low in Africa and cautioned that an improvement in resources does not necessarily mean better learning will take place. He suggested that teachers need support systems and that the community should sustain them. He made a plea for an incentive system for improving the quality of teaching, but at the same time making sure that teachers are provided with adequate teacher guides and textbooks (Verspoor, 2006a).

In South Africa in 1999, The President's Education Initiative Research Project (PEI) was introduced with the purpose of providing a scientific basis for future planning and also delivery of educator development and support programmes (Taylor et al., 1999).

This project which focused on the school and classroom context, found that many of the teachers in South Africa have low levels of conceptual knowledge; tasks are set at low levels of competence and that learners are hardly ever called upon to read or write themselves (Taylor et al., 1999: 159). Some significant studies (Christie et al., 2007; Reddy, 2006; CDE Research Report, 2004) are in full agreement with the fact that the quality of teachers in South Africa needs to improve.

According to Reddy (2006: 110) who analysed the information obtained from the Trends in International Mathematics and Science Study (TIMSS) 2003, at first glance the South Africans who were teaching the participant learners appeared well qualified. In fact, 95% of the TIMSS learners were taught by teachers who indicated that they had obtained some post-secondary qualification. However, when their qualifications were compared with those of the teachers of the international group, the South Africans appeared amongst those having the lowest qualifications.

CDE Research Report (2004: 12) mentions ‘Educator knowledge’ as the major factor leading to success in maths and science. Christie et al. (2007: 126) agree with this finding and, when commenting on the topics, teaching, the teaching profession and teacher recruitment and retention, they stressed the importance of capacity-building for teachers in South Africa.

South Africa employs the principles of Outcomes Based Education (OBE) which place a great emphasis on learner-centredness, on inquiry-based learning and teaching and on developing a conceptual relationship between science, technology and society. The question arises whether the teachers of South Africa are adequately equipped to implement this curriculum. Many studies (Aldridge, Rüdiger, Laugksch, Mampone, Seopa, and Fraser, 2006; Hattingh, Rogan, Aldous, Howie, and Venter, 2005; Onwu and Mogari, 2004; Rogan, 2004; Johnson, Monk and Hodges, 2000a; Taylor and Vinjevold, 1999) show that the situation in classrooms, in general, and in the science classrooms, in particular, in South African schools evidences serious problems in implementing this curriculum. Rogan (2004) found in a study of the science classes of nine secondary schools in the Mpumalanga Province in South Africa that after the introduction of Outcomes Based Education (OBE) very little had changed in the science classroom; in only a few instances did the teachers perform demonstrations or give learners apparatus to perform simple activities. According to him, teachers interpreted the new curriculum as requiring more group work. Consequently although the learners were often actively engaged in group discussions, they were pooling their ignorance and not learning much science (Rogan, 2004).

In a study attempting to obtain a baseline assessment of the learners' performance in acquiring the "outcomes" of the new science curriculum, it was found that low levels of attainment were the result of an inadequate use of the language of instruction, poor reading skills, poor writing skills and poor teaching (Hattingh et al., 2005)

Aldridge et al. (2006) report on developing and validating an instrument to monitor the implementation of Outcomes-Based Education in the classroom - the so-called "OBLEQ instrument". They found that what learners prefer from a science classroom environment is quite different from the real classroom environment. These learners mainly experience science teaching as "chalk-and-talk", whereas they would prefer meaningful involvement in science and an emphasis on science applications in their everyday lives. According to their findings, logistical and organizational factors (e.g., length of periods, large class sizes, availability of textbooks, etc.) are important and also need consideration, besides the "quality" of the teachers (Aldridge et al., 2006). All of these studies point to the necessity of providing intervention programmes and resources to improve teaching.

Since, in general, the South African teachers (as human resources) are not adequately equipped to teach the new curriculum and the classes they teach are mostly large and poorly-resourced, a good number of small but successful initiatives to help teachers have been undertaken (Onwu and Mogari, 2004; Johnson et al., 2003; Johnson et al., 2000c). Onwu and Mogari (2004) pointed out, after a study done in the Malamulele district of the Limpopo Province of South Africa on the implementation of Outcome Based Education, that teachers who had undergone professional development training improved in their effectiveness. Before the intervention most of the lessons were dominated by teacher talk, there was little group work and interaction and the learners did little talking, reading and writing. All these aspects and many more improved with the professional development programme that was modelled on a stakeholders partnership (Onwu and Mogari, 2004).

Thus, not only should teachers be helped and reskilled but the resources available at the schools and the learning support materials or resources needed in the classroom should also be improved. Therefore, a second area of resources (apart from human resources) that needs to be addressed is that of school environment and the accompanying learning-support materials and resources needed in the classroom.

2.3.2 Resources related to school environment

From 1994 the Government of South Africa started a new initiative to address the issue of basic facilities with respect to the structure of the school and the school environment, such as school buildings, electricity, copiers, laboratories and the learning materials used in the classroom such as textbooks, writing materials, workbooks, science kits, desks, chairs and the library. Apart from the Schools Register of Needs Survey (SRNS) report of 2000, improvement to learning resources have been poorly documented (Chrisholm, 2004: 8). What has become apparent, however, is that there are many differences in resources between provinces and, indeed, between different schools - even schools in the same area. As Chrisholm (2004) reported, although many schools may have improved their sanitation, yet ceilings have collapsed and countless window panes remain broken and unattended to. In spite of this emphasis on the improvement of resources in the school environment, many studies (Christie et al., 2007; Crouch and Mobogoane, 1998; and Verspoor, 2006a) have concluded that the emphasis might be misplaced and that qualified teachers are all-important. However important it is to have well-qualified teachers, the present study considers the influence of resources on effective teaching in order to ascertain whether a more balanced view, viz. one including both an improvement to the quality of teachers and the improvement of resources, should be taken.

The “Schools that Work” document by Christie et al. (2007) reports that not one of the schools producing good results that took part in the study had adequate resources - for example, even though science and biology are taught at many of these schools many of them did not have laboratories; also some that had laboratories nevertheless did not use them because of a lack of equipment (Christie et al., 2007). What precisely were they measuring when they reported ‘good results’? If ‘good results’ mean enabling the learners to reproduce quite well from rote-learning in memory-oriented examinations, this still does not make the science teacher a good one. What is that teacher's understanding of the nature of science? How does one identify an effective science teacher? Christie, et al. (2007) refer to research of Foxcroft and Stumpf (2005) which argues that the results of the Senior Certificate exams do not give a clear indication of what learners really know, since their success in exams depends mainly on rote-learning and repetition; teachers can coach learners to answer questions correctly, without them gaining insight. Consequently the results of the exams are not necessarily an indication of the effectiveness of the teacher. Should Christie et al. (2007) then claim that resources do not matter?

As pointed out before, both Crouch et al. (1998) and Verspoor (2006a) asserted that the quality of the teachers is all-important. Nevertheless, they maintain that resources such as textbooks and teachers' guides (resources directly linked to the classroom) might have an influence on effective teaching and should be investigated. In science teaching this would include science equipment for demonstrations or hands-on activities.

Resources related to the Classroom environment

Verspoor (2006b: 3) reports that, in Africa, providing textbooks, teachers' guides and sufficient time for instruction are the most cost-effective ways of improving the quality of schools. With respect to curriculum learning materials needed in the classroom, Chrisholm reported that, in South Africa at any rate, the relationship between curriculum- or learning-support material and new texts and their influence on performance has not yet been analysed (Chrisholm, 2004); what little information is available from the literature on the use South African teachers make of textbooks will be considered in the next section. Another aspect to be addressed, related to resources in the classroom, is the view or conception that science teachers have of the Nature of Science (NOS). The way in which science teachers view science has an influence for example, on whether they teach science through enquiry or merely by chalk-and-talk.

Textbooks

As mentioned in the previous section, teachers in Africa need not only textbooks and learning support material; they need also to be trained in the use of textbooks (Vinjevold in Taylor and Vinjevold, 1999).

In the analysis of TMMSS Report 2003 it was noted that, in contrast to international findings indicating that about half of science teachers use the textbook as a primary resource and only a third use the textbook as a supplementary resource, in South Africa the pattern is reversed - only a third of science teachers use the textbook as a primary resource and half use it as a secondary resource (Reddy, 2006). Could this be because the South African teachers have not been trained to use textbooks appropriately?

That teachers need training on how to use a textbook is further strengthened by a study of Wickham and Versfeld (1999) in Taylor and Vinjevold (1999). They found in their study of seven English second language teachers in previously disadvantaged schools near Cape Town, that the teacher rather than the materials determines the classroom practice. That means that training in the use of textbooks or lack of it might determine the frequency of use of the relevant textbook by the teacher.

Wickham and Versfeld (1999) appealed not only for distribution of textbooks but also for in-service training for teachers to improve their use of the textbooks. However, Schollar (1999), found in a case study of four EQUIP (the Education Quality Improvement Project) schools in Mamelodi in the Gauteng province of South Africa that although textbooks have been provided to schools by the Guateng government, the numbers have sometimes been too few (Schollar in Taylor and Vinjevold, 1999). This study did not report on whether teachers used the textbooks in their classrooms.

In the context of large classes what do effective teachers do? How do they use the textbook?

Resources related to Language competence

The CDE Research Report (2004: 12) mentions three determinants of success in maths and science, viz. (1) teacher knowledge, (2) language competence and (3) school and classroom environment. English is mainly used for instruction and examination purposes. The question arises whether teachers' classroom practice would improve if teachers have the texts and material for lesson preparation in their primary language. An investigation to this end was conducted by Pile and Smythe (1999, in Taylor and Vinjevold, 1999) in the Free State Province of South Africa. Although a few changes were noted e.g. "the range of questions broadened; organisation of concepts and ideas became more logical" (p. 316), it was felt that these changes did not significantly change what happened in the classroom (Pile and Smythe in Taylor and Vinjevold, 1999). Onwu and Stoffels (2005; 86) in the investigation they undertook in the Limpopo Province of South Africa, point out that the participant teachers mentioned that often, when they explain for a second time a concept that they noticed learners have difficulty with, they do so in the mother tongue to help learners understand. These findings seem to be in accordance with findings from the literature that resources alone do not alter classroom practice.

Resources related to Classroom activities

Onwu and Stoffels (2005) mention, in the research cited above, that some of the participant teachers in communicating on the classroom and lesson organisation, indicated that they had too few desks for the learners, or had enough desks but not enough space for them in the classroom – sometimes because stacked broken desks diminished the space. Onwu and Stoffels further commented on how teachers were hampered in their teaching by not having enough textbooks; they expected the learners to copy notes or homework exercises from the blackboard which could have been found in the textbooks. Most of the participant teachers in this study commented on constraints they experience regarding practical work (only 9% of them do practical work in which scientific apparatus is used or student investigations are done, at least once or twice a term, but 22% acknowledge never doing any practical work. Most practical work is of the nature of demonstration by the teacher). They mentioned as constraints, insufficient equipment, being unable to manage the large classes alone and learners taking, or breaking, equipment.

Research (Johnson et al. 2000a; Johnson, Monk, Swain, 2000b) suggests that the environment in which the teacher works often determines his/her actions. Johnson et al. (2003) reported that the initiative undertaken in the Western Cape Province of

South Africa to equip science teachers with paper and pencil translation activities (for improving the skills of learners) was possible since paper and photocopying facilities were available. The investigators emphasized that along with these resources (photocopies of the activities) the teachers received training in implementing the activities and were properly supported in their attempts (Johnson et al., 2003). A government initiative simply to provide resources where there is a shortage is, according to these investigators (Johnson et al., 2000a; Johnson et al., 2000b; Johnson et al., 2003), useless. They argue that the environment the teacher has to work in and the stage on which the teacher operates (Beeby 1966, 1980 cited in Johnson et al., 2000a) determine the practice. They caution that learners also can be a deterrent to change because of feeling threatened by the new activities (Johnson et al., 2000a).

These findings are in agreement with the remarks of Verspoor (2006a) that teachers in Africa need not just a supply of textbooks but guidance on how best to use them.

Hattingh, Aldous and Rogan (2007: 84) are in agreement with these findings also. In assessing to what extent teachers of grades eight and nine science in the Mpumalanga Province use practical work in their classrooms, it was found that practical work is, or is not done, according to the decision of the teacher and not according to government policy or the available resources. They mention that a motivated teacher will find an innovative way of performing practical work, regardless of the resources (Hattingh et al., 2007).

The situation in South Africa is in accordance with a study by Olorundare (1990) which investigated discrepancies between the official science curriculum and what actually happens in science classes in Nigeria. In this study, five case-study schools, in rural, suburban and urban communities were investigated. When the science teachers of the case-study schools reported on the difficulty they experienced in implementing the enquiry approach to science, they mentioned their frustration in not having been provided with adequate resource materials and apparatus. In addition, they indicated that they themselves could not go and buy even the smaller resource materials since there were no funds from government and their own salaries were not adequate and were often paid late. Nevertheless the author points out that when these teachers could have made use of inexpensive and readily available resource material, they did not. He felt that this indicated that the teachers lacked a real interest in teaching science (Olorundare, 1990).

Although "resources alone do not teach" (that is, for example, science laboratory equipment and materials, computers, computer software, library materials, audio-visual resources for science instruction), there is still a plea and recommendation to equip well-functioning schools, as a matter of priority, with the necessary resources (Christie et al., 2007: 131). As Johnson et al. (2003: 94) indicated, in order to sustain the implementation of the "Translation Activities", schools must have copiers, ink and sufficient paper, and teachers should be able to control the resources.

2.4 Science Teachers' view of the Nature of science

Abd-El-Khalick and Lederman (2000: 665) report that the science curricula of most countries are geared toward teaching learners to be scientifically literate citizens. A central component of scientific literacy is "the nature of science" (NOS) (Abd-El-Khalick and Lederman, 2000: 665). However, many studies agree that what comprises NOS is complex (Waters-Adams, 2006; Clough and Olson, 2008). Some researchers like Abd-El-Khalick and Lederman (2000) argue that there is no consensus regarding a definition of NOS, apart from a vague definition such as that given by Lederman in 1992, viz. "*NOS typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge"* (Lederman, 1992 cited in Abd-El-Khalick, 2000: 666). They go so far as saying that they do not believe that a "singular NOS" actually exists (Abd-El-Khalick et al., 2000: 666). Nevertheless, NOS features in the national curriculum documents of various countries e.g. United Kingdom (DfEE/QCA 1999), New Zeeland (MoE 1993) and the National Academy of Science's science education standards in the US (NAS 1996) (Taber, 2008). South Africa is no exception and the NCS lists as the third focus area of Physical Science "the Nature of Science and its relationship to technology, society and the environment (DoE, 2003: 10).

Not only is the understanding that teachers themselves have of NOS important but also the way they transfer their knowledge and understanding (Taber, 2008: 186). Many studies (Waters-Adams, 2006; Abd-El-Khalick et al., 2000) agree that teachers' understanding of the nature of science is often naïve or incomplete. One line of thought (Abd-El-Khalick et al. (2000)) is that if one could only change the concepts the teachers have of NOS, then that NOS would automatically be transferred to their classroom practices and would greatly influence learners for their good. In practice, changing the concepts of teachers is not so easy, as numerous studies show (Waters-Adams, 2006; Smith and Scharmann, 2008).

A further complication is that an implicit understanding of NOS gained through process skills (i.e. 'doing science') does not seem to transfer to the learners as well as an explicit view of NOS (Abd-El-Khalick et al., 2000).

The question arises 'what is the situation in South Africa?' How do South African teachers perceive the Nature of Science? How does their view of the Nature of Science impact their teaching when coupled with large classes and few resources? This study intends to explore the practice of effective teachers in the context of large, under-resourced science classes.

2.5 Characteristics of effective teaching

The Norms and Standards for Educators in South Africa (1998) define seven roles a teacher must be prepared to assume, viz. (1) mediator of learning; (2) interpreter and designer of learning programmes and materials; (3) leader, administrator and manager; (4) scholar, researcher and lifelong learner; (5) community, citizenship and pastoral role; (6) learning area / subject / discipline / phase specialist and (7) assessor. On this view, being a teacher is clearly a complex matter (DoE, 1997). Not only are these roles demanding, but the science teacher in the present South African setting teaches under the added constraint of having large classes and being under-resourced.

Describing the characteristics of an effective teacher under these circumstances is meaningful and important. Three of these roles, viz. (a) mediator of learning, (b) learning area / subject / discipline / phase specialist and (c) assessor are especially significant for this study and will be used as a framework. To what extent they adapt these roles is the question of interest, in formulating a framework for assessing the practice of teachers in the context of large classes, is the extent to which they adopt these roles.

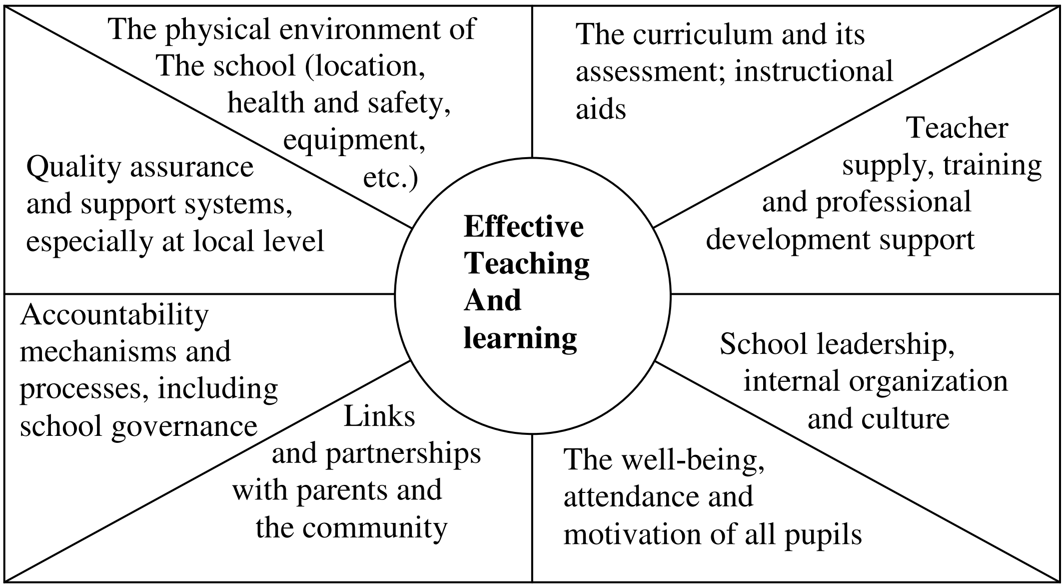
Therefore this section will focus on how the literature ultimately describes the characteristics of an effective science teacher - one with the added constraints of teaching large, under-resourced classes. In the following section the concept of effective schools and how they influence effective teaching will be considered. Features of effective teachers and more specifically, of effective science teachers, as mentioned in the literature, will be verified against the present situation in South Africa so that an effective teacher can be more easily identified, and elements that make such a teacher effective can be described.

2.5.1 Effective Schools and effective teaching

Dorman, Fraser and McRobbie (1997) reasoned that since learners spend so many hours at school, the school environment or school climate must have a direct influence on student outcomes. They tried to establish what psycho-social characteristics of the school environment and the classroom are needed for effective teaching. They concluded that for effective and successful teaching (and learning) both areas are important. The first area relates to the support the teacher experiences from other stakeholders in the whole process of teaching and the second area (the classroom) relates to what happens in the classroom.

Saunders (2000) is in agreement with this line of thought, namely that only effective schools can support effective teaching. Eight domains influencing effective teaching and learning were identified. These domains are best illustrated by the following diagram:

Figure 2.1 *Diagram illustrating the eight domains influencing effective schools (Saunders, 2000).*



These eight domains are self-explanatory. The question arises, 'How do these domains lead to effective teaching in the context of teaching large classes?'

In South Africa a very relevant and significant investigation, in agreement with the findings of Saunders, was undertaken by Christie, et al. (2007) on "Schools that Work". The authors concluded the research by indicating four points that stood out: (1) all the schools had a sense of purpose, responsibility and commitment and were focused on the main task - that of teaching, learning and management, (2) all the schools carried out their tasks with competence and commitment, (3) all had organisational cultures supporting hard work, expecting achievement and acknowledging success, and (4) all had strong internal accountability systems in place (Christie et al, 2007). The immediate consideration that stems from these findings is that there is more chance for an individual teacher to be effective when teaching at a school that has a joint vision, one where all the stakeholders work together towards this shared goal. On the other hand, a teacher might be a very efficient and committed, but when the school as a whole has no vision, and the teacher is not supported by the different stakeholders and, also, the learners are not motivated to learn, then the teacher is unlikely to achieve very good results. The implication of these findings for the present study is that an effective teacher might only be found at an effective school. A priority would be to identify an effective school.

A study in agreement with this line of thought - that the school should first of all be effective and only after such a school has been identified to then consider activities in the science classroom - is that of Hameyer, Van den Akker, Anderson, and Ekholm (1995). These researchers looked at schools where activity-based science learning exists (similar to the learner-centred and enquiring emphasis of the NCS in South Africa) and tried to establish how the activity-based science came about and how it is maintained. They observed elementary science classrooms in schools that had effective classroom practice rather than focusing on individual effective teachers. In all the classrooms there had to be activity-based learning embedded in a theory of constructivism. Hameyer et al. (1995) found that learners participated enthusiastically in the activities. Most of the learners could also recall, quite some time (sometimes months after the activities), what they had done. In trying to answer the question "how it came about?" the researchers found that the teachers mainly decided which activities to do (the activities were not prescribed) and only in schools that followed an open-education approach did they find that learners took initiative for their own activities. (These findings seem to correspond with what is expected from normal conventional classrooms, but do teachers in the South African context take responsibility for the activities in their classrooms?) The researchers (Hameyer et al., 1995) established that group work was common in all of the schools and that the teaching approach was that of stimulation-and-facilitation. In considering the resources they found that in most schools there were a variety of learning materials and that excursions and outdoor activities occurred often. Typical problems they identified were (i) preparing such activity-lessons is time consuming, (ii) the role the teachers play is complex and (iii) it is difficult to evaluate (assess) learner outcomes. (p. 115 – 118). It is important to point out that although this study accords with Saunders (2000) and Christie et al. (2007) in that effective schools were identified, there are significant differences: these schools were not under-resourced, the classes were not large, and a further consideration is that these classes were elementary science classes whereas the present study focuses on senior secondary science classes. However, for a teacher to be effective under more or less similar circumstances in the South African setting such a teacher would have to be able to decide on activities and would have to be competent enough to facilitate in the execution thereof, and such a teacher would have to receive the necessary support from the school leadership and local community. The question arises whether there are such effective teachers in the South African schools? Would such teachers receive the support they need from the principal, parents and community; are the facilities at the school and resources such that these activities could be implemented or is the teacher expected to be innovative? How do effective teachers facing large, under-resourced science classes cope in South Africa?

The studies of Saunders (2000) and Christie et al, (2007) were undertaken to establish what the characteristics of effective schools in developed and developing countries respectively, are. The underlying suggestion or principle for both categories is that once the eight domains influencing effective school are in place, effective teaching and learning will take place. The question arises whether a teacher can be effective in the classroom despite some lacks in the eight domains, or only when all eight domains are well implemented. What then are the characteristics of an effective teacher in the classroom?

2.5.2 Effective classrooms and effective teaching

With another group of researchers (Muijs et al., 2005; Campbell, Kyriakides, Muijs, and Robinson, 2004; Leu, 2004; Reynolds and Muijs, 1999; Chidolue, 1996; Good *et al.,* 1983; Good & Grouws, 1979, cited by Reynolds and Muijs, 1999; Galton, 1980 cited in Muijs et al, 2005) on effective teaching, the emphasis is on the behaviour of the teacher rather than on the school. Some of the earliest research on teaching effectiveness tried to establish whether there existed a link between the teacher's personality and student achievement (Borich, 1996, and Costin and Grush, 1973, both cited in Campbell et al, 2004: 42). If researchers could list these characteristics a teacher could work towards gaining them, which would then make that teacher effective. Campbell, et al. (2004) report on such research, done in the past, which endeavoured to ascertain teacher effectiveness. These studies found no great link with teacher personality and learner achievement (Borich, 1996, and Costin and Grush, 1973, both cited in Campbell et al, 2004: 42). However from a study conducted by Chidolue (1996), it seems that there could be a link between teacher experience and learner attitude and achievement, but further research is necessary to confirm such a link (Chidolue, 1996).

The emphasis on characterising effective teachers has since shifted to seeing if a link exists between effective teachers and their teaching styles, an orientation closely related to what later became known as the "Process-product studies", (so called because it was believed that the teacher's behaviour brought about the desired achievement in the learner). In the UK, the ORACLE study (Observational Research and Classroom Learning Evaluation) (Galton, 1980 cited in Muijs et al, 2005), and in America, a corresponding study - the Missouri Mathematics Effectiveness Project conducted by Good and associates (Good *et al.* 1983; Good & Grouws 1979) were two such studies, believing the teacher's behaviour would lead to achievement in the learner. Both these studies were conducted in the late seventies. The evidence found in these studies (as quoted by Reynolds and Muijs, 1999) was similar, but did not show conclusively that the teaching style of a teacher had a significant influence on the progress of the learners. Furthermore, most of these studies were conducted with learners of primary school age (Muijs et al., 2005). A list of the most important behaviours of effective teachers found as a result of these studies, as indicated by Reynolds and Muijs (1999), has been given in Table 2.1 below.

Table 2.1 *Table Comparing findings on effective teachers of different studies.*

Comparing findings on effective teachers	
"Process-product studies" - specific teacher behaviours as reported by Reynolds and Muijs, 1999.	**Developing a Positive Environment for Teacher Quality**, reported by Leu, 2004.
High Opportunity to Learn • length of the school day, -year, and the amount of hours being taught • quality of classroom management, • time-on-task • the use of homework	1. **Time management**. Concerns such as starting and ending classes on time, not wasting time in moving from one activity to another, regularly giving feedback to students on their work are characteristics of this feature
The teacher' s academic orientation • good understanding of subject knowledge	2. Capable teaching force where teachers have first of all a **good grasp of the subject knowledge**,
Effective Classroom Management • clear rules and procedures • recognized desired behaviour • well-organized classroom • minimal disruption and misbehaviour	3. **Having classroom rules and maintaining them** creating thereby a safe environment for learning to take place.
High Teacher Expectations of the Pupils • emphasize the importance of effort • internal locus of control - the importance of their own work	4. Having high expectations of learners and **motivating them for success** 5. Methods the teacher employs to **encourage learners** 6. **Meaningful student-teacher interactions** (using appropriate strategies for large classes), encouraging higher-order thinking skills amongst learners, and encouraging learners to take responsibility for aspects of their own schooling
A High Proportion of Whole-class Teaching • Present information through lecture and demonstration (most of the time) • Teacher-led discussion as opposed to individual work	

Comparing findings on effective teachers	
"Process-product studies" - specific teacher behaviours as reported by Reynolds and Muijs, 1999.	**Developing a Positive Environment for Teacher Quality**, reported by Leu, 2004.
dominates • Provide more thoughtful and thorough presentations, spend less time on classroom management, • Present lessons in structured way • Enhance time-on-task and can make more child contacts. • Spend more time monitoring children's achievement. • Does not rely on curriculum material or textbooks • Summarize as proceeds	7. Having a well thought out **lesson plan** with achievable objectives using a variety of strategies 8. The **assessment** of the work of learners. 9. The curriculum and learning materials and whether the teacher has **a range of strategies** to implement in order to sustain quality teaching and learning.
	10. Recognising that **differences** exist among learners and having the range of different strategies to implement in order to accomplish effective teaching and learning.
In general, effective teachers teach a concept, then ask questions to test children' s understanding, and if the material did not seem well understood, re-teach the concept, followed by more monitoring.	11. "**Ongoing professional development**" e.g. cluster staff development and in-service training are effective ways of improving teacher effectiveness
	12. **Professionalism and positive teacher attitude** include aspects such as being on time and regularly attending cluster or in-service training meetings, being innovative by trying new ideas, being self-assured when using learning materials.

Campbell, et al. (2004: 4) have since called for a differentiated model of teacher effectiveness, because they claim there are very many aspects to effective teaching. For instance, they argue that teachers may be more effective with some categories of students than with others, they may be more effective with some teaching and organisational contexts than others, they may be more effective with some subjects or components of a subject than with others, and more effective within one context (such as large classes) than another and with some aspect of the professional work than with others. They propose using a model of "differentiated teaching effectiveness" in trying to assess teacher effectiveness, which should take the aspects that have just been mentioned into account.

Leu (2004), lists twelve features that characterises effective teachers working within a school environment that functions well. The twelve features follow from a literature study (Craig, Kraft and du Plessis, 1998 cited by Leu, 2004) to identify the aspects of effective teaching. She used and expanded these twelve issues in the report and suggested that they could be used as a framework for identifying and improving teacher quality. These features correspond well with many of the behaviours found in the "Process product studies". See Table 2.1 for a comparison.

In Science education similar trends to those describing effective teachers in general have been found. All of these investigators (Waldrip and Fisher, 2002; Treagust, 1991: Tobin and Fraser, 1990) tried to develop a list of qualities that exemplary science teachers display. Apart from making random observations of science teachers, most of these studies first identified exemplary teachers and then tried to describe their teaching practice. Tobin and Fraser (1990) identified four such characteristics. The study by Waldrip and Fisher (2002) investigated the learner-teacher interactions, as perceived by the learners, after the teachers had been identified as exemplary science teachers. They agreed to a large extent with the given list of Tobin and Fraser (1990) but added one more quality - that of encouraging learning from students of different ability levels. These qualities are listed in Table 2.2 below.

Table 2.2 *Table Comparing lists of characteristics of effective science teachers from different studies.*

Compare findings from different studies in listing exemplary Science education		
- Tobin and Fraser 1990. What does it mean to be an exemplary science teacher? *Journal of research in science Teaching.* 27(1): 3; - Waldrip and Fisher, 2002. Student –teacher interactions and better science teachers. *QJER.* 18: 2.	- Treagust, D.F. 1991. A Case Study of Two Exemplary Biology Teachers. *Journal of Research in Science Teaching.* 28(4): 329-342	- Tytler, R. and Liou, I. 2005. An Australian School Innovation in Science Initiative. *Educational Resources and Research.* 64(June): 41-59.
Classroom learning environment Tobin and Fraser 1990: 3 Maintain a favourable classroom learning environment. Waldrip and Fisher, 2002: 2 *Manipulated the social environment to encourage students to engage in academic work.*	Social environment Both teachers - manipulated the social environment to encourage students to engage in academic work. - The participant learners perceived the classroom environment positive, similar to their preferred classroom environment. - Both teachers encouraged think and talk, but learners take ownership and responsibility for their work.	Learning environment The learning environment encourages active engagement with ideas and evidence

Compare findings from different studies in listing exemplary Science education		
- Tobin and Fraser 1990. What does it mean to be an exemplary science teacher? *Journal of research in science Teaching.* 27(1): 3; - Waldrip and Fisher, 2002. Student –teacher interactions and better science teachers. *QJER.* 18: 2.	- Treagust, D.F. 1991. A Case Study of Two Exemplary Biology Teachers. *Journal of Research in Science Teaching.* 28(4): 329-342	- Tytler, R. and Liou, I. 2005. An Australian School Innovation in Science Initiative. *Educational Resources and Research.* 64(June): 41-59.
<u>Management strategies</u> <u>Tobin and Fraser 1990: 3</u> Use management strategies that facilitate sustained learner engagement <u>Waldrip and Fisher, 2002: 2</u> *Exhibited classroom management and organization styles that resulted in smooth transitions between one class structure and another.*	<u>Classroom Management</u> Both teachers: - exhibited classroom management and organization styles which resulted in smooth transitions between one class structure and another – gave little opportunity for off-task behaviour; - motivated students; - moved around; - dealt quickly with discipline problems	
<u>Understanding of science</u> <u>Tobin and Fraser 1990: 3</u> Use strategies designed to increase student understanding of science <u>Waldrip and Fisher, 2002: 2</u> *Set academic work that had a high level of cognitive demand*	<u>Understanding of science</u> Both teachers: - expects **academic work** which has a high level of cognitive demand from their learners - emphasize inquiry science - expect their learners to think - give regular feedback	<u>Understanding of science</u> Learners are challenged to develop meaningful understandings
<u>Encouragement and differentiation</u> <u>Waldrip and Fisher, 2002: 2</u> *Encouraged learning from students of different ability levels.*	<u>Encouragement and differentiation</u> Both teachers: - encouraged learning from students of different ability levels - motivated learners to work - praised learners effectively - gave marks for completion of a task - had a encouraging social environment	<u>Encouragement and differentiation</u> Learners' individual learning needs and preferences are catered for,
<u>Participation in learning activities</u> <u>Tobin and Fraser 1990: 3</u> Utilize strategies that encourage students to **participate in learning** activities <u>Waldrip and Fisher, 2002: 2</u> *Used the laboratory in an inquiry mode and as an integral part of the course*	<u>Participation in learning activities</u> Both exemplary teachers used the laboratory in an inquiry mode and as an integral part of the course - inquiry science	<u>Participation in learning activities</u> Science is linked with learners' lives and interests, Science is represented in its many facets, The classroom is linked with the broader community
		<u>Learning technologies</u> Learning technologies are exploited for their learning potentialities
		<u>Assessment</u> Assessment is embedded within the science learning strategy

Treagust (1991) investigated two exemplary biology teachers and then compared the results with those of less effective teachers and found much the same qualities displayed by these teachers. (Ref. Table 2.2). All of these studies list as qualities that (1) the teachers are able to maintain a favourable classroom learning environment (or social environment), (2) the teachers have management strategies (or manage the classroom) that sustains learner engagement, (3) the teachers have a good understanding of science, (4) the exemplary teachers encourage learning from students of mixed ability and (5) the teachers used the laboratory and encouraged inquiry science and learners participation in learning activities (Waldrip and Fisher, 2002; Treagust, D.F. 1991; Tobin and Fraser 1990).

However, all the research thus far was on a small scale - first identifying exemplary teachers and then trying to find out what in their teaching made them effective. A much larger study conducted in 225 schools in the State of Victoria in Australia, had as its aim, developing a framework for describing effective teaching and learning in science (Tytler, Waldrip and Griffiths, 2004). In this Science in Schools (SiS) research project, components had been developed both through case studies and through the teachers themselves reporting on their best practice. These components, which had been mapped and validated should, when used, describe effective teaching and learning in science (Tytler, 2003). The components are

- the learning environment encourages active engagement with ideas and evidence,
- learners are challenged to develop meaningful understandings,
- science is linked with learners' lives and interests,
- learners' individual learning needs and preferences are catered for,
- assessment is embedded within the science learning strategy,
- science is represented in its many facets,
- the classroom is linked with the broader community and
- learning technologies are exploited for their learning potentialities (Tytler and Liou, 2005).

The components have been listed above in Table 2.2, for the purpose of comparing the findings with those of the other studies.

The question arises whether such an emphasis as the components call for is operational or feasible in a large, under-resourced science class in the South African context. Is it possible, where there is a lack of resources, to have open-ended investigations? Is it possible under such circumstances to actively engage the whole class?

In the study of Onwu and Stoffels (2005) where 53 teachers of large secondary science classes of the Limpopo province of South Africa completed questionnaires describing the circumstances of their teaching, they mentioned inadequate furniture (like not having enough desks, learners having to sit on bricks, having only a very small blackboard, not all learners fitting into the classroom so that they have to teach outside under the trees) as some of the constraints. When these teachers described their own practice, according to the paper, 28% indicated that they started with review of the work of the previous day by asking questions and then writing the correct answers - as often shouted out by learners - on the blackboard, with very little discussion taking place. In commenting on practical work, 89% indicated that they do teacher demonstrations, asking verbal questions as they proceed and requiring learners to complete a worksheet afterwards. In these classrooms very little self-investigation or discussion took place (Onwu and Stoffels, 2005). Could these teachers have had more discussions and open-ended investigations? In considering component 8 of the SiS project "learning technologies are exploited for their learning potentialities", is it possible in the local context to achieve this component when many schools are not equipped with electricity, computers or internet connections?

Most of the above-mentioned research on what constitutes an effective teacher was done in first-world countries, but to what values do effective teachers of large, under-resourced classes in an African context, ascribe?

2.5.3 Effective teaching of science in Africa

In a study by Onwu at the University of Venda in South Africa in 1998, forty-one participants (researchers, curriculum developers, university science educators, teacher educators and students) from Malawi, Zimbabwe and South Africa discussed, among other things, the questions, (1) “What is effective teaching?” and (2) “What characterizes effective teachers?” (Onwu, 1999). In this study the various characteristics of effective teaching and an effective teacher, as decided on by the participants, were listed. See table 2.3 below. These characteristics could be used as framework in observing teaching in a classroom to determine whether effective teaching is taking place.

Table 2.3 *Characteristics of effective teaching and of effective teachers. (Onwu, 1999).*

(1) What is effective teaching?	(2) What characterizes effective teachers?
<u>Teacher concerns for learners</u> • taking a personal interest in, and motivating every learner to have a positive attitude towards science, • developing learners’ confidence and their ability to investigate, • improving the skill of learners to question phenomena and • meeting learners’ needs.	<u>Teacher competence</u> • a continued interest in science and inquiry, • innovative ways of utilizing resources, • providing a safe, stimulating and accepting classroom environment
<u>Classroom interaction patterns</u> • managing and utilizing resources especially those from the school environment and local community, • allowing every learner the chance of expressing his/her ideas and • promoting meaningful interaction between learners	<u>Teacher organization</u> • classroom management skills, • facilitating meaningful learning, • encouraging learners to apply their knowledge and • having clearly stated multiple objectives
<u>The availability and use of resources</u> • involving all learners in the learning process, • using a variety of teaching approaches, • setting challenges to learners and • improving learner performance	<u>Teacher use of instructional materials</u> • learner experience as a learning resource, • not being limited by the classroom, • encouraging the scientific process of thinking and doing
	<u>The teacher as reflective practitioner</u> • teacher must be able to critically reflect on his/her own practice, • being willing to admit mistakes, • encouraging learners to question and challenge scientific thought, • have high expectations of learners and • give equal attention to the development of skills, knowledge and attitudes of learners.
	<u>The teacher as change agent</u> • being a good listener, • having a passion for the subject and for teaching, • using a variety of teaching strategies, • having a strong desire to continue to learn and grow professionally and • encouraging learners to become life-long learners, and • a refusal to be overwhelmed by circumstances.

<table>
<tr><th>(1) What is effective teaching?</th><th>(2) What characterizes effective teachers?</th></tr>
<tr><td></td><td><u>The teacher's concern for learners</u>
• a sensitivity to learner's needs,
• using different examples and illustrations in explaining concepts since learners would be of mixed ability, and
• knowing each learner well</td></tr>
<tr><td colspan="2">Onwu, G.O.M. 1999a. Inquiring into the Concept of Large Classes: Emerging Typologies in an African Context. Chapter 8. In Savage, M. and Naidoo, P. (eds). Using the local Resource Base to Teach Science and Technology; Lessons from Africa. African Forum for Children's' Literacy in Science and Technology. University of Durban-Westville, South Africa.</td></tr>
</table>

In a study by Gwimbi and Monk (2003), classroom practice and classroom contexts among senior high school biology teachers in Harare, Zimbabwe, were examined, in order to address the question of how (and perhaps why) teachers organize their lessons the way they do. They found that there is no "best practice", but that the teacher's practice fits the circumstances. The teachers who regard themselves to be in better schools tend to lecture more, believing that they have more capable learners, while teachers in less resourced schools believe that they have poorer learners and should therefore give more support with the duplication of notes and the rehearsing of exercises. These teachers also tend to give less homework and project work, because they know the students do not have well-equipped libraries and the teachers themselves have heavier teaching loads because of the larger classes. The fact that circumstances predict the practice was even more obvious with practical work. A lack of material resources meant that other activities, which were not necessary in well-equipped schools, had to be found, to supplement the usual practice. Again the practices fit the circumstances (Onwu and Stoffels, 2005; Johnson et al., 2000a; Johnson, et al., 2000b).

So far the review of relevant literature on the teaching of large classes, on effective teaching and effective resources has been undertaken to provide the basis for the conceptual framework adopted in this study. A summary of the literature review follows.

2.6 Summary

It is clear from the literature that controversy still exists around the whole notion of "large" class. How large is "large" really? Research that has been done on trying to link large classes with the achievement of the learners has not shown conclusive evidence that learners in smaller classes achieve better results than learners in large classes. Much controversy still surrounds this point. Very little data in the literature exists regarding the link between achievement and large classes where the classes are in the higher grades. Hardly any studies have been done linking the achievement in science where learners are supposed to do investigations, to the class size. Furthermore the literature indicates that there certainly are strategies available for implementation when large classes must be taught. Very little research has been found to verify whether teachers who are effective in teaching large classes make use of these strategies to enable them to cope better with the large numbers.

In South Africa, at present, reports regarding the situation of resources at schools do not give extensive information. Although much has been done to improve the basic facilities at most schools the situations between different provinces and between schools even in the same areas, differ greatly. The information that is lacking pertains to resources that should be used in the classroom like textbooks, teacher's guides and, especially in science classes, the equipment needed for practical experiments and enquiry. It seems that many schools simply do not have science laboratories or the basic equipment for doing practical work in science. The teachers often do not have an adequate number of textbooks available for all the learners in their classes, or they do not have teacher's guides for the textbooks or practical guides. In addition the literature indicates that teachers are not trained in using the textbooks or equipment appropriately so that even when schools are equipped with the necessary resources they are not used. Teachers also need to be trained to implement the new curriculum correctly.

A large number of studies have been done on effective schools and features that schools should have if they are to be effective. From the literature it appears that there is consensus that very little effective teaching can take place if the school as a whole does not have an effective management system in place, with a focused vision embraced by all.

Many studies have been found that have considered effective teachers. Most of the available literature on effective teachers comes from studies conducted in the Western world; there is not much data available regarding effective teachers in Africa where teachers have the added constraint of having large classes, and having poorly resourced classrooms.

Evidence from the literature concerning effective science teachers in an African setting, is not plentiful either. Extensive research done in Australia might not be appropriate for the situations of science teachers in Africa, where they often have to cope with large classes and a shortage of resources. Furthermore very little is known of what an effective science teacher is and does in a science class where the teacher experiences a shortage of resources.

From the literature review the following working definitions were derived/obtained. When there were more than 45 learners in a class, the class was regarded as being a '*large class*'. An '*under-resourced*' science class had certain of the following features missing or they were only partly present, namely (1) a laboratory, (2) a laboratory, but one whose facilities were dysfunctional (3) not enough science equipment and (4) not enough chemicals. An amalgam of the given features on large classes and on being under-resourced leads to the working definition given by Onwu (1999a: 126) "*a large class (and one that is under-resourced) is one where the majority of characteristics and conditions present themselves as inter-related and collective constraints, that impede meaningful teaching and learning*".

The circumstances in the South African schools, at present, are such that there are many schools with insufficient management systems in place, many schools lacking basic facilities and equipment, large classes, many teachers needing to be trained to implement the new curriculum. And yet there are teachers that, despite all these constraints, are successful. The present study is an attempt to find out what effective teachers, who have to teach large, under-resourced, senior secondary science classes, do in the classroom.

The section that follows describes how a framework was developed based on the literature review. It was used to develop the instrument and collect data in relation to what effective science teachers have and do in the classroom while teaching large, under-resourced classes.

2.7 Conceptual Framework

From the literature it is clear that there are many aspects that have been identified and that contribute to making a teacher effective. In this study, effective teachers were identified using as the first criteria (i) teachers of science at a school that has had 'good results' in the Senior Certificate examination for the past five years, (ii) the teacher being identified as effective by the principal and his/her colleagues at the school. (The full process of selecting an effective teacher is discussed in the sampling procedure, section 3.2). Once effective teachers of large, under-resourced science classes, were identified the study seeks to find out what these 'effective science teachers' do and have in the classroom while teaching large, under-resourced science classes and how and why these actions bring about an improved performance in the learners.

Second, the study tries to establish what formative experiences have influenced the behaviour of each of the teachers and how, and why, these experiences have contributed to effectiveness.

Thirdly, the study investigates what in-school support the effective teachers have that sustains the practice and how, and why, this support leads to continuing effectiveness.

In order to answer the first research question, one has to turn to the classroom environment. Some of the aspects of effective teaching practice are familiar and so listed by all those doing research along these lines, "using a variety of teaching strategies", which is highlighted by Tobin and Fraser (1990), Heneveld and Craig (1995), by Onwu (1998), by Muijs and Reynolds (2003), and Leu (2004) - to mention just a few. Heneveld and Craig (1995) have mentioned "homework" as well. It is possible to reason that this aspect would fall under the "continuous assessment" of other researchers, e.g. Leu (2004). Different researchers often use different headings to describe the same, or closely related aspects of effectiveness, for example "high expectations of learners" is listed by Heneveld and Craig (1995) under the heading

"School climate", while Onwu (1998) lists it under the heading "Teacher as Reflective practitioner". To make an exhaustive list of all the aspects of effective teaching and arrange them under appropriate headings is a formidable task. Also, to decide whether all the aspects are evident in a particular lesson really needs more that one observer. Consequently only certain relevant aspects consistent with interests of the case study, that of an effective science teacher of a large, under-resourced science class, will be considered.

Adequate provision of curriculum materials and instructional aids is seen as one of the supporting inputs for effectiveness (Heneveld et al., 1995; Saunders, 2000; Leu, 2004). However, in this study, one of the requirements for the case study teachers is precisely that they must have poorly or under-resourced science classrooms. The other requirement is that they must teach large science classes.

As seen above, in the research of Saunders (2000), eight domains were identified that contribute to effective teaching and learning and, in fact, form a framework or context for what happens in the classroom. Similarly the research done by Christie et al. (2007) on 'Schools that Work' indicates aspects of effective teaching and learning where the school as an entity is effective.

In the present study the focus is not so much on the school as an entity or unit of analysis, but on the particular teacher and what happens in his/her classroom. It seems, however, that certain features of effective schools must be present before effective teaching can take place. Consequently, for the present study just three of the most relevant domains are considered, viz. (1) school leadership, internal organization and culture, (2) the well-being, attendance and motivation of all learners, and (3) teacher supply, training and professional development/support (Saunders, 2000).

In addressing the research questions the conceptual framework had three basic aspects as organisers of the data, viz. (1) teaching and learning process in the classroom,
(2) formative experiences of the teacher, (3) school culture.

Considering the lack of teaching skills many teachers in South Africa have (Aldridge et al., 2006; Hattingh et al., 2005; Onwu and Mogari, 2004; Rogan, 2004; Johnson, et al., 2000; Taylor and Vinjevold, 1999), certain general features or skills of effective teachers such as good content knowledge, good knowledge of general pedagogy (using a variety of appropriate teaching strategies, using a textbook effectively, assessing learners' work, giving frequent, challenging homework exercises, etc.) form another element to be considered. It is important to find out whether these teachers make use of those teaching strategies generally acknowledged as helpful for teaching large classes for any school subject. Other general aspects forming a framework for observation will include the management skills these teachers have. How do they manage discipline, time and resources?

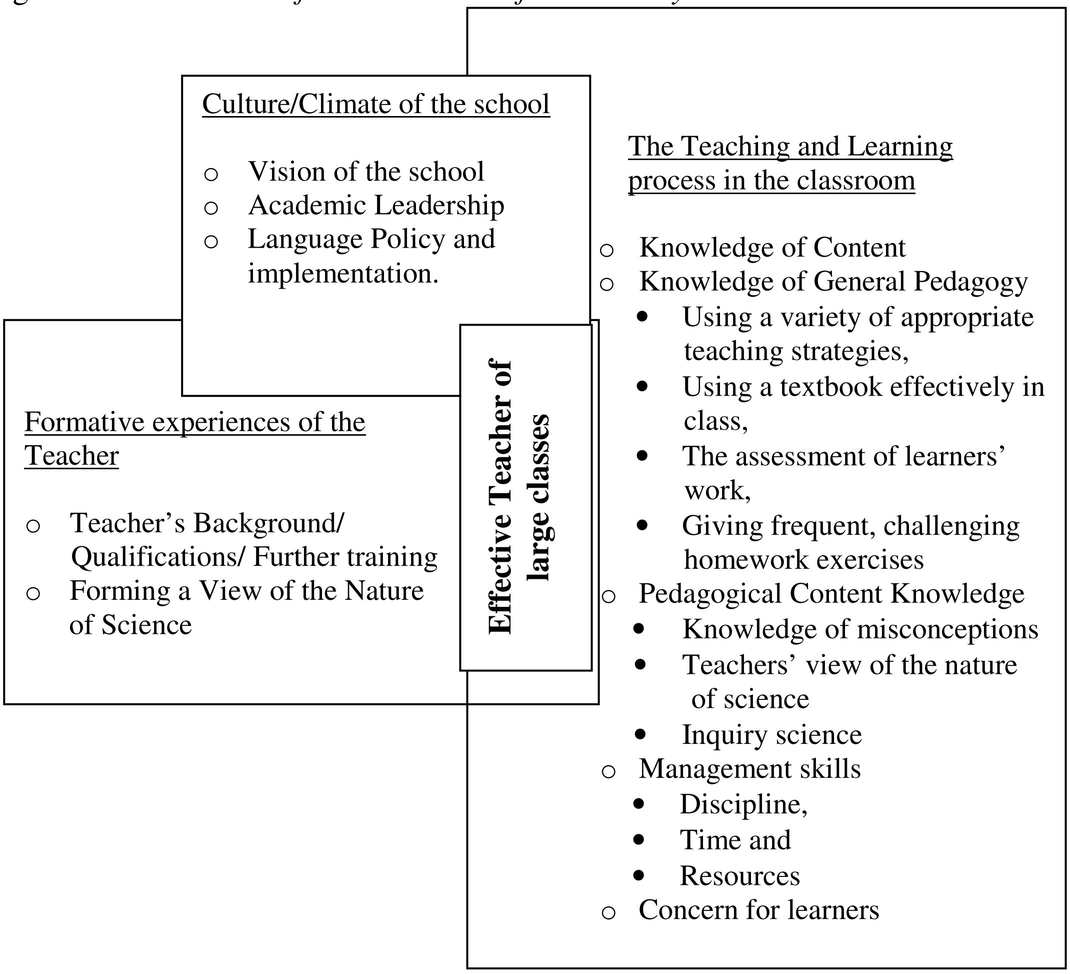
Of great importance is the pedagogical content knowledge of the teachers chosen the case studies. The view these teachers hold of the nature of science is crucial since what they think about the nature of science largely determines the way they teach, the way they manage resources and the innovations they make to overcome inadequacy of resources. The manner in which they organize and manage practical work, or encourage learners to follow the scientific process, is another concern to be investigated. Do discussions, as indicated by the SIS-system (Tytler et al., 2001), follow the practical work, are learners encouraged to ask challenging questions or to question findings? Therefore the teacher's pedagogical content knowledge with an emphasis on his/her view of the nature of science forms another element of this study. Circumstances and experiences that affect the teacher's concern for the learners have in addition been considered for investigation.

The teacher, however, is not an entity in isolation. He/she has a history, grew up in a certain culture (what is that culture?), had early formative experiences (what were they?), met people that influenced him/her (who were they?) and underwent training (what kind, and how did the teacher feel about it?) What qualifications does he/she have? Is he/she improving them, or intending to? Is he/she passionate about the subject? What other influences are there? Does he/she enlist support for his/her teaching program? In pursuing answers to the second research question, "What formative experiences have influenced the behaviour of each of the teachers and how, and why, have these experiences contributed to effectiveness?", naturally these formative experiences, and the teacher's view of the nature of science are considered as elements for investigation. Coupled to the formative experiences of the teachers are, of course, the circumstances that influenced the teacher to pursue a vocation in education. These can be significant in the light of the fact, mentioned earlier, that the teaching profession in South Africa has a low status at present (ELRC, 2005; Rangraje et al., 2005). Therefore these constitute another element of the study.

The elements chosen are consistent with what is seen in the literature (Heneveld et al., 1995; Saunders, 2000; Leu, 2004; Christie et al., 2007). Leu (2004), in agreement with Saunders (2000) and Christie et al. (2007), points out that teaching is a social activity. It follows that the conditions of effective schools (joint vision, strong leadership, motivated learners and teachers) have to be met before effective teaching can take place. The school culture or climate of the schools where the teachers, forming the units of analysis, work, form one of the aspects for investigation. The third question of the research, viz., the extent of in-school support the effective teachers has that sustains the practice and how, and why, this support leads to continuing effectiveness, is explored.

Biographical case studies of two science teachers identified as being effective in teaching large, under-resourced science classes were conducted. The data was analysed within the framework shown below as Figure 2.2.

Figure 2.2. *Outline of the Framework for this study*



Although a framework identifying elements for consideration while conducting the case study was decided on, the researcher tried to observe the teachers in the class situation with an open mind, endeavouring to identify aspects of the teaching that made them effective.

The next chapter will describe why a case study design was followed in this research, what methods were employed for gathering data, how the data was analysed and the validity and reliability of the data.

CHAPTER 3

RESEARCH METHODOLOGY

In this chapter the Research Procedure used to investigate the research questions is discussed in detail. The development of the research, the instruments and their validation are discussed. The sampling procedure for the identification of the case study teachers and the data collection processes are elucidated.

3.1 Research Procedure

An ex post facto research design was used in this study in which differences are known to exist between the participating teachers, after the event. The case study method was used for the collection of data. This is an instance of the qualitative approach which endeavours to describe an event in the social world from the standpoint of the individuals who are part of the ongoing event (Cohen, et al., 2000: 19). The participants not only take part in the event, but their intentions give meaning to the event (Gall, et al., 2007: 32).

Yin (2003: 1) describes a case study as a qualitative research strategy which is suitable when answers to "how" and "why" questions are sought, when the researcher is not able to control the event and when a contemporary real life phenomenon is investigated.

The unit of analysis was identified as effective teachers in the classroom settings where they teach large, under-resourced science classes. In an attempt to give a rich description of what these effective teachers do in their classrooms, and, since qualitative research is multi-method in structure (Denzin and Lincoln, 1994: 31), a number of varying sources of evidence were used to furnish data.

3.2 Sampling Procedure

After the decision to follow a case study method, it was necessary to find teachers who could be classed as effective science teachers. Also it was decided, as a point of entry for "effectiveness" that these teachers should teach at schools that have had good results (more than 80% pass rate) in the Senior Certificate exam, as a whole, for the past five years. Christie, et al. (2007) used similar reasoning to identify the schools that formed the units of analysis in the report "Schools that work", but pointed out that finding schools with good results did not necessarily mean that such a school had performed exceptionally well, but only that the school had achieved better results than the average pass rate in the Senior Certificate exams, which is around 70%, at present.

A district office of the Department of Education was approached with the criteria set out for the study. Two schools that have had 'good results' (more than 70%) for the past five years in the Senior Certificate exams, had large classes and were under-resourced, were sought. The school district office supplied the researcher with the names of two schools that seemed to fit the criteria. An effective science teacher (male) was identified at one of the schools. Upon further investigation it was found that the other school was not really under-resourced. When the district office was approached again for the name of another school that would fit the criteria, the researcher was told that there wasn't really such a school in their district/area. Schools that had large classes and that were under-resourced did not have good results – these schools had pass rates of 70% and less for the exams, while schools with good results were not really under-resourced.

While the researcher was still contemplating whether to approach a second school district that was not too far away, it was decided to try an under-resourced rural school that also had good results in science. There was such a school and a female science teacher was identified as being effective. The performance of the learners in physical science at the school was good in 2005. They had a 100% pass rate in HG and SG physical science.

In this way two effective science teachers, a man and a woman, teaching large classes at different, under-resourced schools that have had good results (above 70%) for the past five years, came to be subjects for this study.

3.3 Research Instruments

The following research instruments were adapted from Onwu (2002) and follow the format he used to gather similar information.

- **Classroom Observation Schedule.** This was used to assess classroom practice, to find out what these teachers do in their classrooms and to present a detailed account of their actions. The observation schedule among other things assessed the classroom management, the time spent "on-task", classroom instruction and the different strategies the teacher used in teaching, the frequency and types of questions asked. In one sense the observation was unstructured allowing the situation to "speak for itself". However, in another sense the observations were structured since certain aspects of the teaching and learning processes in the classroom had been identified and were focused on. (See Appendix A.)

- **Teacher Questionnaire.** This sought information on the demographical profile of the case study teachers (sections A and B), their qualifications (sections C) and experiences in teaching science (section D) and involvement in the community (section E). In section D the questionnaire further probed information on how lessons were prepared and structured, whether textbooks were used, how often tests were administered, and the frequency of homework. (See Appendix B)

- **Principal's Questionnaire.** This was administered to the principal at each school to establish information on the school's vision, its policy with regard to language and discipline, its performance in the Senior Certificate exams over a period, and its demographic data and organization. (See Appendix C).

Some questions in both the teacher's questionnaire and the principal's questionnaire were open, allowing the respondents to include additional information. Both questionnaires were based on the model and format used by Onwu (2002).

- **Resource Questionnaire.** A questionnaire (Appendix D) was used to collect data on the situation of resources at the school. This questionnaire established the physical facilities at the school, viz. the school grounds, buildings and administration (sections A, B and C). The questionnaire further ascertained the availability of science equipment (section F) and physical facilities for teaching science (section E), at the school.

In line with the principle of "triangulation", the researcher interviewed groups of learners from each case study school, as well as the case study teachers.

- **An Interview schedule for each case study teacher.** The interview schedule in this study was designed to gather data from the case study teachers regarding their attitudes, feelings, problems, etc. in teaching large, under-resourced science classes (key informant interview, Gall, et al., 2007: 243), and secondly to verify and elaborate information gained by observation and from the teacher questionnaires (a type of confirmation survey interview, Gall et al., 2007: 244). (See appendix E).

- **An Interview schedule for a group of learners at each school.** The focus of these interviews was to gain an understanding of the learners' ideas on what constitutes an effective teacher, how they experience the teaching of the effective teacher and the learning of science in the classroom. The interview tried to find out how the learners perceived having a shortage of resources and being in a large class. The interviews were semi-structured involving a pre-selected list of guidelines for questions, but probing more deeply with open-ended questions to obtain additional information. Thus these interviews could be described as fairly informal, conversational interviews. (See Appendix F).

3.4 Validation of Instruments

Three educational experts were asked to scrutinize the instruments, in order to establish the face and content validity of each. They worked independently of each other. Construct validity was checked also.

A pilot study in the class of an expert teacher was conducted in order to test the observation schedule and the consistency in the researcher's observations. Changes streamlining the instrument were made in consultation with the expert teacher until full agreement was reached.

3.5 Administration of Main Study

The following research protocols were followed:

- Permission was sought and obtained from the Provincial Department of Education
- Research instruments were validated. (See 3.4 above.)
- The participating schools received a letter from the researcher to introduce the research and to request cooperation. The reaction from the schools was most encouraging.
- In each school provision was made for the observation of science classes. Owing to the preparation and writing of the grade 12 trial examinations at that time, no grade 12 classes could be observed. It was recommended that ten lessons of each teacher be observed during the school visits.
- A record of the visits, including dates, times and activities, interviews and observations has been kept.
- The case study teachers were interviewed individually. There were interviews with the learners in the "focus groups". Observations in the classes (conditions, bulletin boards etc.) and observations of the teaching were made. Questionnaires and the researcher's "field notes" were also used in compiling data.
- All data collected from different sources were "triangulated" in order to ensure consistency and look for emerging similarities and differences.
- Research limitations encountered during field work and departures from the work plan, were recorded.

- The data collected was analysed under different categories that are consonant with the conceptual framework.

3.6 Data gathering Process

After getting permission from the Department of Education (Appendix G) and principal of each school (Appendix H), to conduct the research in the schools, and getting the consent of the teachers (Appendix I) to participate in the study, the researcher started by having informal discussions with each of the two teachers.

Questionnaires

During the first visit at each school, the teacher was asked to complete the teacher's questionnaire. Neither principal was available for an informal discussion at the first visit and so the teachers were asked to request the principals to complete the principal's questionnaire. The teachers were also asked to have the questionnaire on resource availability completed by the HOD for science or an appropriate person.

Interviews

Apart from the different informal discussions with each case study teacher at the start of the research, and later with the principal of case study one, and the HOD of case study two, and the learner groups at each school, the researcher had one semi-structured formal interview with each case study teacher and with each of the groups of learners.

The only criterion set out by the researcher, for a learner being a candidate in an interview group, was that the learner must be able to converse well in English. It was further expected that there would be at least one from each sex in each group interviewed.

Although part of the planning was to have one interview at each school with just one group of learners known to the case study teacher, in the end, four groups of learners were interviewed for case study one, and two groups for case study two. One ex-student was also interviewed.

Case study one

Three groups of grade eleven learners (one group from each of the different classes) were interviewed and a group of grade twelve learners. The grade eleven groups consisted of four learners each, while the grade twelve group consisted of five learners. All the groups were of mixed gender. All the learners had been science learners of the teacher for the previous two years.

Case study two

Two groups of learners were interviewed. The first group of learners consisted of four girls and two boys from grades ten and eleven who all knew the teacher. The second group consisted of three girls and two boys from grade twelve, to whom the teacher had taught science since their grade eight year (i.e. more than four years). For purposes of "triangulation" of data, an ex-student was also interviewed.

Every interview was audio-taped and transcribed.

<u>Classroom Observations</u>

Case study one

Three different grade eleven classes were observed. Eight science lessons were observed over a five-week period - interspersed by a long week-end and the teacher's absence for a few days.

Case study two

Four out of the five grade eight classes were observed. Eight general science lessons were observed over a three-week period. The planning of activities for Spring Day at this particular school so altered class times that the lessons in the week following the first informal discussion with the teacher could not be observed, and then the spring holidays terminated observation. Thus the total period of observation was shorter than in case-study one.

For both case studies, field notes were used to record the observations (Edwards and Talbot, 1999: 97). The lessons were also audio-taped. The recordings were used afterwards for measuring the duration of an event, and for selecting and transcribing the most significant material.

3.7 Data Analysis

The data collected was analysed under different categories that are consonant with the conceptual framework as follows:

- School Profile: culture / language and discipline policies / organization / results for Senior Certificate examinations over a prolonged period.
- Teacher Demographic Profile: formative experiences / qualifications / teaching career and experiences
- Teaching profile:
    - Knowledge of content
    - Knowledge of general pedagogy
    - Pedagogical Content Knowledge, e.g. how to teach using learners' misconceptions, different approaches for different topics.
    - Management skills
    - Concern for learners

3.8 Validity of Data

Validity is the 'degree' to which an argument is valid (Cohen et al. 2000: 105). Having multiple sources of evidence enable "triangulation" to be used and so helps in determining construct validity of the case study evidence.

3.9 Ethical considerations

In the study every effort was made to follow proper ethical procedures as in getting the consent of both teachers, and making sure that their confidentiality and those of their colleagues would be respected. For this reason, in reporting the case studies, pseudonyms are used. Furthermore, consent from the parents of each learner taking part in an interview, was received prior to the interview. The completed questionnaires, interview transcripts and observational notes are kept in a safe place and will be destroyed 15 years after the study.

CHAPTER 4

RESULTS OF CASE STUDIES

4.1 Introduction

This chapter reports the findings of this investigation. To facilitate the reading of this chapter the school profiles of the case studies are first presented in tabular form, as well as the findings of the school culture. A separate narrative account of each case study will follow. The accounts, as written, endeavour to emphasize the main constructs that were identified in analysis of this research.

4.2 Profile of the Schools

A biographical sketch of the Case Study Schools is presented in tabular form (ref. Table 4.1). It deals with location and environment of the school, the socio-economic factors of the area surrounding the school, the profile of the learners and their performance, the school facilities and the facilities for teaching science.

Table 4.1 *Biographical sketch of the case study schools*

Profile of the School:		
	Case Study 1	Case Study 2
Location	Located in a township near big metropolitan city. Easily accessible by tarred road that leads up to school.	Located in rural area, near a fast developing industrial area. The school is approximately ten kilometres from the nearest town. Easily accessible from main road.
Environment of area	Impression of area is one of poverty. The surrounding streets are dirty with rubbish (papers and empty cool drink cans) lying around in the streets. The school is situated next to a well-kept and fenced park. A primary school borders the school on the opposite side.	Neat brick houses, with nice gardens, surround the school. An informal settlement about 5 km away with open veldt in-between.
School grounds and buildings	Entrance to the school is gained through a massive iron gate with the name of the school forming part of the welding. A security guard is on duty. Inside the school grounds, a tarred road leads up to a parking area. The school grounds are fenced with a high palisade fence and well-kept. The school comprises a neat double-storey brick building, with burglar bars at every window.	From the main road, a dirt road leads up to the school. A security guard is on duty. The school grounds are fenced and well-kept. The buildings are ground level brick buildings that could do with some maintenance. There are some broken windows and doors.

Socio-economic status		
	Case Study 1	Case Study 2
Of area where school is situated	The area surrounding the school is fairly poor to middle class. However, the catchment area stretches from a poor (informal settlement) area to a middle class, well established area. Electricity and water are supplied.	The area surrounding school is fairly poor to middle class. The catchment area includes the informal settlement. High unemployment exists in area. Electricity and water are provided to built-up area, but not to the informal settlement, where the stands are set out in neat rows, but have few permanent buildings.
Of learners	Not all learners pay school fees.	Not all learners pay school fees.

Profile of learners and learner performance		
	Case Study 1	Case Study 2
Learners	Only black learners. All learners have proper school uniform which differs for different days.	Only black learners. Not all learners have proper school uniforms.
Enrolment in 2006	± 1400 learners in 2006	± 1300 learners in 2006
pass rate	Average 80% (Except 2005 - 69%)	Average 80% (Except 2005 – 69%)

School Facilities		
	Case Study 1	Case Study 2
Administration building	Yes	Yes (only since 2006).
Staff room	Yes	Yes (only since 2006).
School Hall	No	No
Classrooms	31, few posters on bill boards	25, few posters on bill boards
Furniture: desks, tables, chairs	Adequate	Inadequate, more than two learners share a desk in the lower grades.
Electricity supply	Yes, to school as a whole.	To administration building and one classroom.
Water supply	Yes	Yes
Sport fields	No, use local / common facilities	No, use local / common facilities
Library	Yes, mainly empty shelves (poorly resourced)	Yes, not enough space to function well.
Computer room	Yes, 30 computers for the school.	No, not one computer in school

Facilities for teaching science		
	Case Study 1	Case Study 2
Science Laboratory	Yes – two. One for physical science and one for Life sciences, but largely non-functional.	No
Science Equipment	Fairly adequate. Consumables, such as chemicals, are a cause of concern.	Poorly equipped.
Store room for science equipment	Two in the science laboratory One for chemicals and one for reusable items	None. Equipment stored in recently obtained cupboards placed haphazardly in classrooms or offices. Chemicals stored in old toilet.

The school culture (ref. table 4.2) is an invisible entity, difficult to define but one becomes aware of it on visiting a school. According to Taylor et al. (1999) any institution displays a culture or specific character when a common goal is identified and all the members of the institution work towards achieving that purpose. The vision held by the educators and learners, the quality of leadership, the vigour in implementing the school's policy on language and discipline, and even the in-school support enjoyed by teachers, all contribute to the culture of the school.

Table 4.2 *The School culture and climate of the Case Study Schools*

School Culture and climate of/at the School		
	Case Study 1	Case Study 2
Vision	Clear vision / Learners committed to achieve better results, Attend extra classes during holidays, Saturdays and Sundays.	No clear vision. Learners display a lackadaisical attitude. On 'teachers day' no learner were present at the school after break.
Academic Leadership	Principal always present. Mainly do higher grade work in class. Learners, who wish to change to standard grade, are guided according to career options, before such a change is allowed.	Principal often absent. Standard grade work mainly done in class. Learners, who want to receive better symbols, may switch to standard grade.
Language policy	Mainly English but language switching allowed.	Mainly English but language switching allowed.
In school support	Principal and colleagues supportive in organizing science club, but on occasion have been at odds with the case study teacher	Principal and colleagues give full support and help in organizing the grade twelve camp to case study teacher.

Each case study will be reported separately in accordance with the framework and categories developed during the analysis of the findings.

4.3 Case Study 1 – Teacher: Charles

4.3.1 Biographical information

<u>Early School Years</u>

Charles (pseudonym) is a big man but softly spoken. He attended a rural school during his primary school years and a township school during his secondary school years. Both schools were former DET schools and poorly resourced. He recalls

> *"there was never a practical activity at school. There was not even a lab. In the primary school I attended in the rural area, there was nothing. Even sometimes we were sharing classes. We had a system where the grade four*

class would come in the morning and the grade five class during the afternoon, rotating weekly".

During his secondary years things were not much different.

"In the secondary school we had a lab but … there was nothing in the lab. I want to be honest with you. Even the taps were not there only the desks. It was a lab by name".

Mentor Teacher

He mentions that he has good memories of those years. He can recall one specific teacher, whom he liked, who, when he was in grade seven said to him that he must one day become a teacher. He was greatly influenced by this and kept it in mind whenever he was studying.

"… that is why while I was at school studying; I was just focusing on the field of teaching".

At secondary school he met the brother of this teacher. He too encouraged him to pursue a teaching career.

"He was a loving teacher, I can say, the brother to that teacher. He continued to encourage me maybe because I used to discuss or solve problems with other learners, helping other learners".

Charles thought that the fact that he was always helping the other learners with mathematical problems might have had something to do with the encouragement.

Leadership

Charles was chosen as a prefect at school. He had the sport portfolio.

"At the time, before SRCs, they called us prefects at school …I had the sport portfolio. And to be honest with you I like sports. I am a sport person."

Teacher training

After he left school he first had to work for a few years to raise funds to attend a College of Education where he completed a diploma in education majoring in mathematics and chemistry.

He sees being employed as a science or mathematics teacher as a service to South Africa, for as he says

> *"What has influenced me a lot in this career of teaching maths and science is that the people in South Africa, we, have a problem. We lack science teachers; that is why…I want to do more in this career because I have just seen most of the schools within the whole of South Africa or even in Africa we have a problem with science and maths teachers. That is why… it encourages me a lot."*

Continuing with Education/Training

An Advanced Certificate in Education (ACE) followed and at present he is completing his final year. He mentioned that he would like to first do a university undergraduate course in physics and get a degree before studying for a higher education degree.

Teaching career

Charles is presently in his ninth year of teaching. He started his teaching career working at an adult education centre (ABET Centre) for three months. Then he worked full-time for three years on a temporary basis at a school. He then moved to a second, very well resourced school where he was appointed permanently.

At the previous two schools where he worked, Charles used to teach mathematics as well as science, but, since he came to the present school, he has only been teaching science. He was appointed as Head of Department for science at this school. He is responsible for "*natural science, biology (life sciences), physical science, technology and computer science*". Being HOD has increased his workload greatly. Charles mentioned that he took his position as HOD seriously and once reported a teacher in his department that was not pulling his weight. He did not go into more detail, but recalled that the memory of the whole event is rather distressing.

At the school, they are only two teachers responsible for physical science. He explained that owing to the way in which the timetable was arranged, one of the classes of the other teacher grew to sixty learners. Upon his suggestion, that class was halved, and since the month of May of this year, thirty learners come to him and thirty learners stay with the other teacher.

Leadership Positions

Apart from his duties at school, he has been a senior marker for the Senior Certificate exam for the past five years. He was recognized by the Department of Education and appointed as a cluster leader for science in the area. Apart from organizing monthly cluster meetings in the area he has to moderate the grade twelve portfolios of the other schools in his cluster and advise them if something needs improving.

For example, he indicated that different schools could share apparatus where there is a shortage.

> *"We help each other…. you can come and borrow any thing that you can carry (from the school where a school has such equipment) …then you can use it and return it thereafter."*

Part of his duties as cluster leader and moderator require him to attend various meetings. Often he has to leave earlier at the end of the school day as he travels by taxi to attend these meetings.

Interest in Science

Charles confesses that he used to think of himself as a mathematics teacher, but when he started teaching he had to teach both mathematics and science. It was then that his enjoyment of science started.

> *"… since I started teaching, I was just enjoying it (science)".*

Innovative projects

Charles started a science club that meet on Fridays. For the discussions he usually chooses a topic that he knows learners experience difficulties with, like ‘*equations of motion*’. The learners who come would then be divided into discussion groups and work at solving some relevant problem.

By allowing learners from other schools in the area to attend, the club became a community project and he included demonstrating chemistry experiments to learners. As a means of raising funds to replenish the chemicals, Charles required some payment from the learners of the other schools. He also trained his learners to be the demonstrators.

4.3.2 Characteristics of Teaching

Large classes

Charles indicated that the largest class he had taught was at a previous school where he once had sixty learners in a class. Presently his largest class has fifty-four learners.

Strategies for Large classes

He explained that he uses co-operative learning for this large group:

> *“What I normally do, I group them. Those learners that are intelligent and those learners that understand fast, I group them with those learners that don’t understand fast. Then, most of the time, I use the intelligent learners to help the others in the afternoons.”*

He mentioned that he used to have a card system that he used for forming groups, but since he now knows the learners he often just groups the learners so that each group has learners that do well in science. These learners then help the slower ones when they get stuck.

Another strategy Charles uses in large classes is to move around the class and to make sure that a learner is really busy with what is required of him.

4.3.3 Content Knowledge

Charles knows the content he teaches well and makes sure learners understand the meaning of the concepts as well. He spends time in explaining detail so that learners would understand the meaning. An example is his explanation concerning the reducing action of hydrogen sulphide.

> *"Now there are two half reactions. The reduction is the gaining of the electrons, you know that? And the oxidation is the losing of the electrons. Any substance that undergoes the process of reduction that substance is the oxidizing agent. Is that clear? Any substance that undergoes the process of oxidation that substance is known as the reducing agent.*
>
> *Now we are going to look at the meaning of that. Whenever the hydrogen sulphide reacts with any substance, the hydrogen sulphide will lose the electron. That means the hydrogen sulphide will undergo the process of oxidation."*

4.3.4 General Pedagogy

Teaching strategy

Charles mainly uses direct instruction as a teaching strategy, interspersed with group work for practical activities and co-operative group work when learners work on problem solving exercises.

He usually starts the lesson by announcing the topic. He refers learners to the place in his notes:

> *"Right on page 2 of my notes, page 2 of my notes you check there it says there that the properties of this Hydrogen sulphide …"*

Structure of Lessons

In most of the lessons observed, Charles spent some time recalling previous work, making sure learners understood the work. He did this either by asking questions or by marking homework. Then he introduced new work. He would either do a demonstration or have the learners themselves perform an activity. He would end with a discussion and summary.

Drill and practice

In the explanation of oxidation and reduction reactions, Charles indicated to the learners that he would show them the following day how to use the reduction potential table. He had the following to say,

> *"I am telling you, if you get in the exam and you know how to use this (the reduction potential table) then you've got the memorandum, because all the answers are coming from this standard reduction potential table."*

Explanation

When Charles realizes that there are certain fundamental concepts learners do not understand he will not proceed until they do understand. During one of the lessons, while he was dealing with inorganic gases, he wanted to make sure learners understood the difference between sulphur, as an element and atom, and sulphur in the compounds that form during the various reactions. So he asked them what a compound is - a simple question. To his surprise the learners could not answer him. He then referred them back to the chemistry they did the previous year and did not continue with new concepts until the learners had passed a class test on the difference between atom, element, molecule and compound.

Textbooks

The grade twelve learners indicated that Charles gave them two old textbooks (from the time before the syllabus changed) to use for homework exercises. Charles was quite strict on their using these textbooks at home. The learners gave the names of the books and were aware that the books often explained the same concept differently.

Charles gives learners summary notes containing the main points of a topic,

> *"… because what I normally do; I use the textbook, prescribed book, I can say. I don't use only one book; I use lots of books, references. And thereafter I combine them and thereafter I make one set of notes."*

He insisted, however, that learners must add their own notes. While he explains new concepts no learner is allowed to make notes. The learners must then concentrate and listen. When he has finished the explanation then the learners take notes. However, during a practical investigation/experiment, learners must add notes even while he is talking.

Homework

He regularly gives the learners homework. He expects the learners to complete the homework at home, but he is usually available in the afternoon to help learners when they do not understand the work.

When he gives homework he expects learners to do it. The following day he makes sure that each learner has completed the work. When the learners did not do the homework Charles would 'lecture' them. As one learner said:

> *"He would lecture us. … tell us about the future … if you need to succeed - you must do your work. Work hard, because out there it is tough!"*

Assessment

Charles daily assesses learners. He continually asks questions and assesses their notes. He realizes that some learners make mistakes when copying notes.

When he suspects that learners do not yet understand a concept but that they are either not aware of the fact, or are too timid to indicate to him that they do not understand, he will give a class test. The learners then either mark their own work or exchange papers and mark each other's paper. That way they have immediate feedback and also come to realize any shortcomings in their understanding.

The portfolios that are done by the learners individually are marked by Charles himself. Although he is very strict on learners doing corrections of wrong answers, he makes sure that learners understand where they went wrong.

Since Charles is a senior marker of the exams he also constantly indicates to the learners how certain questions will be marked and what things are important and so must be included.

4.3.5 Pedagogical Content Knowledge

Charles has a good grasp of pedagogy as related to science. He mentioned that from his experience he has come to realize that once the learners know how to write the aim and conclusion of a practical experiment the rest of the seven skills are easily acquired.

Misconceptions

He is aware of areas where learners have difficulties or even have alternative concepts. For example he stressed the difference between sulphur (S), sulphide (S^{2-}), sulphite (SO_3^{2-}) and sulphate (SO_4^{2-}), when teaching about sulphur and its compounds. An alteration of just one letter in the spelling can mean a completely different substance. Learners are not always aware of this.

Questioning technique

When Charles teaches and has to make use of previous knowledge he seldom simply states that knowledge. He asks a short question to make sure learners have remembered such concepts. For example, when he wanted to explain the reactions of the sulphur compounds he started by reminding them of the element sulphur and what they should know of that element.

"What is the valency of sulphur?"

When the learners appeared unsure he quickly went over the Lewis dot symbol and number of valence electrons to re-affirm the concept, stressing the difference between valency and valence electrons. To make sure learners have grasped the concepts he again asked

"What is the valency of sulphur?"

followed by

"How many valence electrons does sulphur have?

But he would also ask questions where he expects the learners to think, e.g.

> *"What does it mean when we say that we investigate the reducing action of this hydrogen sulphide, what does it mean?"*

<u>Science in everyday experiences</u>

An aspect of the way in which Charles teaches science is that he refers the learners to look for examples of science in their daily lives. One of the learners gave the following example.

> *"So in vectors there are no experiments but he gives us examples about things that we do each and every day. He told us something about how they kill a cow in the rural areas. So two guys pull the cow; the one goes this side and the other one goes that side. So it shows there is an angle between those two guys. And maybe those two guys are pulling with different forces, it all depends on them. And so, I found it so simple to understand because he did it in the way that we understand it."*

<u>Inquiry science</u>

How Charles views the nature of science is clearly shown by the emphasis he places on the role of the science laboratory. He insisted on teaching science in the laboratory. As a learner indicated

> *"... before he was here there were no experiments. We never… when we came to chemistry we never mixed chemicals and we never came to the lab. We were just doing science by writing notes. We did not know what to mix."*

The laboratory is not equipped with gas and water is not connected to all the taps. It seems that some of the drains are blocked. Charles mentioned that he requested the principal to apply to the department to renovate the laboratories.

Charles revealed that while he was at the previous school he started doing every practical activity possible. That school had a mentorship with a local university. He said that because of this mentorship,

> *"The other school is well equipped. I am definitely sure that the school is now the best school in science in the whole of the area".*

The learners confirmed that they do a lot of practical work. They could recall experiments on the equations of motion using the trolleys and ticker-timers, electricity experiments, chemistry experiments on the halides, bonding and the inorganic gases.

Since the school does not have a lab assistant, he indicated that he is the person accountable for the stock and does a monthly check.

4.3.6 Management skills

Discipline

The school has a definite policy on discipline. Late-coming is not tolerated.

Charles is very strict. He does not tolerate the learners doing homework of any other subject in his class. Neither does he allow learners to come late. As one of the learners pointed out it does not even help to copy your homework from someone else's book. Charles has some very clever ways of making sure that learners do not copy homework. When Charles suspects that that is what a learner did, he invites that learner to do the problem on the blackboard and then he would ask the learner to explain to the whole class how he did it. Then, if the learner copied it, he would not be able to give an adequate explanation.

Time management

Charles manages the time spent on different activities very well. He prepares well. This is obvious from the way in which he started a practical lesson on the 'types of bonds'. The tables were arranged so that four learners could sit at a table forming a group. Each table was supplied with two boxes containing the microchemistry sets. Each learner received a worksheet. He then gave the learners clear step-by-step instructions of the procedure, waiting for them to complete each step before he issued the next instruction. Later he told them how long they had for the discussion.

> *"Right I am giving you 10 to 15 minutes. Please just discuss in your group, the aim of the experiment and then the conclusion."*

When two minutes were left he told them to get on with their discussions. After demonstrating to them how to clean the propettes, he gave them five minutes in which to rinse the combo© plates and propettes. The learners had to put everything back in the boxes and take the boxes to Charles. Then each learner had to individually write the aim and conclusion of the experiment. After approximately five minutes he called everyone to listen and then asked the learners to share what they had written as the aim for the experiment.

4.3.7 Concern for Learners

Every learner is important to Charles. As one of the learners pointed out, when he failed and wanted to quit school and find a job, Charles not only encouraged him to stay, but gave him something to aim for. Apparently Charles had said

> *"I need an A from you; if I don't get an A from you I will kill myself not you, but myself."*

The learner's response was

> *"Wow! This guy's life is in my hands, so I have to… I have to make it for him!"*

4.4 Case study 2: Teacher – Thandiwe

4.4.1 Biographical information

Thandiwe (pseudonym) grew up in one of the "homeland" areas during apartheid. Such areas were supposed to become independent and self-governing. However, these areas often lacked infrastructure and the people in the areas lacked motivation to improve.

Early school years

She recalls very little of her early school years, except that she attended a rural school that was not well equipped.

Mentor teacher

In grade five Thandiwe had a maths teacher who had a big influence on her life. He encouraged her to continue with maths and science at secondary school, because as she mentioned he used to say to her

> *"when you get to the secondary school you must make sure that you take maths and science as well as your (other) subjects. You have the potential".*

He also made her improve her English by giving her newspaper articles to read. She was in grade six at the time.

During the interview Thandiwe, while reflecting on these earlier years, spoke with great admiration of her first mentor teacher

> *"You know that he is still a teacher. We normally meet at conferences and in workshops and when he sees me he says to the others "this is my product"*

Leadership

During the interview Thandiwe shyly revealed that she was not only a member, but deputy president of the Student Representative Council (SRC) at the school she attended in her grade twelve year. She shared how, at that time, they had to fight the teachers who would not do their work properly. Her parents taught her always to have respect for others and although she used to oppose the teachers, she always showed due respect and today she can face those teachers without feeling embarrassed.

Teacher Training

Thandiwe describes how frustrated she was when she finished secondary school. She did not obtain good symbols for her exam so she couldn't get a bursary to study further and she could not afford a bridging course in order to improve her marks.

She ended up working at a tuckshop because she didn't know where to go. Her mother and sister heard about this "*SYSTEM thing*" (An acronym for a national intervention program called Students and Youth into Science, Technology, Engineering, and Mathematics) and urged her to apply. She applied since it was her *"only solution"*. The SYSTEM project was a pilot project trying to train learners who hadn't done well in grade twelve mathematics and science to become maths and science teachers. She was one of thirty-two students who continued after the first, bridging year.

At the local College were SYSTEM was offered, she had many interesting subjects, doing technology, physical science, mathematics and a research program and whatever else was needed for them to become teachers.

Of her experiences of the program she recalls

> *"So it was then that I became so much inspired, because everything was perfect."*

The department ran the course. The students did not have to pay anything. They were even provided with R250 every month as a stipend.

Continuing with Education/Training

Ten years since she started at the college she is continuing her studies at a local university doing the Advanced Certificate in Education (ACE) course in natural science.

Teaching career

Thandiwe's teaching career started at the present school. Seven years later, she describes her first year of teaching as a disaster. At the beginning of that year she shared grade eleven and grade twelve biology and chemistry classes with another teacher who taught the physics part. She didn't mind the biology section, but the chemistry was another story, but as she said chemistry was one of her majors at the college and she couldn't really refuse to teach it. Later, in that first year of teaching the other teacher was promoted and then she had to teach all the science. She had to do every thing - even set the grade twelve trial exam paper, because, as she indicated, in those years it was not yet a common exam.

Even though she had all this work to cope with, she mentioned that she was never frustrated. She managed the organizing of her files and all the administrative work well. However, she struggled with the content of the science curriculum.

> *"I struggled with the content, I confirm, that I was battling much with content, but when coming to doing my work, organizing my things it was not much of a problem".*

Thandiwe indicated that she saw the implementation of the new syllabus coupled with using continuous assessment (CASS) *"as something to be done"*, and felt she was fortunate to get into the system at that time.

Interest in Science

When Thandiwe started studying at the College most of her enjoyment of science started *"where at least we had a laboratory",* and the students handled apparatus like a glass beaker, a test tube everything they had before only seen in the textbook. Now they were doing the "*real science*". During her school years as she says,

> *"science was far away from me. I was taking science as something that happens somewhere, because I was reading it from the book and couldn't practise it".*

Innovative Projects

Some years before some of the learners at the school were invited to a science camp for girls that the Department of Education of that Province organized. Thandiwe accompanied the learners. The aim of the camp was to show the girls that science is a field with careers that girls can also pursue. The Girls' camp so inspired Thandiwe that she now arranges a camp for the grade twelve learners toward the end of their grade twelve year.

Thandiwe organizes a motivational speaker to encourage the learners to pursue careers in science and to enlighten them on what to expect the following year, should they go to a tertiary institution to further their studies. Since the camp is held close to the final exams she also arranges for another science teacher to explain some of the difficult concepts to the learners, maybe from a different angle. The learners also work at problems and then she and the other teacher are there to assist them. The camp she arranges is for all the learners not only the girls. The grade twelve learners indicated that they were very excited. For this project Thandiwe not only had the blessing of the principal, but also some assistance with the arrangements from other willing teachers.

4.4.2 Characteristics of Teaching

Large classes

On the questionnaire Thandiwe indicated that the largest class she had taught had 72 learners and that the largest class she is presently teaching has 60 learners.

Although the school is in a rural district, owing to the fast development of the industrial area nearby most of the learners take commercial subjects. Only a handful of learners opt for a career in science. There is therefore only one relatively small science class in the further education and training phase (i.e. grades ten to twelve).

Strategies for Large classes

Thandiwe follows a one-to-one assessment procedure. She sometimes marks the books of the learners while the learners are doing class work. She then sits at a desk next to one of the learners (looking a bit like a learner herself). The learners pass the books on to her. After marking all in that vicinity she would move to a new place to sit (the learners make space for her) and continues by marking the books of another group of learners.

When teaching large classes the marking of books, homework assignments and tests is, of course, a lot of work. Although she tries to cover all the material of a topic in an assignment, she admitted that she asked mostly short questions so that the marking would not be too difficult. The tests, also, are short (only one page of short questions).

The test questions are mainly instructions of one-line, for example: "Give three ways of growing", or "Balance the chemical equation". For the latter item she drew lines in front of the formulae on which the learners had to write the answers.

Thandiwe used small group work as a strategy for teaching large classes and knew the name of each learner.

4.4.3 Content knowledge

She struggled with the content of the science curriculum. She admitted that doing the ACE courses assisted her greatly with improving her content knowledge.

She knows what science knowledge is important. To illustrate, realizing how important the charge of an ion is, she once was so upset with the learners for not including the charge, and for calling acetic acid carbon dioxide, that at one point during a lesson she started going from learner to learner twisting each one's ear, because they "do not want to listen!"

The learners also mentioned that she was very strict when it came to safety in the laboratory. They mentioned that she doesn't want learners near dangerous chemicals, like strong acids, and that she herself dispenses such chemicals.

4.4.4 General Pedagogy

<u>Teaching strategy</u>

Thandiwe mainly follows a strategy of direct instruction, teaching the whole class while all pay attention. She used a set of posters in explaining the Body System. She follows an interactive teaching method; asking questions and expecting answers from the learners. The learners seemed to be used to her method, because they responded in a chorus fashion.

She often uses a problem-solving strategy in grade twelve. The learners mentioned that they mainly work on their own or in small groups but if the problem is not solved then the whole class together will work out a strategy to solve the problem.

At the start of her lessons she announces the topic of the lesson clearly. She refers the learners to the place in the textbook where they will find the topic and then points out what it is they are going to study. She also indicates to the learners the depth of an investigation.

Structure of Lesson

Thandiwe starts the lesson with a review and questions to establish how much of the knowledge has been retained by the learners. When learners cannot give a satisfactory answer she changes her tactic to breaking the question down into easier parts. She continues by expounding new knowledge. In lessons following class-work exercises were given and homework marked.

Drill and practice

The grade twelve learners indicated that they mainly use a book compiled of exam papers and memoranda of previous years for homework exercises. Respondent 2 mentioned:

> *"when we do class-work she gives us previous papers to do for class work and for homework".*

Explanation

When Thandiwe explains concepts she relates the concepts to the relevant experience of learners. A grade ten learner had the following to say during the interview about the way in which Thandiwe explains:

> *"Her explanations are outstanding. By the way she tells things one becomes more interested in the science field. Even the information that she gives, is so relevant. When you go to the library or when you listen to the radio, or TV you will see she is a prophet, a science prophet".*

In her explanations she "goes from the known to the unknown." For example, when explaining the Circulatory System, she used 'the circle' to get them to understand the reason for calling it a 'circulatory' system. In one class she said:

> *"So it transports the blood around the body. When you think about around …something that is round, it is circular. That is why the system is*

called the circulatory system, meaning that there is a transport. The movement is in the form of a circle."

Textbooks

Although at the start of a lesson Thandiwe referred the grade eight learners to the textbook, she did not insist on them using it and hardly noticed that only a few of the learners had their textbooks with them.

The grade twelve learners confirmed that they all possess textbooks, but admitted that they seldom do homework exercises from the textbooks. They indicated that the errors in the textbook are the reason for them not using the textbook more frequently.

Homework

All the learners were in agreement that they were often given homework, and that they had to it.

Assessment

As mentioned before Thandiwe marked the grade eight scripts on a one-to-one basis. She marked accurately for at one point she remarked out loud, that they could not spell saying she doesn't know how any of them want to become doctors since they couldn't spell lungs (they spelt "*longs*") and for bladder they wrote "*blunder*"! She was complaining to them that they must be more careful when copying the notes, because she could not check every word they write.

4.4.5 Pedagogical Content Knowledge

One of Thandiwe's greatest frustrations is the fact that the school is not equipped with a laboratory. She sees a laboratory both as an area where science should be done and where scientific equipment can be safely and consistently stored.

Misconceptions

She was aware of misconceptions that could develop because of the way in which colours were used and different parts of the body were shown on the poster. She acted in a preventative way. First she pointed out that the network of veins and arteries that the learners see portrayed on the poster are really there inside each of us but the skin covers them.

Realizing that some learners might think there are two types of blood, because on the poster there are blue and red lines portraying the circulatory system, she asked the following questions:

> *"Why are the colour of the veins and the arteries not the same? Do you have the green blood?"*

Questioning technique

When the learners chorused no, she proceeded by asking:

> *"Do you have the blue blood? …Why? What is the meaning of the blue or the green blood in the vein? What does that tell you?"*

She continues with the questioning and not only makes sure the learners understand the meaning of the colours, but also makes sure they follow the reason for the system being a network.

Science in everyday experiences

Thandiwe uses explanations from the everyday experience of the learners. When she wanted the learners to realize that the arteries and veins in one's body form a network she explained as follow:

> *"What is a network? They say this (referring to the poster showing the network of arteries and veins) is a complex network. What is a network? MTM? Vodacom? Okay, a network is the connection; when things connect. That is why if there is no network you can usually not talk with people. But (referring to the poster) if there is a connection they (veins and arteries) connect so that the blood can move, néh?"*

Enquiry science

Thandiwe mentioned that she felt inadequately prepared for doing practical work when she started teaching even though she had done experiments at the College and handled apparatus there.

She shared how her own fear of practical experiments was overcome by attending a monthly cluster meeting. She also became involved in a programme, run by an overseas country, to equip science teachers with the necessary skills for doing practical investigations. Then she wanted her learners to experience *"real science"* also.

Thandiwe tries to limit the number of demonstrations and rather encourages the learners, as far as possible, to do the experiments and investigations themselves. She feels then they would realize that no "*magic*" is involved.

The learners testified to the fact that they themselves had done many experiments. They said that they had done at least ten practical activities and could, without any hesitation, recall preparing hydrogen sulphide gas and looking at the reducing action of the gas. They could also remember preparing chlorine in an electro-chemical activity and getting a deposit of copper on the other electrode. They remembered their experiment for finding the value of "g". They also mentioned that they had prepared sulphur dioxide in their grade eleven year. The learners referred to these experiments with enthusiasm.

No one at the school has been appointed to take charge of the science equipment and it seems that no stock-taking is being done. The equipment is put in many locations in the school, some in recently acquired cupboards with the chemicals in an unused toilet.

4.4.6 Management skills

Discipline

The learners found Thandiwe *"quite strict*". They indicated that

> *"It's not actually what she does but the way she is. You can see she is mad".*

The grade eleven girls mentioned another aspect:

> *"If you don't know her, you are scared, you'll think she is hard, but when you get to know her better you realize she doesn't want students to push her or to disrespect her. Her discipline is just like our parents' "*

All the learners found that they could approach Thandiwe with a problem. The ex-learner recalled how she used to encourage them to come to her with science problems. He recalls

> *"I can tell 110 percent above 100 she would say: "come to me please"."*

However, he was quick to mention:

> *"… When you go to her, you had to have tried the problem first, you can't just go".*

<u>Time management</u>

Thandiwe's time management was, in the lower classes, at least, relaxed. For example during one of the lessons, she wrote four questions on the blackboard which the learners had to copy into their books and that they then had to answer. The four questions related directly to the notes that they had copied down during the previous science period. The learners had ample time in which to answer these questions. They had only to consult the notes they had written down previously. In the notes they had a heading "Three ways to grow" followed by three ways to grow. Question one was "Give three ways to grow". The answers to all four questions could be found in the previous notes which when typed out did not fill an A4 sheet. The learners did not have to do much thinking either; they could copy the answers directly from their notes. The learners were never hurried along during the activity. Eventually after they had been busy for twenty-five minutes she called them to attention and started corrections.

4.4.7 Concern for Learners

Thandiwe's concern for the learners is illustrated by what an ex-learner and a grade ten learner who was part of the interview group, recall concerning the way in which Thandiwe encouraged them.

The ex-learner mentions how Thandiwe has inspired him:

> *"She has been a role model to me because she said that in life you have to be independent no matter what you do."*

When one realizes that she is not even the science teacher of the grade ten group her intervention in the subject choice of the grade ten learner is even more remarkable. He speaks with great admiration of how Thandiwe motivated him to continue with science.

> *"When she teaches science … she does not believe that … you need to be a genius. You know, she believes in working hard. That is the reward to success. I once quitted science earlier this year. I wanted to do commercial subjects, but she called me, she told me I don't have to be a genius to do science".*

4.5 Summary

A summary of the profile of the teachers are given in table 4.3.

Table 4.3 *Profile of the case Study teachers.*

Profile of Teacher		
	Case Study 1	Case Study 2
Highest Qualification	Final year of Advanced Certificate in Education	Final year of Advanced Certificate in Education
Teaching experience	9 years	7 years
Leadership position	Head of Department for science at present school Cluster leader of area Moderates grade twelve portfolios of area Senior marker of Grade twelve Physical examinations	None at present
Largest class ever	60	72
Largest class at present	54 (Grade twelve)	56 (Grade eight)
Higher grade / Standard grade learners	2 in 2006 (inherited), (25+ in 2007 due to encouragement from teacher)	3 in 2006

Profile of Teacher		
	Case Study 1	Case Study 2
Topic of lessons observed	Natural Science: Bonding/structure in chemistry. Inorganic Chemistry (Sulphur and its compounds) – Grade eleven	Life Science: Body systems – Grade eight

Table 4.4 gives a summary of the formative experiences of each of the case study teachers.

Table 4.4 *Formative experiences of the case study teachers*

Formative experiences of the teacher		
	Case Study 1	Case Study 2
Teacher background	School years at poor, under-resourced rural school	School years at poor, under-resourced rural school in homeland area
Influence of a mentor teacher	Yes, encouraged to become a mathematics and science teacher	Yes, encouraged to continue with science and maths; encouraged to read English
Developing a View of the nature of science	Science is a movement; is everywhere especially in everyday life; emphasizes hands-on activities. He started to enjoy science when he started teaching it.	She sees science as ever changing. (One needs to continue studying to keep up); emphasizes hands-on activities. She started to enjoy science when, at the college, they had proper resources
Initiative - projects	Science club for learners of the area; Raising of funds; Acquiring sponsor for sport equipment	Science Camp for grade twelve learners

The teaching and learning process in the classroom is summarized in Table 4.5 under the main headings of content knowledge, general pedagogy, pedagogical content knowledge, management skills and concern for learners.

Table 4.5 *The teaching and learning processes in the Classroom.*

The teaching and learning process in the classroom		
	Case Study 1	Case Study 2
Content Knowledge	Good grasp	Fairly good grasp – would like to improve understanding of physics
General Pedagogy		
Main method of instruction	Whole class teaching / direct instruction	Whole class teaching / interactive questioning
Other teaching strategies employed	Group work / co-operative group instruction / Problem solving	Problem solving / group work

The teaching and learning process in the classroom		
	Case Study 1	Case Study 2
Use of textbook	Learners mainly use Charles's notes and what they added – Learners use textbook for homework exercises NCS textbooks not yet available	Referred learners to relevant page in textbook. Few learners had textbook at school
Homework	Yes – copy from blackboard, from textbook and paper and pencil exercises	Yes – copy homework assignment from blackboard; one page paper and pencil assignments
Assessment	Paper and pencil tests; Portfolio assignments; Making of own notes; Formal tests Exams	Paper and pencil tests; Portfolio assignments; Formal tests Exams
Pedagogical Content Knowledge		
Emphasize possible misconceptions	E.g. Emphasizes differences between sulphide ion, sulphite ion, sulphate ion.	e.g. Blue/red colour of veins and arteries on poster
Applications from everyday life experiences	Yes – Forces (pulling a cow) Volume (buying a tin of coke) Area (tiling an area)	Yes – Rates of reactions: Grandpa powder advertisement (the powder has a greater surface area and reacts faster), Equations of Motion: travelling by taxi (by knowing the distance and checking the travelling speed the learner could calculate time of arrival).
Inquiring science	Do many practical (hands-on) experiments	Do as many practical activities as resources allow.
Managing		
Discipline	Strict	Strict
Time Management	Efficient Time on task; Manages pacing - well	Sometimes late or leaves while learners work at copying from blackboard; Manages pacing - fair
Managing Resources	Monthly stock taking by teacher	No one at school in charge
Managing the Language Policy in the classroom	Allows language/code switching during discussions of findings of a practical experiment.	Allows language/code switching more often in latter part of lessons (10 times to 3 times in first part of lesson).
Concern for learners	Yes – encouraged grade eleven learner to continue at school and not become a drop-out	Yes – encouraged grade ten learner to continue with science

In the next chapter a discussion of the findings will be given.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 Introduction

The aim of this chapter is to comment on findings from the case studies in relation to the research questions. Similarities and differences in the situations existing in the two case studies are highlighted and discussed in accordance with the framework that guided the study.

Three themes have been identified that could have an impact on effective teachers. The first theme attends to the teaching and learning process in the classroom and endeavours to answer the first research question '*What does an effective science teacher have and do in the classroom while teaching large, under-resourced science classes and how and why do these actions bring about effectiveness?*'

The second theme will attend to the second research question '*What formative experiences have influenced the behaviour of the teacher and how and why have they contributed to effectiveness?*' In reporting on the findings of the case studies aspects pertaining to the individual biographical background and training of each case study teacher and the influence this have had on forming the present views of the teachers, in particular the view of the nature of science will be discussed.

The third theme: is concerned with the third research question *'what in-school support does the effective teacher have that sustains the practice and how and why does this support lead to continuing effectiveness?'* and will be addressed.

5.2 Discussions of the themes

5.2.1 The Teaching and Learning process in the classroom

This theme deals with the following subheadings:

Knowledge of Content

The teachers of both case studies had a good grasp of the content (ref. 4.3.3 and 4.4.3) in relation to the grades they teach. However, both mentioned a desire to get a better understanding of physics.

Knowledge of Pedagogy

The case study teachers were confident in the teaching styles they used. As has been suggested by Johnson et al. (2000a) teachers often have a variety of strategies they can choose from, but they choose the strategy that best fits their environment. That was found to be true of the case study teachers. They also seem to have no difficulty in teaching science in the large classes, almost automatically applying the strategies identified for use in large classes, which are knowing the names of learners, moving around the class, dividing the class into groups - to mention but a few. This finding is in agreement with the conclusions of Crouch et al. (1998) and Verspoor (2006a) that better qualified teachers seem to cope better with teaching large classes.

In case study one the school had not yet procured textbooks based on the NCS curriculum. At the school there were not enough copies of the old syllabus textbooks to issue one to each grade eleven learner. However, the grade twelve learners each had received a copy of the textbook, which they were to consult at home and use for extra exercises. At times, the grade eleven learners worked in groups during a lesson on problem-solving exercises from the textbook used under the old syllabus (ref. 4.3.4). In case study two the learners in the higher grades confessed that although they had all been issued with a textbook, they seldom used it, since it was full of errors. In the grade eight class Thandiwe referred to the textbook during her lessons, but did not insist on them using the textbook and seemed hardly to notice that only a few learners had brought their textbooks with them (4.4.4).

Homework was seen by both teachers as an extension of 'opportunity to learn' (Reynolds et al., 1999). However, in the higher grades the homework (and class work exercises) seemed to be based on training learners for the Senior Certificate exams as Warwick and Stephenson (2002: 146) indicate "*the need for pupils to do well in statutory assessments, dominates attitudes to what is seen as important in the classroom*".

In case study one, homework was given almost everyday and assessed the following day, by either learners exchanging books and marking each other's work or by Charles asking some learners to do the problems on the blackboard and then asking others to explain the answer to the rest of the class (ref. 4.3.4). Neither teacher had problems with regularly assessing the work done by learners in their exercise books. In case study one Charles marked the notes learners added to his notes during the afternoon classes and Thandiwe marked the scripts while learners were engaged in class work exercises. Both teachers marked thoroughly taking care of details such as general spelling mistakes and errors. However, in case study two, the huge marking load Thandiwe experienced in having so many grade eight learners, led to her designing assignments that could be marked easily. Therefore not much writing was required. Learners mainly had to fill in missing words or do simple calculations. Similarly the class work exercises the grade eight learners did, only involved recall-type questions (ref. 4.4.4). These findings are in agreement with what has been found in the literature (Taylor and Vinjevold, 1999).

Management skills

The personalities of both case study teachers were such that they commanded respect. They both had strong leadership qualities which assisted them in managing discipline, classroom environment, and equipment well. They both showed that they could be innovative, and organize, and manage out-of school scientific projects in the form of the science club and the grade twelve science camp (ref. 4.3.1 and 4.4.1). In case study one, Charles maximized time-on-task, and wasted little time in proceeding from one activity or section of a lesson to the next. He had well-structured lessons and told learners how many minutes they had in which to complete an activity (ref. 4.3.6). In case study two, during the lessons observed in the grade eight classes, there was not a maximizing of available time. Thandiwe often arrived late for class (it seems each time for a valid reason), activities were never rushed and learners were not urged to finish in a fixed time (ref. 4.4.6).

Pedagogical Content Knowledge

Both teachers displayed an understanding of ways in which to present subject content that would make it understandable to learners. For instance, in case study one, when

Charles explained the reaction between hydrochloric acid and iron(II) sulphide in the preparation of hydrogen sulphide, he used small steps in his explanation and made drawings on the blackboard. He referred to the particulate nature of chemistry, showing learners how the substances dissociated into ions, how to calculate the charges of the ions and how ions bond to form the products. In case study two, Thandiwe used known concepts to explain the unknown, as in her illustration of the circle for the circulatory system (ref. 4.4.4).

It is equally interesting that both teachers were aware of topics that learners have difficulty with, and spent more time in explaining such topics. The teachers were conscious of misconceptions that learners could develop and took preventative action. Certainly, the amalgamation of content in the teachers' minds and their knowledge of learners' misconceptions, facilitated the understanding of the concepts being taught. The teachers asked guiding and probing questions at various levels that provided insight into learners' conceptual understanding (ref. 4.3.5 and 4.4.5).

The frustration experienced in both case studies in not having functional laboratories, and, in case study two, of the science equipment being haphazardly stored, reflects strongly the view of the nature of science these teachers have and how it should be transmitted and facilitated in learners. The case study teachers view science as experimental and are consequently aware of the need for functioning laboratories. Secondly, they view science as a human activity. By relating the topic to familiar everyday activities both teachers not only make learners aware of the socio-cultural relevance of science, but challenge the learners to use science as one of the organizing factors in their outlook on life. Consequently science becomes meaningful and accessible to learners (ref. 4.3.5 and 4.4.5). The learners were clearly aware of this and could, during the interviews, recall many such instances of finding science in everyday life experiences.

Both case study teachers emphasized practical activities. To them science must be experienced. According to Thandiwe, recalling her own disappointment at school, a colour change should be seen and not merely '*read about*'. Both teachers place a great emphasis on hands-on activities and the lack of resources is keenly felt. The excitement the learners displayed in relating the practical experiments they had done also shows the positive influence such activities have on the attitudes of learners towards science.

Concern for learners

From the observations and interviews with the learners it is apparent that both teachers care for their learners and that the learners are aware of this concern and, in turn, respect these teachers (ref. 4.3.7 and 4.4.7). The teachers are sensitive to feelings of inadequacy learners might have and are willing to explain work over and over to individual learners after hours. Both teachers are doing more than is expected to benefit their learners, which is clear, for instance, from the camp Thandiwe is organizing for her grade twelve learners and the extra time Charles spends in teaching over weekends and in organizing the science club. The learners were able to mention incidents that indicated the concern these teachers have for all their learners.

Christie et al. (2007) found that it is the fine teaching staff (committed teachers, teachers that are passionate about the subject they teach, teachers willing to go an extra mile, etc.) that, in the end, are responsible for a "*school that works*". As is stated in the NCS document "*teachers who are qualified, competent, dedicated and caring*" are the teachers wanted for teaching science (DoE, 2003: 5). Both teachers of the case studies fit these descriptions.

In summary it could be said that both the case study teachers have a good knowledge of the content; they have an excellent understanding of general pedagogy and are accomplished in applying pedagogical content knowledge. In the classroom they apply the pedagogical content and general knowledge to sustain the effective practice. Furthermore the view of the nature of science both these teachers hold influences their teaching styles. The emphasis they place on hands-on activities in return creates a positive attitude towards science among the learners. The learners are motivated and eager to perform well. These teachers show a passion for their subject and both of them are willing to go the extra mile in helping the learners to grasp concepts properly. Their concern for their learners has earned them respect and admiration.

5.2.2 Formative experiences of the teacher

Savage (1999: 147) pointed out that individuals bring about change. He argued that more needs to be known of what inspires and sustains excellence in an individual teacher so that educators can develop support systems and sustain work of excellence. To this end, information on the formative experiences of the teachers was sought.

Biographical background

The deprivation both teachers experienced during their own formative years has resulted in their desiring to give their learners practical science experiences (ref. 4.3.1 and 4.4.1). The fact that they could only "*read about a colour change*", but never saw it happening, and felt that science was '*far away*'; influenced the view they today hold of the nature of science, namely that science is something to be practised.

Influence of Mentor teachers

Both case study teachers had a mentor teacher that they affectionately remember. They both agree that these mentor teachers influenced them to become teachers '*one day*'. In case study two, the way in which the mentor teacher challenged Thandiwe to first become fluent in English and then guided her by giving her newspaper articles shows his foresight in guiding her. The confidence the mentor teachers displayed in the ability of the case study teachers to achieve that goal, sustained these two in difficult times. Savage (1999: 149) mentions a similar finding where the support and challenges of a primary school teacher to "*always strive for perfection*" influenced a learner to pursue a career in teaching.

Influence of families and a political climate

The encouragement they received from their families in becoming teachers, coupled with a political drive Charles alluded to of "*being of some value to his country*' have resulted in them becoming qualified teachers and having a passion for the profession. This is in agreement with Onwu and Mogari (2004: 174) who referred to a climate of expectation vis-à-vis the democratic climate of the 'new' South Africa as one of the things that brings about favourable changes in teachers. Christie et al. (2007: 59) also pointed out that, to some teachers their teaching is much more than a profession; they are contributing significantly to the future of the country.

Training and Classroom learning and teaching environment

The opportunity the case study teachers had of each studying at a well-resourced College of Education, contributed to them having a good grasp of content knowledge sufficient and relevant for the FET level. Studying science at an institution where '*everything was perfect'* for Thandiwe, and, for Charles, teaching science at a very well resourced school has some bearing on the view they have of the nature of science. Thandiwe realized that the subject is not necessarily difficult or easy, but that one needs to "*find out*". Charles displayed the same concerns and, in his teaching, did more than the required number of experiments. That both teachers are in the final year of ACE (FET) courses, however, indicates their awareness of the fact that their knowledge of the physical science content should still improve. In case study one, Charles referred to the help he had received at the previous school where they had a mentorship with a local university. In case study two Thandiwe mentioned how she became part of the MSSI (Mpumalanga Secondary Science Initiative) and how this partnership had contributed to her ability to do practical work.

In summary, the influence of mentor teachers, coupled with the encouragement of family members and a political drive to be of value to the country have led to both case study teachers pursuing the teaching profession. The deprivation they themselves suffered as children, never having been able to do science practically, only experiencing a dysfunctional science laboratory, have become a motive behind the emphasis both teachers place on doing and experiencing science and on the importance they place on the laboratory as the place where scientists work. The lament of both teachers that they lack proper facilities is a clear indication of how much they value a functional classroom learning environment. The view of the nature of science as being a human and social activity that must be experienced practically has not only influenced their teaching but led to them creating a positive attitude towards science in the learners they teach.

5.2.3 Culture/climate of the School

Vision of the schools

In case study one, the shared vision (of working together to improve results) of both staff and learners in the school was obvious, as shown, for example, by learners and teachers coming to school during the holidays and on Saturdays (and even Sundays, on occasion).

In case study two, owing to the lack of a shared vision of the staff and learners, the learners were not as motivated as one would hope. Only grade twelve learners attended afternoon classes and on "Teachers Day" there were hardly any learners left on the school grounds after break, despite the fact that the minister of education had emphasized that it was not a school holiday. Although all the teachers seemed to be there, they did not seem particularly upset about the learners being absent. Whether the learners took the initiative to organize the stay-away (or maybe the "not return" after break) is not clear. This evidences a culture of slackness.

Academic leadership

The academic leadership of the school principal in case study one, was positive - showing not just interest, but taking pride in the achievement of learners. In an informal discussion the principal referred to the fact that the school acknowledges excellence and that teachers and learners appreciate this. The School Governing Body (SGB) was at that time organizing a prize-giving evening to honour those learners that had performed well. Charles's science club had become the science club of the community. All these factors led to the sense of *well-being* of the school.

However, in case study two, the image the principal seemed to convey to the learners was that he was a very busy man - one who did not take a direct interest in the learners and their activities. A teacher with a vision and a passion for success, who is driven to improve, must then put in an added effort to motivate learners - like Thandiwe, in organizing the camp for grade twelve learners. She took the initiative, and involved the school principal in her camp by asking him to be the guest speaker and to motivate the learners to success in his address.

The institutional support is also evident in terms of school policies (discipline, language, security, etc.) and the implementation. Though at both schools English was the medium of instruction, a temporary change to the vernacular was made whenever it would increase the understanding of learners. At the rural school (case study two), a change to the vernacular in class occurred more often than in the township school, doubtless because English is used less in the rural areas and so learners are less proficient in it. This implies that increasing the proficiency in English of the learners should improve the results in science - proficiency in the language of instruction is, after all, one of the determinants for success in science and maths (CDE, 2004).

Job satisfaction

An entity that was not an element in the original framework but that seems to contribute to a teacher being effective is that of ‘job satisfaction’. Reddy (2006: p. 108) mentions ‘*teachers’ job satisfaction’* as a contributing factor to school climate. Although both the case-study teachers complained of a huge work load, they nevertheless were committed and passionate about their teaching. Charles had previously sacrificed much to arrange his science club on Friday afternoons and lamented that he did not have enough time with his added responsibilities of HOD and cluster leader to continue with the club. Thandiwe put a tremendous effort into arranging the grade twelve camp which took a lot of her free time. She did it heartily and enthusiastically for the benefit of the learners. Neither seemed to regret the extra time they put into their teaching. Both these teachers expected much from their learners and the learners were aware of the expectations. From all this it is clear that both teachers took initiative, could organize well and received due support for their efforts from the principal, colleagues and the community. Commitment is certainly one of the key qualities of an effective teacher in teaching large classes.

In summary, when a school has a shared vision, then everybody contributes to the well-being of the school. Where such vision is lacking, the individual who strives to improve matters must put in an effort. Sometimes such an ‘added effort’ cannot be sustained. However, often the effort of a single person alone is not enough to improve matters. In case study one everybody in the school worked towards improving the school results, not only the grade twelve learners. Learners and teachers alike were supported, encouraged and motivated to change. The school was functional. In case study two at times the school was not functioning properly, yet there were teachers really helping each other and the learners. A greater effort on the part of individuals was required. Such practice and support lead to continuing effectiveness.

5.3 Conclusion

The study tried to gain an insight into what an effective science teacher does in the classroom while teaching large, under-resourced classes, how such effective teaching is sustained and what factors in the background of the teacher led to the teacher being effective. Furthermore the study probed the in-school support and how it contributes to the effectiveness of the teacher. In addition the study attempted to gain some insight into how the view of the nature of science that an effective teachers has, was formed and how the teacher's view of the nature of science influences his or her teaching.

In an attempt to focus the investigation of the study a framework was developed and used in gauging the effectiveness of a teacher. Within the framework, first the characteristics of the teacher in the classroom were investigated under the headings content knowledge, general pedagogical knowledge, pedagogical content knowledge, management skills and concern for learners. Second the influence of the formative years of the teacher was analysed, since the biographical background of the teacher influences and directs his/her view on teaching and of the nature of science. Thirdly, the culture of the school where the teacher works is described, for it appears, in the light of recent research, that effective teaching is to a large extent only possible at schools with a positive culture, aimed at working together to produce good results.

The findings of this study are as follows:
The effective teachers first of all had a good grasp of the content of the subject. Second, the teachers had ample pedagogical content knowledge. The teachers recognized when misconceptions could arise. They explained concepts in small steps using examples from everyday life experiences of the learners. Thirdly, the teachers applied general pedagogy. They knew and used a variety of teaching strategies such as co-operative group instruction and problem-solving strategies. They were aware of those strategies that had been identified as useful in large classes, e.g. knowing the

names of the learners, moving around the class and using small-group instruction, and could apply them. The effective teachers had well-planned structured lessons. They started with reviewing previous concepts, then expounded new content, followed this up with class activities and ended by extending the ‘opportunity to learn’ in giving homework exercises. They placed a great emphasis on ‘opportunity to learn’ (sometimes referred to as ‘time on task’) by moving quickly from one activity to the other, and managing the time in the classroom well. They motivated the learners to work. They were strict and expected learners to be responsible and disciplined. They expect much of their learners, and insist upon frequently and regularly assessing the learners’ work and then give constructive feedback.

The vision and passion those teachers have were at least partly due to their mentor teachers. Encouragement from family and having had the opportunity to study at colleges of education and having been part of a mentorship (for Charles with a local university and for Thandiwe having been part of the MSSI partnership) at the start of their teaching careers contributed to the effectiveness of these teachers and the view they have of the nature of science.

However, the shortage of resources these teachers experience hampers them in their teaching. Both teachers see science as something to be experienced. Therefore they emphasize hands-on activities. In an attempt then to teach science in that way, they insist, at the least, on a well-resourced laboratory, one having its facilities in working order and having the necessary equipment for all learners to do practical investigations and standard experiments.

The culture of the school influences the practice of the teachers. Where a school has a joint vision, strong academic leadership and in-school support, effective teaching seems to occur, and is sustained.

5.4 Limitations of the Study

A limitation of this study is that it deals essentially with just two cases – certainly many more would have expanded the time and work involved beyond the original intention. However the questions asked can only be answered using a case-study method. The limitation is the small number of samples. Indeed Yin (2003: 37) cautions that generalizing from a single case to a larger group can only be done if the study can be replicated. He mentions that case studies could expand or generalize theories but should not be generalized to populations (Yin, 2003: 10). In this regard one could usefully form theories from the findings of this present study and perhaps incorporate them in a teacher-training program.

5.5 Recommendations

The view teachers have of the nature of science influences the way they teach. Teachers, who view science as a human activity that must be experienced, should then be provided with the minimum equipment and facilities. Teacher education should emphasize professional identity of reform-minded, pre-service teachers in science.

Both these effective teachers had support at the start of their teaching careers on implementing practical activities and doing science. There should be an on-going support system for the teachers to help them cope with the demands of the curriculum. Even in pre-service teacher training programmes the value and techniques of practical work should be inculcated in the prospective teachers. This of course can be furthered by practical work, which should form a large part of the atmosphere of their training at university or college.

Recommendations for further research

Although the teachers acknowledged that they use textbooks in their lesson preparation, both these teachers used the textbook mainly as a book with extra exercises, and did not use the textbook as a curriculum interpreter. It would be of interest to find out why teachers do not use the textbook as such in large classes, and why learners seem to find textbooks of not much help, either.

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APPENDICES

Appendix A: CLASSROOM OBSERVATION SCHEDULE

TEACHING LARGE UNDER RESOURCED SCIENCE CLASSES: A CASE STUDY CLASSROOM OBSERVATION SCHEDULE
This classroom interaction instrument is to be completed by the observer for each classroom session on each of the stipulated days of observation.
SECTION A: GENERAL

Date:	**Name of observer:**
School:	
Name of teacher:	
Subject:	**Grade:**

Number of students present	Number	Boys	Girls
Number of students absent:	Number	Boys	Girls

Time of day:	1st period	Before break	After break	In between	Last period
Time:	Started	Ended	Duration	Total time	

Period number:	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th

SECTION B: OBSERVATION

Time	**Observation description**	**Teacher:**		**Learners:**	
		Talks		Listen	
		Asks question to learners		Thinks	
		Waits		Answer teacher's questions	
		Answers own questions			
		Answers student's questions		**Ask questions to teacher**	
		Demonstrates		**Observe**	
		Asks: "Any questions?"		Read	
		Writes on blackboard		Talk to each other	
		Dictates question		Copy from blackboard	
		Marks exercise books		Copy dictation	
		Not in room		Muck about	

Time	**Observation description**	**Teacher:**		**Learners:**	
		Talks		Listen	
		Asks question to learners		Thinks	
		Waits		Answer teacher's questions	
		Answers own questions			
		Answers student's questions		**Ask questions to teacher**	
		Demonstrates		**Observe**	
		Asks: "Any questions?"		Read	
		Writes on blackboard		Talk to each other	
		Dictates question		Copy from blackboard	
		Marks exercise books		Copy dictation	
		Not in room		Muck about	

Time	**Observation description**	**Teacher:**		**Learners:**	
		Talks		Listen	
		Asks question to learners		Thinks	
		Waits		Answer teacher's questions	
		Answers own questions			
		Answers student's questions		**Ask questions to teacher**	
		Demonstrates		**Observe**	
		Asks: "Any questions?"		Read	
		Writes on blackboard		Talk to each other	
		Dictates question		Copy from blackboard	
		Marks exercise books		Copy dictation	
		Not in room		Muck about	

Appendix B: TEACHER QUESTIONNAIRE

TEACHING LARGE UNDER RESOURCED SCIENCE CLASSES: A CASE STUDY TEACHER QUESTIONNAIRE				
This questionnaire is to be completed by the teacher after the introductory meeting.				
GENERAL				
Name of researcher:				
Title of Teacher:				
Age:	18 - 25	26 - 35	36 - 45	45 - 60
Gender:	Male		Female	
Language most often used in Teaching:	Mother tongue	English	Both English and mother tongue	
HISTORY				
Your Primary School Years:				
Area in which school(s) is/are situated?	**Rural**	**Township**	**Mid-city**	**Suburban**
Type of school?	**Former DET**	**Former homeland**	**Former white**	**Independent**
How would you describe your primary school years?	**Happy**	**Sad**	**Good**	**Bad**
Give a short description of your primary school years. Was there any event, person (individual) or decision that had a profound influence on your life? Mention it shortly.				
(c) Your Secondary School Years:				
Area in which school(s) is/are situated?	**Rural**	**Township**	**Mid-city**	**Suburban**
Type of school?	**Former DET**	**Former homeland**	**Former white**	**Independent**
How would you describe your secondary school years?	**Happy**	**Sad**	**Good**	**Bad**
Give a short description of your secondary school years. Was there any event, person (individual) or decision that had a profound influence on your life? Mention it shortly.				
(d) Your Post School Years:				
How did you spend the first few years after you had finished with schooling?	**Worked**	**Studied fulltime**	**Worked and studied part-time**	**Other**
Give a short description of the first few years after you had finished your school career. Was there any event, person (individual) or decision that had a profound influence on your life? Mention it shortly.				

QUALIFICATIONS

Please indicate your academic and professional qualifications

	Qualification	**Majors**	**Institution**	**Year obtained**

To which level have you studied natural science?	
To which level have you studied Mathematics?	
Are you currently registered for any science or mathematical studies?	
If yes, **Which studies are you registered for?**	
If yes, **At which institution are you registered?**	
Have you participated in INSET in the past three years?	
If yes, elaborate:	

TEACHING EXPERIENCE

Number of Years employed as a teacher			
Number of different schools where you have taught			
Type of schools where you have taught	Primary school	Secondary school	Special needs school
Number of years employed as a teacher at the present school			

(a) First teaching experience

Were you adequately prepared?	Yes	No
Was there any mentor(s) (present and past) that had a profound influence on you? Elaborate.		

(b) Experience as a teacher of grade 12 (matric) class.

After how many years in teaching did you have your first matric class?	
First year (date) in which you had a grade 12 (matric) class.	Year
First year (date) in which you had a grade 12 (matric) class for science.	Year
How many times (number of years) have you taught a grade 12 (matric) class for science (Include the present year if applicable).	

(c) Teaching experience in general

Teaching which grade do you find most challenging?				Grade
How would you describe a large class?	Large number of learners.	Inadequate classroom space.	To many Learners to handle	A combination of the afore mentioned
Numerically how large was the largest class you taught?				
Is the school equipped with a science laboratory?			Yes	No
Do you usually do practical work in a science laboratory?			Yes	No

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Appendix C: PRINCIPAL QUESTIONNAIRE

TEACHING LARGE UNDER RESOURCED SCIENCE CLASSES: A CASE STUDY PRINCIPAL QUESTIONNAIRE				
This questionnaire is to be completed by the School Principal. If available, then by Deputy School Head or Person in Charge.				
GENERAL				
Name of researcher:				
Name of School:				
Title of respondent:				
Gender:	Male	Female		
Highest grade offered at school:		Grade		
SCHOOL POLICY DATA				
Does the school have a clear policy on the following:				
(a) Language policy at the school:			Yes	No
(i) If Yes (elaborate)				
(ii) What is the predominant medium (language) of instruction at the school				
(b) Policy on personal responsibility: The demands made on learners and staff concerning personal responsibility, (such as absenteeism, insufficient preparation and poor motivation) and certain expectations, and the consequences of not living up to the demands			Yes	No
(iii) If Yes (elaborate)				
(iv) What do you estimate to be the daily absentee rate for learners (%)?			%	
(v) What do you estimate to be the daily absentee rate for the teaching staff (%)?			%	
(c) Policy on the academic subjects and activities the school offers:			Yes	No
(i) If Yes (elaborate)				
(d) Assessment policy and policy for providing information about learner attainment:			Yes	No
(i) If Yes (elaborate)				

(e) Policy on activities and events available to learners outside classes:	Yes	No
(i) If Yes (elaborate)		
(f) Policy on guidance and counseling of learners:	Yes	No
(i) If Yes (elaborate)		
(g) Policy on the numbers of learners in a class:	Yes	No
(i) If Yes (elaborate)		
SCHOOL MANAGEMENT PRACTICES		
(a) Supervision:		
(i) By whom are educators in the school supervised in respect of:		
• Preparation and appropriateness of term/year programme (scheme of work)		
• Preparation and suitability of lessons and assessment tasks		
• Recording and reporting of assessment		
(ii) Describe process and frequency of supervision. In particular describe processes for checking progress in the delivery of the curriculum.		
(b) How often are staff meetings held?		
(c) What responsibilities are delegated to educators?		

(d) Who is responsible for acquiring equipment (desks, chairs, equipment for science laboratory assignments)?

(e) Liaison with parents:

(i) Who at school is responsible for liaison with parents?

(ii) What structures are in place for liaison with parents?

(f) Liaison with the community:

(i) Who at school is responsible for liaison with the community?

(ii) What structures are in place for this?

(g) In what ways do parents and the broader community (distinguish clearly) contribute to the delivery of education and management of the school?

	Parents	Broader community
Parent teacher association (PTA) input		
Financing		
Labour		
Materials		
Skill/knowledge input		
Sports, drama, coaching		
Decision making		
Influential groups of individuals		

LEARNERS

(a) Matriculation pass rate**:**

(i) Is the school matriculation pass rate falling or rising in the last 5 years?

School pass rate		Pass rate for boys		Pass rate for girls	
Falling	Rising	Falling	Rising	Falling	Rising

What are the main reasons for improvement or decline in performance?

(ii) Is the school matriculation pass rate in science falling or rising in the last 5 years?

School pass rate in science	Pass rate in science for boys	Pass rate in science for girls

Falling	Rising	Falling	Rising	Falling	Rising
What are the main reasons for improvement or decline in performance in science?					
(b) What is the learner achievement of which the school is most proud? Elaborate					
TEACHER SUPPORT					
(a) Improving Qualifications:					
(i) Are teachers encouraged to improve their qualifications by further study, attending workshops, other means?				Yes	No
(ii) Are teachers who are studying allowed time-off for exams?				Yes	No
(iii) Are teachers who are studying allowed time-off for completing assignments?				Yes	No
(b) After school activities					
(i) Are teachers encouraged and supported to take learners on excursions related to the subject they teach after school hours?				Yes	No
(ii) Are teachers encouraged to let learners participate in school related competitions?				Yes	No
(iii) Have the school participated (in the past) in any of the following competitions?					
MinQuiz	Expo for Young scientists	Olympiads	Essay competitions	Art competitions	Other
(iv) Are teachers expected to help with the coaching of sport after school hours?				Yes	No
Thank you for completing this questionnaire.					

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Appendix D: SURVEY OF RESOURCES

TEACHING LARGE UNDER RESOURCED SCIENCE CLASSES: A CASE STUDY SURVEY OF RESOURCES				
This survey of resources is to be completed by die Head of Department for Science or someone appointed by him/her.				
SECTION A: GENERAL				
Date:	**Name of researcher:** **E. S. Randall**			
School:				
SECTION B: SURVEY OF RESOURCES				
School grounds				
Is the school fenced?			Yes	No
Is there a hut for the security guard?			Yes	No
Number of dustbins on the grounds?			Number	
Number of motor sized gates for entering grounds?			Number	
Number of pedestrian gates for entering grounds?			Number	
School buildings				
Are the school buildings built with bricks and mortar?			Yes	No
Are there any pre-fabricated buildings?			Yes	No
Is there a school hall?			Yes	No
Are there chairs for spectators during a function in the hall?			Yes	No
Is there a larger than normal room wherein a Grade could gather?			Yes	No
Number of classrooms?			Number	
Number of other rooms?	Store rooms	Library	Tuck shop	Other
Is there running water from taps at the school?			Yes	No
Approximately how many taps?	Less than 5	10 - 15	More	
Place where taps are found?	On school grounds	In classrooms	In ablution	
Is there electricity?			Yes	No
Does each classroom have electrical plug connection?			Yes	No
What are plug connections in classrooms mainly used for? (Elaborate)				
Are there sufficient light fittings in the classrooms?			Yes	No
Light fittings require:	Ordinary light bulbs	Neon strip lights	Other	
Is the ablution sufficient?	For Staff	For Learners	Insufficient	
Are the toilets		Water based	Non water	
Administration				
Is there a separate administration building?			Yes	No
Are there toilets in the administration building?			Yes	No
Is there a staff room?			Yes	No
Is the staff room furnished with?	A chair for each teacher		Desks	Tables
Offices are available for?	Principal	Deputy	HOD's	Other

Is there an office for the secretary?			Yes	No
Is there a safe?			Yes	No
Is there a copier?			Yes	No
Is there a store room?			Yes	No
Is there a fax machine?			Yes	No
Is there a telephone?			Yes	No
Are there cubicles (post boxes) for each teacher?			Yes	No
Is there a kitchen?			Yes	No
Is the kitchen furnished with?	A stove or hotplate	A microwave	A fridge	A kettle
Class rooms				
Is there a table or desk for the teacher?			Yes	No
Is there a chair for the teacher?			Yes	No
Is there a cupboard for storing things?			Yes	No
Does the cupboard have a lock?			Yes	No
Are there any shelves?			Yes	No
Is there any billboard for posters / notices?			Yes	No
Is there sufficient number of desks for each learner?			Yes	No
Is there sufficient number of chairs for each learner?			Yes	No
Is there a blackboard?			Yes	No
Is there a whiteboard?			Yes	No
Is sufficient chalk available?			Yes	No
Are sufficient white board markers available?			Yes	No
Is there an overhead projector?			Yes	No
Is each class equipped with a dustbin?			Yes	No
Is (at least one) classroom equipped with curtains? (To darken the room?)			Yes	No
Are there any heaters / coolers (fans) in the classrooms?			Heaters	Fans
Science Laboratory				
Is there a science laboratory?			Yes	No
Is there a laboratory for biology?			Yes	No
Number of laboratories at the school?			Number	
Are the laboratories equipped with electricity?			Yes	Yes
Are the laboratories equipped with gas?			Yes	Yes
Are the laboratories equipped with running water?			Yes	Yes
Is the science equipment sufficient for demonstrating each experiment?			Yes	No
Is the science equipment sufficient for doing each experiment in small groups?			Yes	No
Are there sufficient storerooms for science equipment?			Yes	No
Are there sufficient shelves (cupboards) for equipment?			Yes	No
Are there enough chemicals?			Yes	No
Is there a storeroom for chemicals?			Yes	No
Is there a storeroom for dangerous chemicals i.e. concentrated acids?			Yes	No

Are there sufficient shelves (cupboards) for chemicals?	Yes	No
Are there posters i.e. Periodic Table?	Yes	No
Are the posters stored in library?	Yes	No

Science Equipment			
Chemistry apparatus			
Beehive shelves?	Yes	No	Number if available
Bell jars?	Yes	No	Number if available
Bourdon gauge	Yes	No	Number if available
Bunsen burners?	Yes	No	Number if available
Burettes?	Yes	No	Number if available
Cork borer sets?	Yes	No	Number if available
Crucibles and lids	Yes	No	Number if available
Drop pipettes?	Yes	No	Number if available
Electronic scale?	Yes	No	Number if available
Erlenmeyer flasks?	Yes	No	Number if available
Filter paper	Yes	No	Number if available
Funnels?	Yes	No	Number if available
Gas connections?	Yes	No	Number if available
Gas cylinders?	Yes	No	Number if available
Gas syringes	Yes	No	Number if available
Gauze flat form	Yes	No	Number if available
Glass beakers?	Yes	No	Number if available
Do the glass beakers have different sizes?	Yes	No	
Glass plates?	Yes	No	Number if available
Glass tubes?	Yes	No	Number if available
Measuring cylinders?	Yes	No	Number if available
Do measuring cylinders have different sizes?	Yes	No	
Microchemistry sets (Somerset)?	Yes	No	Number if available
Microchemistry sets fully equipped?	Yes	No	Number if available
Organic chemistry sets?	Yes	No	Number if available
pH-meter?	Yes	No	Number if available
Pipe clay triangles	Yes	No	Number if available
Pipettes?	Yes	No	Number if available

Pneumatic trough	Yes	No	Number if available
Retort ring	Yes	No	Number if available
Retort stand	Yes	No	Number if available
Round bottomed flasks?	Yes	No	Number if available
Rubber stoppers?	Yes	No	Number if available
Scalpel	Yes	No	Number if available
Scalpel blades	Yes	No	Number if available
Separating funnel	Yes	No	Number if available
Spatulas?	Yes	No	Number if available
Spirit burners?	Yes	No	Number if available
Test tube brushes?	Yes	No	Number if available
Test tube racks?	Yes	No	Number if available
Test tubes?	Yes	No	Number if available
Thermometers?	Yes	No	Number if available
Three beam balances?	Yes	No	Number if available
Triangular files (for cutting glass tubes)?	Yes	No	Number if available
Tripod	Yes	No	Number if available
U-tube	Yes	No	Number if available
Volumetric flasks?	Yes	No	Number if available
Watch glasses	Yes	No	Number if available
Winchester flasks?	Yes	No	Number if available
Physics apparatus			
AC power supply boxes?	Yes	No	Number if available
Ammeters?	Yes	No	Number if available
Oscilloscope?	Yes	No	Number if available
Ball and ring apparatus available?	Yes	No	Number if available
Circuit boards?	Yes	No	Number if available
Coils (demonstrating Lenz's law)?	Yes	No	Number if available
Different lengths of wire?	Yes	No	Number if available
Different types of wires (copper; nichrome; etc?)	Yes	No	Number if available
Electric bells?	Yes	No	Number if available
Electroscopes?	Yes	No	Number if available

Energy conversion set?	Yes	No	Number if available
Equipment to demonstrate the electric motor?	Yes	No	Number if available
High voltage power supply?	Yes	No	Number if available
Joule meter?	Yes	No	Number if available
Lenses (concave; convex)?	Yes	No	Number if available
Light beam sets?	Yes	No	Number if available
Light bulbs (torch)?	Yes	No	Number if available
Loudspeakers?	Yes	No	Number if available
Magnets?	Yes	No	Number if available
Masses (weights)?	Yes	No	Number if available
Meter rules?	Yes	No	Number if available
Perspex triangles (prisms)?	Yes	No	Number if available
Polaroid lenses?	Yes	No	Number if available
Ripple tank?	Yes	No	Number if available
Rheostat	Yes	No	Number if available
Slinky?	Yes	No	Number if available
Sound generator?	Yes	No	Number if available
Specific heat capacity sets?	Yes	No	Number if available
Spectroscope	Yes	No	Number if available
Spring balances?	Yes	No	Number if available
Static electric sets?	Yes	No	Number if available
Stopwatches?	Yes	No	Number if available
Stroboscope	Yes	No	Number if available
Ticker-timers?	Yes	No	Number if available
Transformer demonstration kit?	Yes	No	Number if available
Trolleys?	Yes	No	Number if available
Trolley runway	Yes	No	Number if available
Tuning forks?	Yes	No	Number if available
U-shaped strong magnet?	Yes	No	Number if available
Vacuum flasks?	Yes	No	Number if available
Vacuum pump?	Yes	No	Number if available
Van de Graaff generator?	Yes	No	Number if available

Voltmeters?	Yes	No	Number if available
Wire connections with banana connections?	Yes	No	Number if available
Wire connections with crocodile clips?	Yes	No	Number if available
Wires with differing thicknesses?	Yes	No	Number if available
1.5 V cells (batteries)?	Yes	No	Number if available
12 V car battery?	Yes	No	Number if available
Power supply boxes (1 – 12 V DC)?	Yes	No	Number if available
Long (15 m) tape measure?	Yes	No	Number if available

Earth and beyond			
Different types of rocks available?	Yes	No	Number if available
Anemometer?	Yes	No	Number if available
Aneroid barometer?	Yes	No	Number if available

Computer laboratory				
Is there a separate computer laboratory?			Yes	No
How many computers available for use by learners?			Number	
How many computers available for use by staff?			Number	
Is there internet connection?			Yes	No
Is there a printer available?			Yes	No
Library				
Is there a separate library?			Yes	No
May learners borrow books from the library?			Yes	No
Period for which books may be borrowed?			Period	
Periods for which Library is open?	Every day	Once a week	During break	After school
General				
Mention any thing you may deem important:				
Thank you very much for the time spent in completing this survey.				

Appendix E: INTERVIEW PROTOCOL WITH THE TEACHER

TEACHING LARGE UNDER RESOURCED SCIENCE CLASSES: A CASE STUDY SEMI STRUCTURED INTERVIEW WITH THE TEACHER
This interview is held with the teacher after the Teacher questionnaire has been completed to clarify some of the points of the questionnaire and to gain additional information that follows from the questionnaire.
Regarding your own school years: were there any event / person that had a profound influence on your life? Discuss it shortly.
Were you a leader at school, or a chairperson of a club or society? Discuss any leading role you played.
What events led to your decision to become a teacher?
Describe your college / university years.
Describe your first experience as a teacher of a science class, (of a grade 12 class). Were you adequately prepared?
Did you have any mentor teacher? Elaborate. When did you start to feel comfortable in your career?
How has the change in the curriculum (OBE) influenced your teaching? How do you now feel about the new curriculum?
Teaching which grade, do you find most challenging? Please elaborate on reasons why you find a certain grade most challenging. Do you teach different grades differently?
How would you describe a large class? How else could you describe a large class? How large is the largest class that you have taught? Which grade was that? How large was your largest grade 12 class? What is different in teaching a large class to teaching a smaller class? Discuss some strategies that you use in teaching large classes. How large are your present classes? Do you have standard grade and higher grade pupils in the same class? How do you differentiate?

Describe your experiences with practical work (experiments) in science. Were you adequately prepared for practical work? Elaborate. Do you have adequate resources to conduct the experiments? How do you conduct portfolio experiments with your learners? Do you do practical work differently with different grades?
Do you give the learners assignments where they have to do investigations in class? Have you given learners assignments where they had to do practical investigations at home? Have you given learners research investigations to do where they would have to make use of books in the library or make use of getting information off the internet? Would you give such assignments if the learners had adequate resources? Elaborate.
What was your worst experience during your first year of teaching? During your career so far? What teaching experience will you always remember?
Do you encourage learners to take part in science competitions? How do you find out about such competitions? Have you had learners that have taken part in the Expo for young scientists? Have you had learners that wrote the science Olympiad? Discuss briefly.
Do you take learners on excursions? Elaborate.
How do you cope with a huge work load, and studies?
Elaborate on your involvement in the community.

Appendix F: INTERVIEW PROTOCOL WITH THE LEANERS

TEACHING LARGE UNDER RESOURCED SCIENCE CLASSES: A CASE STUDY SEMI STRUCTURED INTERVIEW WITH THE LEANERS
This interview is held with a group of learners. They will represent the learners whom the teacher is presently teaching or had taught and/or learners with whom the teacher has had some contact. Questions regarding the following aspects will be asked:
<u>Large classes</u> How do the learners perceive a large class? What would they say constitutes a large class? How large was the largest class that the learners had been part of? Do they think that the classes they are now part of are large classes?
<u>Resources</u> Does each learner have a desk to sit at? Is the light in the classrooms sufficient or do they feel that the classes are dark and stuffy? How well is the library equipped at the school? Will the learners be able to do research on science topics from the books and magazines in their school library? Are there enough textbooks available for each learner? Do learners have to buy their own copy of the textbook or are the issued with a book? Are learners given photocopies of relevant work? Or do learners have to copy all notes from the blackboard? Are tests given as photocopies or are the questions written on the blackboard? Do the learners think that the school is adequately equipped with necessary resources for doing practical work in science? Does the teacher make use of posters in the class, while explaining certain topics? Are there relevant posters on the walls of the science class / laboratory to enhance a science atmosphere?
<u>Personalisation:</u> Does the teacher show a personal interest in the students – by o talking to them, o helping them when they are in trouble, o consider their feelings?
<u>Independence</u> Does the teacher make all the decisions? How are the learners organized in class? Are they told where to sit? Are they told how to behave in the classroom? How are groups formed when they do practical work? Are different learners assigned different jobs (like chairperson, scribe, etc.) during practical work? Do learners alternate the jobs? Do learners have a say in what is happening in class?
<u>Investigation</u> Do learners do investigations? Could they elaborate on at least one, please? Where do learners find the answers for investigations? From textbooks? From doing the investigation themselves? Form doing the investigation, but getting the answer from the teacher? What information is given to learners when they carry out investigations? Are investigations followed by class discussions? Are investigations done on totally new work, or to emphasize practically something that they have learned about in class? In doing investigations must learners explain the meaning of statements, diagrams and/or graphs?

Participation May learners give their own opinions during discussions? Are learners scared of being laughed at or mocked if they give the wrong answer or are they encouraged to try and make mistakes rather than always be correct or to keep silent? Learners are encouraged to ask questions? Learners are encouraged to say if they don’t understand something? Are ideas or suggestions of learners used during class discussions? Are learners required to do homework on the blackboard? Are learners given a chance of participating in assessment, through self-, or peer assessment?
Differentiation Are learners doing science on standard grade and on higher grade in the same class? Does the teacher give them different work? Do learners use different text books, equipment and/or materials? Or is everyone doing the same work at the same time? Are faster learners allowed to move on to the next topic? Or are faster learners given extra work on the same topic? Or are faster learners asked to explain the work to the slower learners? In explaining the work, does the teacher use the same teaching aid for all learners?
Motivation Are learners encouraged to work hard? How does the teacher encourage his learners to work hard? Are learners given little incentives for hard work?
Discipline Is the teacher very strict? What does the teacher do to give the impression of being strict? Does the teacher have a sense of humor? Is the teacher sarcastic or say things (sometimes) that cut right through you? Does the teacher manage his class well? What happens if you are found mucking about? Or doing the homework of another subject in this teacher’s class? What happens if the learners do not do homework?
Presentation Does the teacher explain the work well? What make the learners say so? Does the teacher make use of everyday examples in explaining work? Do the learners gain a better understanding that science plays a role in the world outside the school? Do the learners realize that science is a developing subject and has a history? Are learners allowed to express their opinion / ask questions / complain? Are learners given a scope – to help them plan what to learn? Does the teacher give an indication of time available to be spent on activities? Are there any incentives to teach learners how to assess themselves and their peers? Do learners have a chance to develop communication skills?
Excursions Are learners encouraged to take part in science competitions? Do they themselves hear about such competitions or does the teacher encourage their participation? Are they encouraged to go on excursions to SciFest, the open day at the Universities, science exhibitions, etc? Are learners encouraged to bring community projects to the classroom and discuss participation there?

Appendix G: PERMISSION FROM THE DEPARTMENT OF EDUCATION

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YUNIBESITHI YA PRETORIA

Appendix H: LETTER TO PRINCIPAL

University of Pretoria
Faculty of Education

Science, mathematics and
Technology Education
Groenkloof campus, Pretoria 0002,
Republic of South Africa

Tel: (012) 420-5572 / (012) 420-5621
http//www.up.ac.za

20 August 2006

The Principal
…………….Secondary School

Dear Sir

I hereby request permission to conduct research in your school. This research, part of my master's study at the University of Pretoria, revolves around science teaching of a high performing teacher in an under resourced school. In order to complete my research I need to visit your school on a regular basis over the next few weeks. I need information on a teacher teaching science in a large under resourced science class. Mrs. ……………. has gracefully agreed to assist me in this regard.

In order to gain information the following will have to be done:
A questionnaire to be completed by the principal.
A questionnaire to be completed by the teacher.
An interview conducted with the teacher to clarify information from the questionnaire.
Observations (10) of the teacher in class. Together with the teacher an observation schedule will be compiled.
Occasional pre- and post observation interviews with the teacher.
A questionnaire on the resources at the school (especially concerning science) - to be completed by the head of the science department.
An interview with a group of learners (10) who are taught by the teacher. The interview protocol (questions) will be provided.
Informal discussions with you, your staff and someone from the community.

I undertake to maintain confidentiality and that neither the school nor the teacher or any one involved in my research will be identified, and, will be free to withdraw at any time.

In line with departmental regulations letters of consent will be sent to the parents of the sampled learners (10).

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I will appreciate your assistance in this regard.

Yours sincerely,

E. S. Randall
(Researcher)

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Appendix I: LETTER OF CONSENT TO PARENT.

University of Pretoria

Groenkloof Campus, Pretoria 0002
Republic of South Africa
Tel: +27 12 420-5685
Fax: +27 12 420-5621
http://www.up.ac.za

FACULTY OF EDUCATION

12 September 2006

Dear Parent / Guardian

Your child has been selected as part of a group of learners with whom I wish to hold an interview. The interview is necessary for completing my master's study at the University of Pretoria. My research revolves around science teaching of a high performing teacher in school that fits the profile of my research.

The purpose of the interview will be to gain information from the learners on how they perceive their science teaching.

I undertake to maintain confidentiality and that neither the name of your child, nor the name of the school or the teacher or any one involved in my research will be identifiable. Your child will be free to withdraw at any time.

I will appreciate your permission to allow your child to be part of the group of learners who will be interviewed.

Yours sincerely,

____

E. S. Randall

Please sign below as a token of your agreement that your child may be part of the group.

I, ____ (parent / guardian), of

__________________________________ (name of learner), hereby give my consent that my child may be part of a group of learners that will be interviewed by Mrs. E. S. Randall (ID.: 5511160006087).

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(Signature)	(ID. Number)	(Date)

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ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF PRETORIA

FACULTY OF EDUCATION

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	**CLEARANCE NUMBER : SM06/11/01**
DEGREE AND PROJECT	M.Ed (Science and Technology) Teacher development in the context of teaching large under resourced science classes - a case study of a successful teacher
INVESTIGATOR(S)	Me Elizabeth Randall - 7323328
DEPARTMENT	Science, Mathematics and Technology Education
DATE CONSIDERED	22 January 2007
DECISION OF THE COMMITTEE	APPROVED

This ethical clearance is valid for a period of 2 years from the date of consideration after which the application must be renewed.

CHAIRPERSON OF ETHICS COMMITTEE	Dr S Human-Vogel
DATE	10 April 2007
CC	Prof GOM Onwu Mrs Jeannie Beukes

This ethical clearance certificate is issued subject to the following conditions:

1. A signed personal declaration of responsibility
2. If the research question changes significantly so as to alter the nature of the study, a new application for ethical clearance must be submitted
3. It remains the students' responsibility to ensure that all the necessary forms for informed consent are kept for future queries.

Please quote the clearance number in all enquiries.

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Appendix G: PERMISSION FROM THE DEPARTMENT OF EDUCATION

3-'07 13:34 FROM- T-917 P02/03 U-690

UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Date:	**05 March 2007**
Name of Researcher:	**Randall Elizabeth Sylvia**
Address of Researcher:	**213 Hugh McKinnel Street**
	Constantia Park
	0010
Telephone Number:	**0124205685**
Fax Number:	**0124205621**
Research Topic:	**Teacher development in the context of teaching large under-resourced science classes – case studies of two successful teachers**
Number and type of schools:	**2 Secondary Schools**
District/s/HO	**Gauteng North and Tshwane South**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*

4. *A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Senior Manager (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher must supply the Senior Manager: Strategic Policy Development, Management & Research Coordination with one Hard Cover bound and one Ring bound copy of the final, approved research report. The researcher would also provide the said manager with an electronic copy of the research abstract/summary and/or annotation.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Senior Manager concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

ACTING CHIEF DIRECTOR: OFSTED

The contents of this letter has been read and understood by the researcher.	
Signature of Researcher:	Randall.
Date:	06-03-07