TEACHING PHYSICAL SCIENCE IN RURAL (UNDER-RESOURCED) SECONDARY SCHOOLS

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All the work for this thesis was completed and submitted in partial fulfillment of the requirements for the Degree of Master of Education at the (former) University of Durban~Westville, in the Faculty of Humanities, School of Educational Studies.

DECLARATION

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I, **Kgomotso Legari,** hereby declare that this dissertation, submitted to the (former) University of Durban~Westville, in partial fulfillment of the requirements for the degree of Master of Education, represents my original work, and has not been previously submitted to this or any other university.

Signed: ____________________

Date: ______/_______/_______

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Abstract

The study provides a closer look at Physical Science teachers in the rural secondary schools (of the Bafokeng area). It puts focus on the different teaching methods that they use in order to overcome the realities of teaching in an under-resourced environment. This includes different aspects that affect the teaching and learning process, both directly and indirectly.

In view of the above, the study displays the necessity and roles that different stakeholders have to play. For instance, the contribution of NGOs/ companies towards the development of teachers and school learning areas. The need for parental involvement in their children's learning process has also been highlighted.

In the midst of having problems with resources, and learners from disadvantaged backgrounds, this study enlightens that " by going an extra mile, teachers can make a difference in the (disadvantaged) teaching environment, as well as to the lives of learners. Teachers in this study do not use any unknown special methods to deal with their situation. They do what they feel has to be done in order to continue with what is expected of them.

The study has not managed to link any direct negative impact between class size and learning, since the school which had most learners in Physical Science, seemed to have being doing well under similar conditions as others. Also highlighted, is the importance of the relationship amongst Physical Science teachers themselves. Since most of the schools in this study did not have enough materials for teaching Physical Science/Chemistry, building relations with other teachers from different schools seemed worthwhile.

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CHAPTER 1

1. INTRODUCTION TO THE STUDY

1.1 Introduction

"Everything connected with education apart from the students has been in short supply, schools, classrooms, teachers, teaching materials, ...indeed everything needed for the proper education of the youths is in short supply," Ukeje (1986 cited by Akinmade, 1999)

The teaching of Physical Science in secondary schools takes place in different methods. The key difference is determined partly by the school environment, which the teachers find themselves in. In light of this, most researchers who deal with issues concerning the lack of resources in the schools mainly invest their energies on investigating about the lack of sufficient apparatus, large classes, teacher qualifications, as well as extremely under-resourced school context, such as lack of water, electricity and sanitation. In most instances, focus is put on the above to such an extent that the conditions outside the schools, and in the surrounding communities end up not getting enough attention, as they may have direct and indirect influence towards what's taking place in the schools.

In South Africa, different research areas in education have established that most schools are under-resourced, especially when looking at Physical Science as an area for teaching and learning. For example, the Third International Mathematics and Science Study published by the HSRC (2002) outlines that about half of the schools researched felt that instruction in mathematics and science was hampered by a shortage of materials and facilities. The majority of schools that offer mathematics and science have a serious problem with regard to facilities such as laboratories and equipment to promote effective teaching. (DoE, 2001). Sewell and Burger (1998) also assert that we, in South Africa, have acknowledged that resources are a problem for Science Education. The foundation for this kind of situation has arisen from grave inequalities of access in the provision of services and opportunities between black and white schools during the apartheid era in South Africa (ICT Focus, 2002). It is also asserts that before 1994, more than ninety percent of the state's education budget went to "white" education. The other groups ("Coloured", "Asian", and "Black") had to share the remaining ten percent (ICT Focus, 2002). Amongst them all, black schools always constituted the majority of the student population.

The low numbers of mathematics and science educators also pose as a problem, as this affects the human resource negatively. The National Strategy for Mathematics, Science and Technology (DoE, 2001) shows that there is a very low number of Grade 12 learners who choose the teaching of Maths and Science as their career. So, schools may be under-resourced also due to lack of qualified teachers, or because they may have few teachers for Mathematics and Science.

Part of the basis for argument in this study is to look at conditions that affect the communities surrounding the schools in the rural areas. In terms of literature, this is not as much available as the research that focuses on the school conditions alone. It seems common that when research is conducted on poor communities as well as the schools thereof, the two are usually not well fused. Focus would be on either one of them, while the other would get little attention. Some of the studies in South Africa that were able to merge the issues of poor communities with school education very well, were conducted through the Nedlac Summit (1999), as well as by a group of researchers, consisting of Malcolm, Keane, Hoohlo, Kgaka, and Ovens (2000). The Nedlac Summit (1999), which commissioned a report on the Challenges Facing Public Education highlighted points that looked at schools, especially those in rural areas, that are characterized by lack of resources and poor communities (further aggravated by a generally low morale amongst the teachers). The latter study by Malcolm et al, on the other hand, dealt with the issues of 'working together towards enhancing successful schooling' in poor communities.

Whether schools have enough resources or not, Physical Science is not one of the easiest learning areas to teach. For instance, over the past years, the pass rate of Mathematics and

Physical Science matriculants has been very low (DoE, 2001). Beyond resources and conditions in the schools and their communities, teachers are often looked to by other stakeholders as the ones who can enable a suitable atmosphere and programme for the teaching and learning process to take place. In light of this, teachers in rural schools often find themselves caught up with multiple roles apart from those that are directly related to teaching in the classroom. Such roles are those of trying to meet the demands of (science) teaching and learning, while having a burden of other responsibilities that are imposed to them by the school and learners from different family backgrounds.

1.2 Rationale for the study

The Human Sciences Research Council's TIMSS study (HSRC, 2002), asserts that one of the first actions of the 1994 government was to release a national teacher audit report, which amongst other issues, highlighted the extent and size of the country's expenditure on teachers' salaries.

The same study also outlined that more than 95% of the Department of Education's budget was being spent on teachers' salaries (HSRC, 2002). This meant that until recently, there has been insufficient money for resources such as textbooks, equipment and new facilities. As a result, teachers were retrenched and redeployed. Other teachers left the teaching profession, including well-educated and experienced teachers in critical areas such as mathematics and science (HSRC, 2002). This as a result leaves the remaining teachers with unending challenges of having to cater for the process of teaching and learning. This also becomes aggravated in the rural areas when there are other problems such as: the communities surrounding the schools in the rural areas being poor, and the lack of parental or stakeholder support (for both the schools and the learners), as well as the different family backgrounds which learners come from.

Based on the above, the rationale of this study is an attempt to show that the issue of under-resourced schools goes beyond materials and resources that some of the schools in the rural areas always run short of. In other words, it extends beyond the classroom teaching towards the profiles of the communities surrounding the schools. In this context, the rationale of the study is centered around the fact that there are (other) complicated situations that teachers in the rural secondary schools have to face in order to enhance teaching and learning. This includes some of the challenges that always arise due to the gaps that exist between the learners' school lives and their home lives, especially when they come from poor family backgrounds. Here, the differences in family backgrounds is looked at as one of the major determinants for teachers to extend their duties in order to try to make sure that learners who come from poor families also acquire their learning like all the others. The reason for looking specifically at Physical Science in this study is not to overlook other learning areas, but because science on its own seems to be more of a demanding learning area than others.

1.3 Focus and Purpose of the Study

This study focuses on the other side of teaching and learning – that is working in an under-resourced educational environment. In addition to what has been outlined above, the study looks at the different methods that Physical Science teachers in the under-resourced secondary schools employ in response to the demands that they face. In a way, it seems that such demands have become part of their normal working lives. In the study, the geographical area of focus is secondary schools in the Bafokeng area, near Rustenburg, in the North West region of South Africa. The Bafokeng secondary schools were chosen as they are located in a single district, where class sizes usually differ and resources are often inadequate. The performance of learners also differs in the district according to individual schools, ranging from high to low pass rate at Matric level. This provided an opportunity to work with Physical Science teachers in schools with varying levels of performance.

The teaching and learning of Physical Science as a learning area requires a consideration of appropriate techniques, methodologies as well as environment, which may be used to enhance learning. According to Kumar (1999), the following resources are required for the development of science education: suitable textbooks, materials-equipment, chemicals, and science research. As well, one of the strategic objectives of the

Implementation Plan for Tirisano (DoE, 2001-2002) clearly states that there is a need to empower mathematics and science educators with content and pedagogic skills.

Recent history in South Africa has created problems in the education sector. As a result of an unequal education, particularly in science, there is a general lack of science literacy and awareness (Rijsdijk, 1997). The importance of the scientific issues in our daily lives and the national economy demands a population which has sufficient knowledge and understanding to follow science and scientific activities in order to understand the environment in which we live.

Attention must also be paid to teacher education in order to expose teachers to current and ever-changing science curriculum needs (DoE, 2001-2002).

By now it is clear this study is multi-dimensional. It ranges from concerns for 'resources' in the particular sense of laboratory equipment and related facilities, the usage of resources which the schools may have, and learner participation in the classroom activities through to the conditions in the community. The different schools in the study may have science laboratories, and the very same schools may not have (most of) the relevant chemicals as well as other types of science equipment to run scientific tests and experiments. Such problems in the schools may sometimes be increased by other matters such as the lack of proper security and as a result, they are subjected to vandalism (Nedlac, 1999).

As conditions in the schools and surrounding the schools may differ, teachers themselves become significant in the educational resource structure; their unique roles and practices become a central part of what the outcome of this study will be. A study by Ogunniyi (1999) highlights the necessity of providing proper training of science and mathematics teachers. Perhaps educators must also be empowered with the necessary life-skills that may be of importance towards catering for learners from different family backgrounds, with different needs.

According to Ogunniyi (1999), there is a demand for more science teachers in South Africa, due to varying levels of learner enrolments in the schools, especially in areas which were former homelands. Under such conditions, lack of enough teachers may lead to difficulties for those who are already in service, especially due to other demands that have been mentioned above. At the end of the day, it is not simply the teachers' fault or learners' fault for the situation to turn out in this manner, it is largely a matter of the situation or environment in which they find themselves.

The issue of being 'under-resourced' is multi-dimensional: in a different context, a school may have lots of resources, but such resources may not be in line with the current day curricula. For all of the above, there are different explanations. Schools may have their individual situations when it comes to teaching, but most of the above-mentioned contexts may apply because there is still a lot that needs to be done in South Africa's education and society.

In this study each selected school will be looked at in its own unique context, in order to avoid over-generalizing at early stages of the study. It will center on the strategies that Physical Science teachers apply in their day to day teaching and learning process while being affected by other issues that may become obstacles towards the process of teaching and learning. In this regard, the key components are the coping strategies that teachers have developed, in order to deal with situational constraints. It seems that the coping strategies can become ingrained in the teachers' patterns of practice (Clark, 1999), and become an integral part of their survival. In this regard, teachers' knowledge of how learners' backgrounds affect their general performance is also important.

The end-goal of this study is to be of help to teachers in general, especially the science teachers who battle with the performance of learners who come from poor family backgrounds in rural villages.

In its report, the Department of Education (2001) asserted that the improvement of learner achievement in science and mathematics is largely dependent on competent teaching. This is true in most instances, but does not necessarily serve as a guarantee that teacher commitment will lead to high learner achievement.

1.4 Critical Questions

The study aims to answer the following critical questions:

- How do physical science teachers in rural secondary schools define 'under-resourced' in their schools?
- How do Physical Science teachers in rural secondary schools deal with an under-resourced teaching environment?
- What beliefs do such teachers have about effective Physical Science teaching and learning, in these contexts?

1.5 A Brief Overview of the Study

The remaining sections of the study will focus on aspects such as: literature review, research method and analysis, and findings of the study based on the data obtained.

1.5.1 Literature Review

The literature review looks at how different studies describe the state of resources in the teaching of mathematics and science in South Africa, and ways that such obstacles might be overcome. It explores research into effective schooling, highlights the importance of teachers, and looks at the profiles of communities against the role that is played in the schools.

This section also considers, from the research literature, possible methods that teachers might use to enhance effective learning, and their suitability to schools in the non-rich areas. In terms of learner performance, some schools have a lower pass rate, while others perform very well under similar conditions. A clear evidence was highlighted in a study conducted by Malcolm, Keane, Hoohlo, Kgaka, and Ovens (2000), but their study focused on extremely under-resourced schools in a poverty stricken community. It has shown that there are schools that do exceptionally well in mathematics and science under harsh conditions. And the major contribution to this was played by the level of co-operation amongst the stakeholders:

> "*In the townships and rural areas of South Africa, there are some schools who do remarkably well at producing matriculants in Science and Mathematics... The schools achieve their success in spite of the poverty around them, and often appalling lack of facilities and resources. They achieve success when other schools in their neighbourhoods do not. Our primary task was to explore why the students in these schools are so successful."(Malcolm et al, 2000)."*

1.5.2 Research method and design

The sample for this study consists of Physical Science teachers, males and females, whose teaching has been based in rural schools for some time. The research has a number of components: assessment of the resources available in the schools, general descriptions of the schools and their communities, descriptions of the teachers, interviews with teachers, questionnaires which teachers completed, and observations of classrooms and their surroundings. The design of the research, its theoretical framework, and the design of instruments are described in detail. As already mentioned above, for the sake of fairness, the study has attempted by all means to look at an area that has got schools with an unbiased level of academic performance. Also highlighted is the importance of outside help, such as teacher training and development workshops, organized by different companies and NGOs.

Another important point that receives more focus in this section is the level of commitment that teachers display in their teaching. This in other words, looks more at the creative techniques that they come up with, different personal sacrifices and contributions, and the extra miles that teachers often go in order to cope with the situations in their schools.

1.5.3 Analysis

An analysis of the study puts focus on different aspects such as the participants' profiles, their teaching experiences, how they feel about the environments in which they work in, experiences with the learners, support from the stakeholders. Details of the analysis will unfold in chapter three.

1.5.4 Conclusion

The rationale and purpose of the study attempted to explain that the study is not just centered around the lack of some resources in the rural secondary schools; it tried to understand the meaning of under-resourced as going beyond the immediate curricular needs. In other words, it explored how the surrounding communities affect the ways in which teaching and learning take place. It also reports on the alternative methods that teachers use in such a situation. The findings are summarized and brought together in the Conclusions chapter.

CHAPTER 2

2. LITERATURE REVIEW

2.1 Introduction

Before 1994, vast disparities existed between blacks and whites in accessing educational opportunities. The extent of exclusion for blacks was much greater in the learning and teaching of mathematics and science (Department of Education, 2001). Even up to this day, the conditions in most of the so-called "black rural schools" are much the same. One of the reasons is that the pace of educational development in South Africa is not as fast as most people wanted or expected. Due to the effects of apartheid, schools in the rural areas, as well as their communities, are usually the ones who are more affected. Engineering of educational policies along the lines of ethnicity and language within "homelands" was preceded by poorly managed authorities, who had been tasked with providing education for disempowerment (Naidoo, 1997).

Since 1994, the Department of Education has developed policies and legislations such as the South African Schools Act no. 84 of 1996, Curriculum 2005 and Whole School Evaluation which aimed at transforming the education system. The emphasis of these policies and legislation is on achieving equitable access to education, improving the quality of provision, encouraging the involvement of different stakeholders (especially learners and parents) in the running of school matters (Potgieter, Visser, van der Bank, Mothata, Squelch (1997) and Mathonzi (2001). While policies have changed, and much has been done, the general pass rate for Grade 12 learners in rural areas, for example, has remained low, especially in mathematics and science (DoE 2001).

This chapter reviews how different researchers through their literature, provide insights into the situations experienced by teachers in under-resourced schools. This encompasses their ways of dealing with different under-resourced environments. It begins by looking at teachers as a human resource in the field of teaching, especially science. Then it looks at different ways of defining resources in general. Another aspect reviewed in this chapter is the science teachers' alternative teaching methods when finding themselves without adequate resources. And importantly, it reviews research on constituents of successful teaching and learning.

2.2 A Brief Look at the *(South)* African Situation.

2.2.1 The State of Science Teachers

Human resource serves as one of the most vital parties in the driving of any process, including the education system. In this case, reference is made to Physical science teachers, because they serve as the actual human resource factor as far as teaching in this area of learning is concerned. Just as Sewell and Buirski-Burger (1998) affirmed, the role played by resources includes better-qualified teachers. A challenge can also be put onto the roles played by the communities in process of educating the learners in the schools, because teachers cannot be expected to be the "know it all, and do it all". According to the Department of Education (2001), the low level of output due to differing aspects (including the society as one aspect) has a direct impact on the capacity of the system to produce qualified educators and learners in mathematics and science.

A report published by EduSource in 1997 found that most of mathematics and science educators were not qualified to teach these subjects (DoE, 2000). Out of 84% of science educators who were found to be professionally qualified, only 42% were qualified in science. An estimated 8000 mathematics and 8200 science educators needed to be targeted for in-service training to address the lack of subject knowledge. The lack of proper content knowledge in particular, leaves teachers poorly prepared to teach their learners (TIMSS, 2002). In the past few years, it was also found that over 45% of General science teachers and almost 40% of Physical science teachers had less than two years' experience teaching their subjects (South African Institute of Race Relations, 1997/1998, cited by DoE, 2001).

One of the major roles played by teachers is that they influence the development of learners' knowledge and attitudes towards science more than most other stakeholders. Unfortunately it has turned out that most of the learners who perform well in science find it less attractive to choose teaching as a career, and therefore opt to further their studies in other science-related fields (DoE, 2001). Bencze (2000) also states that: "in many parts of the world, school science, especially at the secondary school level, is a sort of selection and training camp for future scientists and engineers." As a result, few students enter teacher-training programmes in mathematics and science. But even more broadly, South Africa has significantly fewer science and engineering graduates, as well as scientists (Fredericks, 1999).

According to the Department of Education (2001), many studies suggest that more qualified and experienced mathematics and science educators are associated with higher levels of learner achievement. But that need not be the case, since teachers' qualifications may be only one part of a bigger challenge in the schools being considered. Instead, the learners' performance in these schools varies between high and low pass rates despite the schools' generally similar conditions and backgrounds.

2.2.1.1 Comparing South African Teachers with other Developing Countries

The problem of lack of qualified science and mathematics teachers does not only exist in South Africa; other African countries also experience it (DoE, 2001). This is confirmed by Caillods, Gottelmann-Duret and Lewin (1997) when they explained that many African countries suffered from a serious shortage of mathematics and science teachers.
Brown-Acquaye (2001:70) on the other hand reveals that "most science educators in Africa were educated in Europe, the USA and Canada, and they seem to know more of Western Modern Science than their own respective Indigenous Sciences". This raises questions about the range of knowledge that an African science teacher needs, and what constitutes 'qualification'.

2.2.2 Education and HIV/AIDS

The problem of resources is magnified by the HIV/AIDS pandemic. The report on HIV/AIDS by Nedlac (1999) points to HIV/AIDS as the most critical challenge that threatens the workforce of South Africa and its neighboring countries. Teachers form one of the bigger portions of the workforce in this case.

The cost of HIV/AIDS to the workforce is astronomical. It mainly arises from absenteeism from work due to illness, and as a result, increased scarcity of workers (Nedlac, 1999). Science education in this regard may be affected most, as it consists of fewer educators in the country, and as science graduates are increasingly in demand to fill vacancies in industry and other jobs. HIV/AIDS is not only incurable, but it is an epidemic of discrimination and prejudice in the workplace. Not much has been done in the education sector yet to give more attention to HIV-positive educators in our country. As Mabuya notes (Sibanda, 2002), workers need medical, spiritual and material support when they are HIV-positive. HIV/AIDS is increasing especially in poor communities, especially in the black, rural parts of the South African society. HIV/AIDS affects mostly teenagers and middle-aged members of these communities. Many learners end up being away from school, and many learners end up being without parents and siblings. Morale falls, and competing demands on resources increase.

2.2.3 School Management and Parental support

Coming back to the school context, Caillods et al (1997) found that it was quite common in many African countries that head teachers did not have a science background. The role of many principals was found to be more administrative, with little direct involvement and concern for classroom activity, thus making decisions for science just like all the other subjects. This does not mean that the heads cannot exercise leadership in science education, but they must receive appropriate training, and make effective use of their teachers. Science teachers must have a role to play in the management process. Within any school, management structures and management skills must allow proper development of science teaching, and appropriate support for it.

It has also been evident that some schools have a low rate of parental involvement in the teaching and learning processes. There are different assumptions about lack of support from parents, especially in the rural schools. Some of the reasons are that parents lack confidence of being actively involved in their children's education, since they themselves did not receive proper formal education. Epstein (1990) and Rich (1993) as cited by Pena (2000) explain that some parents choose not to participate or cannot participate in school-family relationships because of their limited education. Another factor that makes some parents not to be able to participate in their children's education is the migrant labour system, by which fathers and perhaps mothers too move away from their homes in order to find work. This has affected the family setups of many rural households (McDaniel and Zulu, 1996). A third one is that, if parents are too poor, they cannot afford to buy uniforms, books, even food for their children and so cannot provide this practical support either.

2.2.4 Curricula Problems

Aubusson and Watson (1999) maintain that curricula and associated teaching methods (although perhaps well founded in theory, pedagogy, and empirical research) often have difficulties when implemented across the nation. Such difficulties may be exacerbated when the curricula and teaching approaches are imported or transferred from developed to developing countries (Aspin, 1993, Sarre, 1995 and Watson, 1994 cited in Aubusson and Watson, 1999). This may be a particular issue in the public schools in developing countries, because those schools are not well-resourced. South Africa's current curriculum policies, such as Curriculum 2005 (DoE 1997, 2002) and the draft FET curriculum (DoE, 2003) make new demands on schools and teachers, based on ideas that have been largely developed overseas.

Halse, Ismail, Jaleel, Akhmeema & Ahmed (1996, as cited by Aubusson and Watson, 1999) assert that the globalization of education was intended to widen access to education, raise the quality and support mobility of ideas in teaching, learning, and curriculum. Pinar et al. (1995 also cited by Aubusson and Watson, 1999) on the other hand state that globalization of education has resulted in cultural imperialism, as new curricular in developing countries are often based on existing curricula in developed countries. And resources such as text and apparatus are imported from large companies usually based in developed countries such as Britain, the U.S., Germany and France.

Thus, Aubusson and Watson (1999) maintain that importing of curriculum is likely to result in a curriculum that poorly fits the current educational environment in developing countries. Communities in the rural parts of South Africa may be further isolated from their children's learning of science since the curriculum may sound foreign to them (because it tends to be oriented to urban life and experiences). And they may be unable to link what their children learn in the schools with the experiences in their daily lives.

2.2.5 Resources

2.2.5.1 Laboratories and Specialized facilities/equipment

According to the Department of Education (2001), the majority of schools that offer mathematics and science in South Africa have a serious problem with regard to facilities and equipment to promote effective learning and teaching. The DoE (2001) has also made it clear that good mathematics and science teaching is expensive, and the necessary resources (qualified competent educators, well-resourced laboratories and libraries) are scarce. Without resources, the teaching of science remains at a theoretical or book level without experiments to enhance understanding and application of knowledge. Teachers may well believe that the teaching and learning of science should be student centered, and students should be engaged in hands-on activities (Levitt, 2002), but resources and time are limiting factors. There is also an issue of equity: students and teachers that have access to resources have a different kind of education from those who don't.

The lack of equipment prevents teaching with an emphasis on practical activities. Even where there are a sufficient number of laboratories and enough equipment, maintenance can be a major problem. Few developing countries have laboratories assistants (Caillods et al, 1997). In South Africa, few schools have laboratory assistants. Most teachers have not had any form of training to carry out laboratory maintenance, or even purchase and supply of equipment and chemicals.

The argument in this study is not simply about levels of resources, but unique ways that science teachers come up with, given the generally poor and similar conditions that they find themselves in. One example can be seen from a study by Levitt (2002), one teacher, representing a group of others, expressed a belief that the reason to change from non-hands-on to hands-on programmes was that students would get to be more involved; they could do something for themselves and reap the benefits right there.

While this requires laboratories and equipment or perhaps kits, other approaches are possible, such as improvisation of equipment or learners bringing equipment from home.

2.2.5.2 Textbooks

Caillods et al (1997) highlight various issues about textbooks, including their availability, cost, quality and relevance. In some developing countries, the majority of science textbooks are imported. This has been the case for many years, particularly in African countries. Because of high costs, learners and school libraries in rural areas face a problem in terms of affordability. While the government provides some textbooks, the distribution process adds to the problems schools face.

In most of African countries, learners do no have adequate access to textbooks in science as well as other subjects (Caillods et al 1997). For example, in a research made in Kenya, where a significant proportion of learners could not afford to buy textbooks, teachers ended up writing the content of lessons on the board and learners spent most of their time in class copying all that. Similar research showed that in Mexico and Chile, learners in rural and marginal urban areas often did not have textbooks. In these cases, teachers were known to photocopy their notes and sell them at a price to their learners (Caillod et al 1997). This leads us to further question what creative strategies teachers in this study can come up with in order to overcome such hurdles.

2.2.6 Class Size.

A larger class size is sometimes considered to be a major stumbling block to the practicing of regular group activity and learner-centered science (Caillods et al, 1997). Their study revealed that the average number of learners per class varied a great deal from country to country, with most African countries at the highest rate.

Onwu (1999) looks at large, under-resourced classes as a major constraint that "limits" effective science teaching in Africa's sub Saharan countries. Even though this might be the case, most research studies on class size fail to identify learning achievement differences related to the number of learners in the class.

Sometimes the schools with smallest classes have the poorest results, because they tend to be remote rural schools. Having a small number of learners does not necessarily mean that the teaching process is of high quality; conversely, a large number does not necessarily mean that teaching is ineffective (Caillods et al 1997).

According to Naidoo and Savage (1998) most African countries have a reality of large and poorly resourced classes. Under such circumstances, the burning question that Naidoo and Savage pose is to "whether there is a relationship between large classes and outcome measures such as pupil achievement and teacher satisfaction?" (1998:122).

2.2.6.1 Classroom size and outcome measures.

A study by Naidoo and Savage (1998) informs that teachers swear by the benefits of small classes. Policy makers and administrators on the other hand focus on the higher costs involved, demanding that smaller classes be justified on the basis of increased pupil achievement (Smith and Glass, 1979, cited by Naidoo and Savage, 1998). The research has been unable to clearly resolve the problem of learner achievement. While some studies have shown that pupils mostly do better in smaller classes, other studies suggest that large classes are more effective, given the appropriate methods (Mock and Harbison, 1987; Hanushek, 1986, cited by Naidoo and Savage, 1998:122). Perhaps this reference to 'appropriate methods' is the key: if, for example, teachers teach small classes as though they are big classes, differences in achievement might be small. But, as noted earlier, there are other variables that are important, such as poverty levels, location and school management: achievement is not only about teaching methods and class sizes.

The outcomes that define achievement are also important. Naidoo and Savage suggest that class size and science laboratories may be irrelevant to pupil performance in rote-memory examinations, but may affect performance in examinations that asses higher order thinking skills. Class sizes may affect pupil achievement through intervening variables, such as teacher support services, pupil attitudes and classroom environment.

During a survey conducted by the University of Ibadan in Nigeria, on primary and secondary science teachers to determine their views on teaching large classes, some of the interesting responses were that, when teaching large classes:

> *"It is more difficult for teachers to do practical work and to give pupils individual attention...pupils are not actively involved and become easily distracted... teacher-centered teaching is encouraged, restricting the range of teaching and assessment strategies and making it difficult to identify pupils' learning difficulties or needs; there are heavier demands on facilities and instructional materials... science is an experimental subject – without hands on activities which large classes do not allow – one cannot be said to be doing science...."*
>
> Adapted from Naidoo and Savage (1998:126).

A related study by Ndukwe (1995) compared the achievements of senior secondary pupils in laboratory classes of 30 and 100. Pupils in the smaller classes performed significantly better. Differences were attributed to a shortage of instructional materials and facilities in larger classes and the inability of teachers to respond to individual needs.

Naidoo and Savage (1998) also highlight the ways in which class size affects teachers. In smaller classes, their morale becomes better. There are more opportunities for teachers to innovate and adapt learning programmes to the needs of individual pupils. However, even though some classes have low numbers of learners, some teachers continue to use traditional methods.

The argument in this study is not whether large or small classes are good, but whether there are suitable ways to promote teaching in such classes. Naidoo and Savage pose the following questions: How can science teachers in such classes maintain a conducive learning environment that promotes pupil activity, that provides opportunities for first-hand experiences, that challenges pupils to ask questions and initiate the learning process, and use local resources to overcome infrastructural constraints?

2.2.7 Lack of Support from the Society

According to Mathonzi (2001), in many schools, principals and School Governing Bodies are struggling with poor resources, and absence of a culture of teaching and learning. Even if the communities around the rural schools are willing to make active contributions, they themselves are the victims of poor education, unemployment and general poverty. It is indeed problematic to compare physical indicators with social indicators in rural areas. For instance, the argument in this case is that the construction of new schools in rural areas does not in a way change the profile of the community, and may have limited impact on educational achievement (Mathonzi, 2001).

2.3 *What is suggested to determine* **Effective Schools** *(and teaching).*

2.3.1 Teacher Support and Development

According to Rojo and Martinez (1991, as cited by Caillods et al, 1997), schools judged to be effective have a coherence between the school and teachers, achieved through management and participation. Malcolm et al (2000) provide instances of how this can be achieved, even in very poor communities and schools. Providing adequate support systems to teachers, learners and communities – within the school and outside it - enhances educational effectiveness.

Opportunities for professional development for teachers arise within schools, but need also to include outside workshops for teacher development. Rijsdijk (1997) informs of the aim of workshops as being, in part, to try to establish awareness of the environment on a larger scale. These workshops should be seen as an integral part of teaching and not merely as an interesting interlude in the routine. They are designed to encourage skills, thus enhancing a sense of curiosity, and build knowledge and networks. Looking specifically at the South African context, the president of SADTU, in 1999 raised a concern that by then there had been little attempt on the side of the government as the employer to develop a policy on teacher development and the provision of relevant in-service training for teachers. SADTU believed that the development of co-ordinated national policy on teacher upgrading and retraining was essential to public education transformation and efficient human resources (Nedlac, 1999). Much has been done by the Department of Education since then, including programmes to upgrade teachers' qualifications, and the restructuring of higher education as a major provider. Teacher development is especially important as part of devolution of curriculum to schools: the philosophy of the South African Schools Act is that schools are encouraged to become self-managed, and in future schools will be judged on how well they deliver quality education to learners (Mathonzi, 2001).

During the launch of the National Strategy for Science, Mathematics and Technology Education in 2001, the Minister of Education, Professor Kader Asmal said that:

> *"One area we need to concentrate on is teacher development. A three-year programme for the professional upgrading of 30 000 educators will begin in July 2001…Financial aid to the tune of R90 million will be made available for this purpose from funds set aside for the under-qualified educators by the Education Labour Institutionalized during 2000…*
>
> *In addition, under the new immigration policy, we like other countries, shall seek to attract people whose skills we need, be they technologists, doctors or educators…These trainers will not take away jobs: after all there is a critical shortage of subject support staff at district level…Cuba, after all, is a leader in biotechnology, which position they have attained on the base of quality science and mathematics that their schools provide…"*

The role of Non-government organizations should be recognized. These NGOs target schools for development in areas such as in-service teacher training, materials and curriculum development (Link Community Development, 2002). Role players in science and mathematics such as NGOs and other national and international funding and enabling agencies have an important task to play (Kuiper and Taole, 1999).

2.3.1.2 Increasing and Enhancing *(teacher)* Human Resource capacity.

The Department of Education (2001) suggests that improvement in science largely depends on the competence of science educators. George and Kaplan (1998) also acknowledge that the quality of teaching is determined by the teacher's overall performance and practices. Other researchers emphasize the relative influences of the teacher as well as learning environment on student attitudes. As outlined above, the Department of Education (2001) addresses issues concerning the ongoing professional development of in-service educators as well as preparations for new educators. It highlights the need for programmes that can equip educators with competencies to teach at all levels of schooling, as it is the case that in some under-resourced secondary schools it is common for teachers to teach across the board without any assurance of the skills to do so. Higher education institutions as well as the non-governmental organizations are encouraged to play active roles in improving the knowledge and skills of educators. They have to develop new programmes for educator preparation, strengthening subject matter and pedagogical content knowledge. Mastery of content knowledge and good classroom practice would enhance the confidence of educators.

The following is an example that symbolizes how educator commitment, co-operation from the learners, and support from the community can outweigh the worst of resource situations:

"No electricity, no water, no textbooks, no excuses, just success."

(Pretorius, 2001)

Pretorius (2001) outlined a story about Sandi Senior Secondary School in a hillside rural area located in the Eastern Cape, east of Umtata. The school has experienced an incredible increase in matric pass rate that went from 3.3% to 93% in just three years. Yet Sandi Senior Secondary School does not have electricity, telephones, running water, laboratory, its buildings are crumbling, and they had only one mathematics and science textbooks until the year 2001. The staff of the school is very supportive towards the learners, especially their young principal, Mr. Bongi Peyana who is still in his mid-twenties, as well as mathematics and science teacher, Mr. Les Makhonza. In the year 2000 all 66 Grade 12 learners passed in standard grade, and 59 passed in higher-grade science. Mr. Makhonza said that the relationship between the teachers and learners made him to stay at the school. This mathematics and science teacher said that there is nothing *special that he does, except for describing every chemical reaction and physical law step-by-step, painting a picture that sticks in his learners' minds.*

In this school, teachers and learners sacrifice some of their afternoons, weekends and holidays to further their learning process. Pretorius also explains the role of parents. He said that they played a very significant role because in 1996 they, together with the learners, pestered the then school principal on introducing mathematics and science subjects.

Looking deeply at the above outline, it is obvious that traditional methods of teaching are still being used. In this case, this might be mainly due to the existing circumstances. The school does not have resource materials, and the socio-economic status of the surrounding community is very low. However, these conditions did not discourage the teachers and learners to try their best. The situation also did not hinder parental involvement in the teaching and learning process. No one was discouraged by what used to previously happen. In short, lack of resources has not been highlighted as a constraint towards success, but creativity and dedication from the stakeholders paved the way for better outcomes.

The teacher must also encourage the learners to develop an attitude to exhibit the skills of improvising apparatus, models, or whatever limited resources that may be available (bearing in mind that the teacher as well as every stakeholder is a resource). This goes hand in hand with the development of interest of self-help, self-reliance, and teamwork. Such a practice seems to be effective under different teaching/learning conditions.

The teaching methods that teachers employ must go beyond certain limits, but in a professional way. This includes the degree to which students feel that teachers care about their learning and the extent to which the communities give support to the schools. It is also essential for educators to have the willingness to risk change.

Another example is a study by Malcolm, Keane, Hoohlo, Kgaka and Ovens (2000), which focused on the schools in South Africa that are doing remarkably well in spite of lack of resources. One of the qualities that seemed to be keeping them in that way was that there were close relations among the teachers, learners and heads. Commitment of all the parties, as well as discipline and planning were the driving forces behind their success.

2.4 Theoretical Frame for teaching, learning, and change

Learners bring to a classroom multiple discourses reflecting the communities in which they live. These can vary from a wide range of beliefs that they bring into class, to sharing the problems that they bring from their homes. Thus a classroom can be considered as a small community that practices multiple discourses associated with the teachers and learners. The problems as well as positive experiences that learners bring from home to school can lead to dynamics of education that go beyond the syllabus and the schools' physical resources. Curriculum has to create a shared language that permits those within a classroom to co-participate in activities. According to Schon (1985, cited by Tobin and Tippon, 1996), co-participation implies that the participants share a language and can understand what is happening, and that there is freedom to participate, learn, and understanding each other's problems. In these ways, learners can access the language of the teacher and there is a free flow of ideas. The implication for change is that the teacher and learners ought to have different roles and agree that changes will be beneficial for them.

2.5 Looking Forward...

The Department of Education (2001) is trying to encourage different stakeholders to be actively involved in the teaching and learning processes that take place in the schools, especially the communities surrounding the schools. Caillods et al (1997) assert that several conditions have to be met for successful teaching. There has to be suitably trained teachers, sufficient space, books and equipment, motivated learners and society, as well as appropriate curriculum design. These are not satisfied in many poorer or developing countries. Satisfying them may provide answers that can show that teachers cannot entirely succeed on their without the help of the society. Naidoo (1997) outlines the important implications of South Africa's present capacity to transform the system in the context of renewal of culture within education for the new millennium.

2.5.1 <u>The urgency to improve participation from the society.</u>

Mobilizing the community that surrounds the school as well as attracting distant bodies can be one of the more difficult tasks that a school can face. For instance, calling upon parents, educators, business people, volunteers and general citizens to take part in the improvement of participation and performance of learners can lead to little response.

The Department of Education (2001) suggested that one part of community mobilization has to include a campaign to persuade alumni of schools that were performing well in the earlier years to engage in current support programmes for their schools. It is because there might be a possibility that some, if not most of such people currently occupy key positions in the government as well as in the private sector. Their involvement could include: serving as role models to current learners; providing motivation and encouragement and making financial contributions where possible.

It is common that when there are shortages in resources as well as many other needs in the schools, the government gets highly criticized. This is in part because the government as a whole – through its economic and social programmes – can set priorities and coordinate different efforts of improvement. The private sector has shown some willingness to support the improvement of learner participation and performance in mathematics and science. Contributions have come in the supply of learning support materials as well as bursaries (DoE, 2001). This support must be encouraged. The Department of Education hopes to mobilize the public sector, private sector, and the professional organizations to develop strong network of local partnerships aimed at improving learner attainment. It is not clear how successful this will be, or who will coordinate such partnerships. One of the important aspects that seems to have generally been left out, is the issue of putting attention on family profiles, health and social support, especially for learners and communities from poor backgrounds.

2.5.2 Parental Involvement

Pena (2000) explored the need for involvement of parents in their children's education. He conducted interviews, document analyses, and observations of parent activities, which revealed that parental involvement was influenced by factors such as language, parents' education, attitudes of the school staff, and family issues. The study showed that some teachers easily accept parental participation and use it effectively to support students, while other teachers have not felt secure enough to have parents around. It is often said that parents encounter structural barriers that have kept them from participating in their children's education (Bauch, 1993; Chavkin, 1989; Kerbow and Bernhardt, 1993; Moles, 1993; Scott-Jones, 1993 cited by Pena, 2000). If included at all in school activities, working-class parents have tended to be mostly in the traditional roles of fundraisers and chaperones. George and Kaplan (1998) describe the work of researchers such as Keith and associates who seek a broader conceptualization of parental involvement, measured in terms of parental educational aspirations, and parent-child communication about schoolwork.

Notwithstanding the difficulties of achieving effective parent involvement, some studies have supported its benefits for students, parents and schools (Epstein, 1985; Henderson, 1981, 1987; Rich, 1987 cited by Pena, 2000), as well as influences on teacher efficacy (Epstein and Dauber, 1991). Pena cited Berger (1995) that one of the primary factors for children's educational success or failure is the level of parental interest and support. George and Kaplan (1998) make a similar point when they assert that parental involvement has direct as well as indirect effects on learners' science attitudes, mediated through science activities and library/museum visits. Well-implemented school-community practices yield positive results for the students, the school and the parents. According to Epstein (1987) and Henderson (1988) as cited by Pena (2000), schools that favour the involvement of parents outperform schools with little parental involvement.

2.5.3 Curricula needs and design

Up to so far, both developing countries as well as developed countries have adopted the practice of Western modern science as a major dominant science in the school curricula. This is also the case in South Africa. As a result, we have to face the demands thereof. Presently, in most developing countries, science and technology are seriously acknowledged as agents for development (Brown-Acquaye, 2001).

As part of the new South Africa, curriculum change gives strong emphasis to science and to competencies such as critical thinking and problem solving. According to Chisholm (2002), it is vital for curriculum to be designed in such a way that teachers are able to respond to new knowledge, and in interesting and challenging ways. Knowledge is not static, so the curriculum needs to be broad and flexible enough. Flexibility is central to outcomes-based education, where an active learning process is as important as content. Curriculum developers in South Africa were asked by the Department of Education not to overload the curriculum, thus leaving flexible time for teachers to facilitate different activities such as experiments, drawing on new and local resources, conduct fieldwork, and engage in a range of other activities that will supplement the minimum core to be learnt (Chisholm, 2002).

Chisholm (2002) also asserts that the curriculum has to be fleshed out by textbooks and teachers. Teachers and texts are crucial to interpret the curriculum and bring it to life in the classroom. It is necessary to leave room for teachers and text in order to ensure that innovation, creativity and resourcefulness are built into the teaching experience. The flexibility of the curriculum has to be designed in such a way that learners are able to see its meaning, and where it's heading. An example of curriculum design that negatively affects learners' minds is the one explained by Haussler and Hoffmann (2000), when they proclaim that:

> *"A student who is interested in learning something about a particular natural phenomenon or the functioning of a certain apparatus does not necessarily favor…the kind of physics that is offered in class."*

2.5.4 Using the local environment as a resource for teaching.

According to Naidoo and Savage (1998), pupils can be creative in identifying and collecting materials and resources for activities in which they are interested. Encouraging this with learners can serve as a starting point for teachers to extend their teaching and learning activities. Doing this also makes it possible for improvisation to be practical.

Unfortunately up to this time, many teachers are still unable to link resources, environments, and culture with topics in the curriculum, largely because many textbooks provide little assistance for such matters. According to UNESCO (1988, cited by Naidoo and Savage, 1998), many secondary school science teachers need help in order to see how everyday materials can provide a basis for learning. However, other countries such as Ghana might provide the way forward for the problem. For instance, the Science and Technology in Action in Ghana (STAG), a project of the University of Cape Coast, sponsored by the African Forum for Children's Literacy in Science and Technology (AFCLIST), has produced a resource book that describes technologies in Ghana. In this instance, learning materials are based on the science inherent in local industry (formal and informal) and manufacturing (Naidoo and Savage, 1998)

Looking at improvisation, the local resources can help, by representing unavailable resources that are expected in the curriculum. For instance, Rijsdijk (1997) noted that equipment used for demonstrations can be made up from scraps and other odds and ends, such as plastic soft drink bottles, styrofoam cups, and other different materials that are within reach for both the learners and teachers. Winch (1958), as cited by Kelly, Brown, Crawford, (2000) emphasized the importance of the uses of symbols. In this case, Winch identified how in order to recognize an event as an *"instance of"*, the investigator must have a concept referring to relevant characteristics. This can be learned efficiently during experiments in a science class, including cases where improvised equipment is substituted for commercial equipment.

The improvisation of resources at some stages goes hand in hand with constructivism. In his discussion about constructivism, Osborne (1996) acknowledged that *"the justification of place and time for science education on the curriculum lies in the claim that methods of science…need to produce reliable knowledge."*

2.5.5 Other Teacher Support Mechanisms

A 1995 National Teacher Audit showed that South Africa's 360 000 teachers are in need of in-service training (Naidoo, 1997). As a result, the government of South Africa, with the support of Non Government Organizations is in the process of trying to attain measurable gains by upgrading teachers through in-service strategies. Naidoo also outlines the contributions of NGOs in general, and those of the Open Learning Systems Education Trust. Through such programmes, more focus is laid on: teacher capacity development and related inservicing (INSET) programmes; curriculum reform and outcomes based activities; equity of access and quality of instruction; and transformation of management capacity for expediting open learning environments. They also provide teachers with skills of working under different conditions.

2.5.6 Group discussions for sharing knowledge

Group work relates to a wide range of classroom activities. Since Physical Science may be looked at by both the learners and teachers as a complicated learning area, group discussions and problem-solving can provide important peer discussion mechanisms that help in sharing knowledge. In a study by Rivard and Straw (2000) on exploring the learning of science, it was found that two groups that used discussions benefited more compared to another two groups that did not use peer interaction in class. Significant differences were reported.

It has also been argued that small group discussions enhance student understanding by extending available knowledge (Glaser, 1991 cited by Rivard and Straw, 2000). Again in a study by Rivard and Straw (2000), it was suggested that peer talk is important for distributing knowledge, especially when students who worked individually lacked the knowledge base for constructing adequate explanation for various problem tasks. It was also found that students who worked alone did not learn as much as students who discussed problems with peers.

Naidoo and Savage (1998) also supported the idea of group work. They asserted that cooperative learning seems to be a fruitful way to teach both large and small classes. It involves delegating control and methods of learning to pupil groups who work together, sometimes competing with each other. Learners work together on assigned tasks, make decisions by consensus and argument, and ensure that members contribute (Naidoo and Savage, 1998). A study by Okebukola (1984), as cited in Naidoo and Savage (1998) showed that 81 senior secondary pupils in Nigeria confirmed that cooperative learning is an effective way to promote pupil achievement. Cooperative learning facilitates problem solving by learners, effective discussion, individual contribution and peer tutoring. It also promotes positive attitudes and problem-solving competence more than individualistic learning, and pupil's discussion and communication skills improve as they ask questions (Naidoo and Savage, 1998).

Bianchini (1999) highlighted the fact that groupwork has been offered as one of the ways of meeting the challenges of access and equity in science education. She looked at it as having an effective role in addressing issues of student diversity and fostering conceptual learning; creative problem solving; positive interdependence and individual accountability; delegating of authority to learners by their teachers in order to be responsible for their own behaviour and learning.

However, Naidoo and Savage (1998) also make us aware that there can be limiting factors to cooperative learning, such as the teachers' lack of action research skills; ways of organizing cooperative learning; and most importantly, prescribed curricula and examinations. Bianchini (1999) too notes that groupwork is by no means a simple or fool-proof solution to inequities in science education. A study by Kelly, Crawford, and Green (1997, as cited in Bianchini, 1999) found that a group may accept or reject its members' ideas based on their classroom stature rather than on their arguments' merits. Thus group work may re-enforce rather than counter existing power-relations in the classroom. Similarly, Richmond and Striley (1996), also cited in Bianchini (1999), suggested that students' academic reputation influenced how often their insights were disregarded by other group members; how easily their opinions were swayed; and how quickly they were drawn off task. In addition, a group's pattern of social interaction, especially the group leader's style, shaped all members' access to and understanding of scientific concept, reasoning and argumentation (Richmond and Striley, 1996).

In Science, as in classrooms, the status of the speaker or leader can stifle other ideas. Hereunder is an example:

Burning question: *(What does it take for a scientific discovery to be accepted?)*

> *"In a chapter from Schaffer (1989), cited in Bianchini (1999) about Newton's Prisms and the Uses of Experiment, it was argued that Sir Isaac Newton used his position as president of the Royal Society to engender widespread acceptance of his theory on the immutability of colour. In the late 1600s, when Newton was not yet well known, his experiments on light and colour generated controversy: colleagues questioned the quality of his glass prisms, the adequacy of his experimental designs, and the veracity of his claim that singularly coloured light rays could not be split into additional colours. After Newton assumed presidency of the royal society,...he used his newfound influence and allies to squelch his critics, establishing his prism as standardized technology and his claim for the immutability of colour as scientific doctrine"*

Source: Bianchini (1999)

2.5.7 Adhering/Falling back to the traditional method

Even though different modern teaching methods are widely encouraged among teachers, and often supported by research findings, it may be that traditional methods are more effective in under-resourced schools. Sometimes even when teachers are trained to employ new teaching methods and techniques that can trigger learners' interest in the classroom, they still go back to the traditional method. This may apply in schools that have resources as well as those that are under-resourced. A possibility on this matter is that: even though some schools have enough/relevant materials for science teaching, teachers still find traditional methods much comfortable, no matter what the consequences may be towards the achievement of learners.

For some teachers, it may be because there is just not enough support from the stakeholders, so the teacher ends up being the sole provider of science knowledge as well as other more responsibilities towards the learners. There are many reasons or excuses for teachers to stick to traditional method of teaching. Naidoo and Savage (1998) highlight the 'minds-on' activities as well as 'thought experiments' that learners in the classes can hang on to, in cases where apparatus are limited in order to conduct experiments or demonstrations. Teachers must realize that the lack of teaching and learning resources does not limit them to come up with creative methods of involving learners actively in class, just as in the earlier outline by Pretorius (2001). In this case, a consensus might be possible that bridges the traditional methods with the modern methods of teaching that are part of the requirements of OBE, where everyone contributes actively towards teaching and learning.

2.5.8 Teaching Through "talking and writing"

Science educators have argued that science classrooms ought to be active learning environments in which students construct personal meanings within the classroom (Erickson and Mackinnon, 1991 and Roth, 1990 cited by Rivard and Straw, 2000).

Teaching through talking and writing is part of the tradition that has always been one of the most common methods in both resourced and under-resourced schools. It mostly happens in the normal classroom as well as the laboratory settings. Studies by Driver (1996); Keys (1996); Meyer and Woodruff (1997) as cited by Rivard and Straw (2000) have documented science classrooms in which students are active learners, interacting with peers on cognitively engaging problem-solving tasks within a collaborative learning environment. In this case, Rivard and Straw (2000) have suggested that talk is important for sharing, classifying, distributing knowledge among peers, while asking questions, hypothesizing, explaining, and formulating ideas together are all important mechanisms during peer discussions. Analytical writing is an important tool for transforming ideas into knowledge that is more coherent and structured (Rivard and Straw, 2000:565). Talking in a science class context is mostly due to the needs for problem solving and explaining, which can lead to learners re-constructing their knowledge. Constructivist ideas about learning have been embraced by scholars in many fields, including literacy and science education (Bruner, 1986; Green and Ackerman, 1985; Appleton, 1997; Tobin, 1993 cited in Rivard and Straw, 2000). Some constructivist approaches have emphasized personal construction of knowledge which reflects the individual's experiences within the learning environment, others have emphasized construction as a social activity, situated in a particular context. Classroom activities that feature listening, talking, reading, and writing can all be used to enhance the cognitive processing and the reconstruction of knowledge (Rivard and Straw, 2000). These approaches can be applied in under-resourced schools as well as in well-resourced, though differently because of the different resources that are available or not available.

2.5.9 The Need to Visit Science -related Centers

One other solution for schools that don't have resources is to pay visits to places that may be directly related to Science (-education) and going on field trips. Possibilities include: Science Centers, factories, mines, museums, nature reserves, and so forth. According to Baeta and Machado (1999), Science Centers have been conceived as part of the non-formal education, with the purpose of enriching the experiences of the public, but they also provide rich opportunities for schools and are important educational resources (Gadelha and Schall, 1999).

Lucas (2000:524) asserts that "there has been a remarkable growth in the number of informal learning centers such as museums, interactive science centers, and field study centers in many countries over the past 20 years." Several comprehensive reviews of research literature concerning this matter have been produced by researchers such as Lucas (1983), Anderson (1994), Dierking and Falk (1994), Ramey-Gassert, Walberg and Walberg (1994), Burnett (1995), Rennie and McClafferty (1996), as cited by Lucas (2000).

Johnston and Rennie (1994) as cited by Lucas (2000), investigated the types of interaction that occur between students and explainers in Science Centers. A significant outcome of their research was that the interactions are in most ways different from those that might be expected between students and their regular teachers. Explainers in such centers seek to facilitate understanding of exhibits and not to teach. Students apparently sense and responded favorably to this difference between explainers and teachers. This argument is not to degrade the normal classroom teacher, but to enrich learners' experiences by leaving their usual school environment, getting some exposure from science related areas outside the school, and learning in different ways. This may also serve to motivate learners in their core learning areas, as well as to give a clearer direction concerning their future careers.

Henriksen and Jorde (2001) also believe that the use of museum exhibitions is worth further exploration. They argue that the potential will only be realized if new ways of improving the cooperation between museums and schools are found. For teachers and learners, visiting such centers can serve as one of the rare chances of being exposed to additional resources. However, such visits require teachers to take leadership in organizing them and linking them to the school curriculum, and have costs (for travel and admission) that have to be met by schools or parents.

CHAPTER 3

3. METHODS OF RESEARCH AND ANALYSIS

3.1 Introduction

This chapter outlines the methods that were applied in order to design and put together this research study. It provides an overview of the theoretical framework and research design, the reasons for choice of schools and teachers, procedures for accessing the schools, and the instruments for data collection.

3.2 The research framework

The research was guided by the critical questions:

- How do physical science teachers in rural secondary schools define 'under-resourced' in their schools?
- How do Physical Science teachers in rural secondary schools deal with an under-resourced teaching environment?
- What beliefs do such teachers have about effective Physical Science teaching and learning, in these contexts?

In order to address the critical questions, this study makes use of qualitative research methods. The choice was made in view of the nature of the critical questions and the communities involved. According to the Mercator Research Group (2003), qualitative research is used to gain an understanding of underlying reasons and motivations, and to provide insights into the problems and solutions. That is, to look at how teachers in particular schools and communities identify and deal with the concept of an "under-resourced" environment. At the center of the data collection process, are structured interviews with teachers, followed up by questionnaires, and classroom and school observations.

According to Neuman (1997), an interview allows the interviewer to ask different types of questions, including those that are complex. As a result, it becomes easier for the interviewer to give clarity for complex questions. The interviews were followed up by questionnaires. This was to enable a stronger reflection of the responses during the interview: the questionnaires enabled the teachers to 'summarize' their ideas in the light of the interview. The questionnaires employed different questioning styles, such as, short questions, choice questions, and questions that required brief explanations. Participants in this study were given about two weeks to answer the questionnaires using their own pace, and their own time. Observations were made in two areas. One concerned resources: classrooms, laboratories, furnishings, libraries, photocopiers, toilets and general facilities. This was to enable descriptions of the resources and ways in which the schools were 'under-resourced'. The second area for observations was in classrooms. This was to see what the teachers and classes did, in practice, to overcome problems of resources. This was essential for the later stage of comparing the observations with the written and oral responses that were given by participants.

3.3 Trustworthiness of the data

In order to test the validity of questions, the interview questions and questionnaires were first circulated among non-formal participants of the study, who were also science teachers. This was to see if the questionnaires were going to be understandable to the participant-science teachers, and generate answers for the critical questions. This piloting also served to determine the approximate time that the instruments would require when being answered in the actual study. After the pilot study some changes and corrections had to be made to the instruments, and the critical questions were re-worded as they became clearer.

3.4 SELECTION OF SCHOOLS

The Bafokeng secondary schools were selected because they are located in a single district. This district mostly comprises rural areas in the form of villages. Traditional Authorities and Culture in these villages are highly valued. The communities surrounding the schools are of a working (and non-working) class, whereby some of the parents are employed in places that are far away, such as Johannesburg, and some are of a poorer background. As a result, the schools are both directly and indirectly affected, since the learner population consists of children from such families. This does not necessarily imply that all the schools have exactly the same set problems, the situation may differ according to each particular school.

After having informal conversations with some of the teachers from the Bafokeng schools, it was clear that even though the infrastructure of the schools were generally well maintained, there were other outstanding issues in terms of working in under-resourced environments, including the profiles of the family backgrounds from which learners come. Also in terms of the general requirements, Physical Science remained one the learning areas that had a few problems due to lack of enough resources. This further enhanced curiosity in terms of needing to know how the teachers viewed such matters, as well as what they usually do in response, since these were ongoing problems.

During these informal conversation, some of the teachers highlighted the fact that there were sometimes difficulties when schools had to be maintained in terms of the resources that are required to serve curricula needs, especially for Physical Science, which is known to be the most demanding learning area. It is because the schools would always have some resources for Physical Science lessons and experiments, but turning out not have most. The types of resources that most learners and teachers would commonly rely upon were textbooks and/ or even some of the old chemicals. In other words, most of these schools would be on their own in terms of trying to maintain their level of teaching resource needs.

It also turned out that a few teacher development projects by NGO's had just began. This seemed to be a positive sign, based on the Department of Education's call for service providers to offer training on different strategies and skills for coping with the demands and responsibilities in teaching, especially in Mathematics and Science (DoE, 2001). Most importantly was the need to know the teachers' views and points as to how they were affected by the conditions of teaching science, as well as the general conditions in their schools. This also led to the position of being ambitious about the role of these service providers towards teacher development.

3.4.1 My relationship to the study

"I was born and raised up in a village known as Phokeng, in the district in which the schools exist that were part of my study. In other words, I have first hand experience of life in the Bafokeng area, as well as the education system there.

"As I was growing up, there were few secondary schools that served the Bafokeng people. Most of them emerged or were rebuilt within the last fifteen to thirty-nine years. They were all built by the Bafokeng Authority The infrastructure of these schools is similar to that of other South African public schools that were built or renovated during the above-mentioned years.

3.5 ACCESSING THE SCHOOLS

After identifying the schools and finalizing the research proposal, as well as being granted ethical clearance by the University of Durban-Westville, I then made arrangements to obtain postal addresses from the Tlhabane Educational Circuit, which serves as the central educational district office to the schools that are part of this study. Since the schools are located in the rural areas, most of them did not have physical addresses by then. So, postal addresses were commonly the most effective way of formal communication with the schools. I immediately wrote letters to the school principals. The purpose of the letters was to request permission to conduct research in their school premises. The format in which these letters were written to the principals was the same. The letters explained the following aspects: aims of the study; who the participants/subjects were supposed to be; instruments for data collection; suggested dates for data collection; the estimated time that the data collection instruments were going to require; a list of all the schools that I intended to conduct the study in; as well as all my contact numbers and addresses.

Subsequent to the above written letters were regular telephonic follow-ups (where possible) to further all the enquiries with the school principals. These follow-ups served to ensure that all the school principals had received the letters, and clarify my intentions. They also became a way of letting me know if permission was granted to conduct the study. Even though I tried to encourage most of the schools' principals to also respond in writing, it seemed that they were always busy. So, it seems to have turned out that the process of responding by writing and posting was more time consuming for them. Some of the schools did not have telephones, so in that case, I arranged to get any possible contact numbers from the teachers who worked in different, but nearby schools. Fortunately, permission for the study was granted by all the schools' principals.

Following the granting of permission to conduct the study in these schools was the consent from the participants-to-be. Then afterwards, we all agreed on the dates that I was going to see them for data collection. Contact times were mostly based on the teachers' timetables as well as their flexibility to make time to attend to me.

3.6 STUDY POPULATION AND SAMPLING

According to Huysamen (1994:8), a population is the entire collection of cases about which there is a wish to make conclusions. Due to different reasons such as time factor as well as avoidance of more repeated responses, it was not practical to include the entire population of science educators in the study, so a sample was chosen. Huysamen highlights the necessity of representativeness of the sample. This raises an issue of whether the study was concerned mainly with communities, schools or teachers. I resolved this by choosing schools in somewhat similar communities (all part of a particular district), limiting my study to Grade 11 Physical Science, and then allowing these choices to constrain the choice of teachers. Thus the focus of my study was on teachers – teachers of Grade 10-12 Physical Science, in rural high schools in a particular, generally poor, district in the Bafokeng community. As a result, participants in this study may represent other science educators in these rural schools, but not schools in other areas or other communities. It is assumed that the kind of representation in this study can at the end provide an idea of issues that affect the teaching process in the rural schools with roughly similar conditions.

Webster (1985), elucidates a sample as a finite part of a statistical population whose properties are studied to gain information about the whole. When dealing with people, a sample can be defined as a set of respondents selected from a larger population for the purpose of a survey. A sample is expected to mirror the population from which it comes from, however, there is no guarantee that any sample will be precisely representative of the population from which it comes.

The type of sampling used in the study can be referred to as a probability sample (Lapin, 1987). This is when a sample allows a known probability that each elementary unit will be chosen. In this instance, I knew the schools in which I was going to conduct the study, but I did not know the teachers I was going to deal with, or their teaching methods. As a result, each of the Physical Science teachers in the schools stood an equal chance of being chosen.

The study dealt with one Physical science teacher per school. This choice was made in order to maintain one-to-one correspondence between teachers in the schools and the researcher. As it turned out, the sample included similar numbers of male and female teachers, who were generally well qualified and experienced.

3.7 DATA *(-COLLECTION)* RECORDING AND INSTRUMENTS

All the interviews and observations were conducted within the schools' premises, and teachers completed the questionnaires in their own time. The interviews and observations did not follow a systematic order, took place in the modes that were practical and flexible to the teachers in terms of their daily teaching schedules. In other words, both interviews and classroom observations stood an equal chance of being utilized first on each day of data collection.

3.7.1 Interviews

All the interviews that were conducted for this study were audio recorded. The purpose for the audio recording was to have back-up information. Such a back-up system became essential in terms of data review as well as for future reference.

Interviews were held in isolated classrooms and/or laboratories in the schools, to avoid interference from the people who were passing by. Each of the interviews was conducted for about fourty to sixty minutes.

The interview schedule (Appendix B) for all participants covered the following: Physical resources; strategies for teaching Physical Science (bearing in minds the concept of an under-resourced environment); the level of aid/co-operation from stakeholders and neighboring schools; and the teachers' views on learners' backgrounds, experiences and the effects thereof.

3.7.2 Classroom/general observations

Observations were done during both the single as well as double lessons. The observations took place in the classes of grades ten, eleven, and/or twelve, as was convenient. During each of the observations, an observation schedule was used to record data thereof. The observation schedule was adapted from one developed by the Center for Educational Research and Policy Development (CEREP) at the University of Durban~Westville.

The resulting observation schedule covered classroom management; goal direction and planning of the lesson; teacher's content knowledge; level of learner engagement and activities; communication between the teacher and learners; classroom conversations; problem solving and creativity; classroom understanding; science and underlying assumptions; group-work; individual and group progress; learners' connectivity to previous lessons; and improvisation.

Observations took place in classrooms or laboratories, depending on where participants conducted their lessons for those days. Participants were encouraged to be as natural as they could. In other words, they were encouraged not to change their usual methods of teaching, assuring them of their anonymity in this report. One observation session was conducted with each class, sometimes a single period session, sometimes a double period.

3.7.3 Questionnaires

Subsequent to the interview sessions and the observations, questionnaires (Appendix A) were distributed to the participants. Each questionnaire was accompanied by the researcher's self-addressed and stamped, fast-mail envelope. The aim for this was to try to make it easier for the participants to send the questionnaires back to the researcher within a set period of time. All that they had to do was to answer the questionnaires and send them back afterwards.

Huysamen (1994) asserts that questionnaires may be used for obtaining the biographical particulars, opinions, beliefs and attitudes. The content of the questionnaires was categorized into the following sections: biographical details and teaching profile; the teaching environment and school context; methods and alternative ways of teaching Physical Science; and experience with learners based on their learning as well as their different family backgrounds.

3.8 ETHICAL CONSIDERATION

Ethical concern is one of the most significant aspects that have to be considered for the sake of both the researcher and the participants.

When consent was requested from the teachers, they were assured that their anonymity and confidentiality in this study would be respected if they wished. Maintaining confidentiality allows the subject to answer questions without fear (Leedy, 1989). However, while changing names of teachers, and breaking up their stories provided some confidentiality for them, it weakens the data. Disconnecting the teachers' stories from the particulars of their schools meant sacrificing relationships between teaching approach and specific contexts, and the ways in which a particular teachers' answers constituted an integrated picture for that teacher. Further, while it was straightforward to change the names of the schools, it made no sense to change also the name of the district, because the history of the district is part of the resource-levels and achievements of the schools. To ensure that the educators were given the anonymity promised them, I have chosen in this report not to present the stories of each teacher and school as coherent stories, but to break up their stories under themes and issues.

The research title and aims were thoroughly explained to the participants, and exactly what was required of them. It was also made clear that the aim of the study was not to judge or assess their ways of teaching as well as dealing with the learners, but to draw possible similarities and distinctions that may exist amongst them, while finding themselves under nearly similar conditions. Participants were also assured that the researcher would try by all possible means not to expose the participants to any risks, such as putting them in any situation that may cause harm to them physically or psychologically, invading their privacy, as well as upsetting them. In the actual sense, virtually all studies involve some risk, but researchers have to always ensure the use proper safeguards when carrying out their studies.

In most studies, subjects are first given a brief description of their duties in the research and then given the choice to participate or not, hence the informed consent. Informed consent serves to remind subjects that they can terminate their participation in the study at any time if they choose to do so. According to Sharpe, Adair, & Roese (1992), people who have participated in research projects don't report any negative feelings about the experience after they are told about the study's true purposes and the risks that it may entail. All of the teachers approached to participate in this study agreed to, and participated openly and enthusiastically.

3.9 CONCLUSION

This chapter has tried to present a clarification of the methodology that was used during the course of this study. It also highlighted the procedures that were followed during data collection process. They include: a procedure for accessing the schools; the entire data collection procedure; and how the instruments thereof were utilized. The study design, and selection of schools were also elucidated.

CHAPTER 4

4. RESULTS

4.1 Introduction

This chapter is aimed at providing a discussion of the data that was obtained from the schools and teachers. It is based on the information that was collected using a combination of interviews, observations, and questionnaires.

As this chapter directly refers to the experiences I had with the educators, I also had to consider their anonymity. So, educators' views are grouped according to the similarities and differences drawn from their responses. This poses a disadvantage of weakening the holistic descriptions of individual educators in the context of their schools and communities, but better protects the confidentiality they were promised. Educators as individuals are referred to as Educator: A, B, C, D, E, F and G, and their schools, correspondingly as School A, B, C, D, E, F, and G.

4.2 General description of the area

All seven schools in the study are widely situated around the Bafokeng villages. The schools and the villages are all under control of the Bafokeng Authority. The Bafokeng Authority is the official body that maintains an administrative process of a close community of the Bafokeng villages. This Authority is based in Phokeng village. Some of the villages that fall under the Bafokeng Authority are: Luka, Chaneng, Robega, Rasimone, Kanana, Tsitsing, Tlaseng, Mogajana, Mosenthal, Photsaneng, and there are many others. They may be viewed as a cluster of communities that form a single district. The socio-economic status of communities varies from working to non-working classes. The commonly spoken language is Setswana. The Bafokeng population consists of about 300 000 people, and their nearest town is Rustenburg. As a bigger community, they associate themselves with a Crocodile, and this makes them to be selectively known as the "Bakwena".

As a larger society, the Bafokeng people are found in the North-West Province of South Africa. They possess a land that turns out to produce one of the most valuable minerals, platinum. This enables the Bafokeng community to be a somewhat independent society. However it does not necessarily imply that the Bafokeng people as individuals are rich: there are still many of them who are practically underprivileged - as Mathonzi (2001) outlined, it is difficult to compare the physical indicators with social indicators in rural areas.

The Bafokeng communities are currently under the leadership of King Leruo Molotlegi, with major assistance from the Queen Mother, Semane Molotlegi. In the strong name of the Bafokeng people, King Molotlegi leads a council that consists of Headmen, who serve as leaders as well as representatives of all the Bafokeng communities in the surrounding villages.

The Royal Bafokeng Authority built primary, Junior-secondary and Higher-secondary schools during the reign of King Leruo Molotlegi's predecessors, between the 1960s and the late 1980s. Some of these schools were renovated due to damages as well as ageing of their structures.

4.3 The school environments

The secondary schools selected for this study have some resources. They generally have classrooms that can accommodate their learners. Each of the schools has one laboratory that serves Physical Science/Chemistry, Biology, and other science related learning areas. The schools have electricity, sufficient water supply and toilets. Some of them have classrooms that were converted to libraries, though often with only a few books.

All of the schools' classrooms I visited were furnished, but the desks were usually old and too few for the numbers of learners per class. In schools A, D, and F, there was lots of empty space in certain parts of the classrooms. About a third of the classroom was vacant, without any desks or chairs, and learners sitting in clusters of two to three per desk. The classes in school B were much the same size as the other schools, but the rooms were smaller so there was little space left. Learners here also shared desks in groups of two to three, crowded into the room.

Each of the schools has one photocopying machine, generally used for learner worksheets, as well as for the general running of the schools. Educators in most schools reported that facilities such as the photocopying machines are used under strict conditions, because of the costs of copying and because the schools have to pay if anything goes wrong with the machine.

Most of the learners in these schools were wearing correct uniforms. They shared textbooks, worksheets and other instruments such as rulers and pencils. They seemed not to be bothered at all by this. For general safety reasons and disciplinary measures, the schools are fenced, and gates are commonly locked throughout the school day, except during break times. Educators explain that this is to stop trespassing, and to encourage learners to come on time. Those who come late are usually disciplined by being given different tasks to do.

Because most of these schools were located some distance away from the village center, security of property can be an issue. School D, for example, reported specific problems of theft of resources.

4.4. The community

Resources at home – ranging from food, health and personal care through to provision of books and support for schoolwork are important aspects of school achievement. Further, in the learner-centered framework of Curriculum 2005, life out of school is intended to be part of the curriculum (Department of Education, 2002). Looking beyond the schools' premises, community life in these villages was very quiet, compared to urban areas. Perhaps that's how it always is during school hours, as most young members of the society are swallowed by the schools' classrooms. In these schools, one seldom sees or hears a bus or car passing during school hours. Sometimes it was so quiet, it felt lonely.

According to the educators, learners come from various family backgrounds, with the majority from poor backgrounds. At the same time, educators noted that it is often difficult to tell the levels of poverty and the conditions of living that the learners experience. Educator A explained that she was new in her school, and needed more time to know her learners well. Educator B said that in his school there have been cases where a learner fell unconscious, and follow-up has found that such a learner was not well fed at home. As a result, there has been an initiative in school B to introduce a food programme called 'Namola Leuba', which in English means 'Reducing Starvation'. During every school break time, a van carrying bread and fruits comes to school B in order to provide for such learners. Educator B believes that the learners' family background and health greatly affect their academic performance, and that they need some form of support in order to cope.

Educator C said that his learners 'do not have much', but on average, he would not classify them as poor because they were able to survive. This points to the difficulties in defining 'poverty'. He said that the main problem was the distance they had to travel to school, which takes time or money, and leaves them tired. Most of them stay with their grandparents, because parents lived and worked away from the village, or had died. His view was that even though they cannot afford many things, their usage of money was not good. For example, they didn't use their money for school purposes, but for drinking and other night activities. He said that learners tend to look poor because they don't have the things required for school, and as a result, teachers think that their learners are poor.

The educator in School D described learners' backgrounds as very poor. She presented various cases that had been witnessed in her school:

> *"We have a learner who cries in class sometimes. Her mother is married to a man who is highly dominant in the family, and everyone in the family is afraid of him. And then we also have another learner whose mother doesn't take care of him. One of the teachers even approached his mother to inform her that she must at least make sure that the child comes to school with clean clothes. Last month, one learner pleaded with us to encourage her mother to be patient with the minor jobs*

that she gets. Her mother usually does the washing of clothes in several households, but as soon as she gets some money, she leaves the job. As a result, the family stays for a long time without money.

But generally, many of the learners stay with their grandparents...and learners take advantage by coming late at home, and doing all sorts of naughty things. Usually when we want the parents to sign documents, we have to wait for weeks because learners don't stay with their parents...When winter comes, some learners won't have warm clothes to wear, while others will wear jerseys of different colours, claiming that they don't have money to buy school jerseys. It's difficult, but we always console ourselves that we will try our best."

This is how educator E described his learners:

"Generally our learners come from different families. You would find that some learners don't have parents, and it becomes difficult for them in the classroom. One can easily notice that, because they come late and they hardly focus on their work, and there are other reasons as well. But in such cases, I try to advise them on ways of trying to focus."

In School F too, some of the learners come from extremely poor families.

"And unfortunately it is very difficult to find out since learners don't just open up about their personal lives, especially boys. Some of the learners don't eat supper and breakfast.

Right now there is a boy that I always prepare a lunch box for on a daily basis. There are other girls who are being taken care of by other teachers. It takes a lot of time to discover such learners. Some learners don't have parents, while others are usually neglected by their parents. Every year, we try to came up with a ways of encouraging previous learners to donate their textbooks, or sell them to our current learners at lower prices".

Educator G echoed Educator F's point.

> *"It's not easy to identify all of them because some can fool us. Some of them come from families that have serious problems, even though they might not show us because they always struggle to be on the same level as other learners. In most instances, we manage to trace their problems when their performance deteriorates, only to find out later that they actually come from families with serious problems."*

The distances that the learners travel to school, as noted earlier, create a number of problems. All but one of the schools was located outside of the villages. Transport reaches the schools' premises only during set times, in the mornings and afternoons. Many learners, if they miss transport or can't afford it, have to walk long distances to school. However, educators felt that generally learners were used to this situation, and neither learners nor teachers view it as a serious problem. It has become a norm.

Table 4.1 *The teaching environment and school context*

SCHOOL	Electricity	Sufficient water	Library	Enough books in the library	Sufficient books for Physics learners	Laboratory	Sufficient laboratory/ testing equipment	Relevant Physics teaching aids	Scientific models
A	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
B	Yes	Yes	Yes	No	No	Yes	No	Yes	No
C	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
D	Yes	Yes	Yes	No	No	Yes	No	No	No
E	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
F	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
G	Yes	Yes	Yes	No	No	Yes	No	No	No

4.5 Resources for laboratory work and projects

While all the schools had science laboratories, they were often poorly equipped and poorly maintained. In some, apparatus such as chemicals and other instruments were kept in small corner-rooms with shelves. At others school laboratories were about one and a half times bigger than the classrooms, with long enclosed shelves mounted on one wall. Especially at schools B, E and F the places where apparatus were kept seemed to have been cared for on a regular basis. In the other schools, there was dust over most of the apparatus, especially where bottles with liquids were kept. Only in schools B and E were usable chemicals and other liquids clearly separated from old outdated ones.

The conditions of available resources, as well as the quantity of resources, are relevant. Some educators reported that, of the resources that they have, some are very old and outdated. Educators A and E pointed to chemicals that might have been ten years old or maybe more: they were there and dust-covered when A and E started teaching in these schools. This raises issues not only of resources, but safety and disposal of hazardous chemicals. From my observations of the schools, chemicals that might react with one another were not carefully separated, and neither were special arrangements made for chemicals that were highly flammable.

As has already been said, in some schools, a classroom had been converted into a small library to serve learners and teachers. But it seemed like it was mostly teachers who made use of the books. It was only in schools B and E where I saw learners going in and out of the these libraries. In school G, the mini library also served as a staff room, with most of the shelves about eighty percent empty. The teachers in school G said that they were forced to use the library as a staff room due to increasing number of learning areas, with additional areas such as accounting, economics and agriculture, and hence an increasing division of learner interests and an increasing demand for classrooms.

On the timetable, most of the language-learning areas were allocated one lesson per day for three days, a double lesson once a week and no lesson on the fifth day, though not necessarily in that order. Other learning areas, including science, were taught on a daily basis with two to three double lessons per week. Teachers said that this was due to the fact that mathematics and science subjects had more difficult content to deal with within a short space of time. (In most schools, periods were 30-40 minutes long.) Thus, in all schools, mathematics and science were given special emphasis.

4.6 Teachers

During my visits, I found in all schools that classrooms were operating, teachers were teaching, learners chattered to each other during breaks. The schools were tidy, and seemed busy as they went about their work.

Science educators in this study are high school teachers who fall within the age group 26 to 45 years. This is an age group of active working people perhaps at the peak of their career as educators. One of them is originally from Zambia, and the rest are South Africans. Like the learners, the educators speak Tswana as their first language. All of them speak English as their second language, and speak it proficiently. All of the schools had at least one Physical Science teacher (Table 4.2). Some of the schools had three teachers to teach Physics. Most of these teachers were qualified to teach Physical Science, with at least a diploma or a university degree. Only one of the teachers was not qualified to teach science, but she had a degree. In the schools studied, about half of the Physical Science teachers were female. Their teaching experience ranged from about five to ten years. Thus all the schools had teachers available who were qualified and experienced.

One of effects of learners' travel arrangements is that teachers do not conduct lessons outside school hours. But they do try to conduct extra lessons during the winter break. Educator B saw the difficulties of learners' travel as a problem because he would like to conduct extra lessons after school hours and on weekends.

In terms of workloads, some of the educators teach Physical Science across Grades 10 to 12. School C had only one Physics teacher, who taught all the Grades. In school F, there were three Physical Science teachers who, though they taught all the Grades, had their own specializations within Physical Science. For example, one teacher had mastered chemistry content, while another was skilled in balancing equations, and a third in Physics. Educators in schools A, B, D, E and G teach Physical Science to only one grade per year.

A number of the educators in this study also turned out to carry administrative responsibilities. Those educators who usually taught only one Grade of learners were typically those who had more administrative roles in their schools. One of them was a school principal, while the others were HoDs for Mathematics and Sciences (Physical Science, Biology, Geography, and Agriculture.) Situations varied according to individual schools.

School- and class-sizes varied, with one to four Physical Science classes per grade. Class sizes averaged about 30 in most cases, with higher numbers in Grade 10, decreasing in Grades 11 and Grade 12. In school D, science teachers usually taught one grade per year, and moved from grade to grade with their learners. They felt that in that way, they got to know their learners more as individuals, and it becomes easier to develop mutual understanding in terms of teaching and learning.

The educators saw the low numbers of Physical Science teachers in their schools as problematic. They said it not only added to their workloads, but also made it difficult to attend workshops or be absent from the school. For example, Educator C was the only Physical Science teacher in his school. If he was absent, sometimes the Mathematics teacher took over his lessons (for the Mathematics teacher was trained in both Maths and Science).

Table 4.2 ***the teachers:***

SCHOOL	Gender (of the teacher)	Age-Group	Qualifications	Qualified to teach Physics?	Teaching Experience (Years)	Current Grade(s) teaching	Current Physics teachers in the school	Average Physics learners per class
A	Female	26-35	Degree + Diploma	Yes	5-10	10, 11, 12	2	Below 20
B	Male	36-45	Degree + Diploma	Yes	11-15	12	3	Over 40
C	Male	36-45	Degree only	Yes	16-20	10, 11, 12	1	Over 30
D	Female	36-45	Degree + over	No	11-15	11	3	Over 30
E	Male	26-35	Diploma only	Yes	5-10	12	2	Over 30
F	Male	36-45	Diploma only	Yes	11-15	11	3	Over 30
G	Female	36-45	Degree + Diploma	Yes	11-15	11, 12	2	Over 25

4.7 Learners

Most educators were not happy with the progression of Physical Science learners from grade ten to grade twelve: more learners opt out of Physical Science at each successive grade, and those who stay, even when they pass, often do not do well. Educator C was particularly concerned. He said that the problem lay mostly with the learners, who were simply not committed to their schoolwork. Educator B felt that Physical Science learners in his school were doing better than neighboring schools in terms of their passing rate. While pass rates had fallen (from 100% some years ago to 87% in 2000 and 82% in 2001), the number of learners had greatly increased, tripling over that time period.

Only half of the educators believed that the academic performance of learners was deeply affected by the lack of some resources in the schools. They felt that this problem affected Physical Science learners across the Grades, especially those who are in grade ten. When asked if they believed the availability of all the necessary resources would lead to the improvement of their learners' performance, most of them believed so. They felt it would be easier for them as teachers to conduct experiments effectively if they had proper resources. One of the educators stressed the fact that *"when you see, you remember; and when you hear, you forget."*

On the other hand, other educators said that even though they also felt that laboratory resources affected the performance of their learners, they did not believe that such resources are the sole or even the major reason for a lower performance. They referred to lack of learner commitment, that their learners were not working hard enough. One of the educators observed that some learners were very passive in class, but in the streets they were different people, highly active and confident. He said that he has met several of such learners outside of the school a few times. One of the educators explained that it does not just take resources to improve learners' performance, there's a lot to do. For instance, learners need a lot of motivation and encouragement. Some of them generally don't have the courage to take their schoolwork seriously because their older siblings stay at home after they have completed grade twelve. So, in this case some learners do not see the purpose of studying. They only do so for formality.

4.8 <u>Teachers' perceptions of resources</u>

The concept of 'resource' emerges as a complex one in this study. In the interviews, educators first settled on laboratory equipment and materials as primary resources, but as the interviews progressed, they talked more and more of community income, food, health, travel problems, family disruption and parental levels of education as resources: it is difficult for learners to concentrate on their schooling when they are hungry, tired and distracted. Educators have little capacity to impact on such resources – as they do on provision of laboratory equipment – but many of them try, assisting with school lunches, provision of clothes, and so on.

In the case of resources for teaching, as in community resources, it is clear from the study that ideas of 'adequate resources' are relative: all educators, regardless of the schools they were in, would have liked more resources. Some educators compared the conditions in their schools with those in their previous schools. Educator A said that even though her current school did not have some of the needed apparatus, it was still much better than her previous school. Educator B compared the situation he is in, where his school is located in the bush, with his previous school, which was located inside the village, and a boarding school. There, he was able to call the learners at anytime in the morning, afternoon, or on weekends, for extra lessons. To those who stayed some distance from the school, he could give money for transport, or use his own vehicle to transport them (because they were few in number). These solutions are not feasible in his current school where busses only function within set times during weekdays, and most learners would not be able to afford them anyway. Further, there are more learners who live far from the school, so he cannot afford to provide them all with transport money.

In relation to their teaching environments, teachers gave different meanings of how they understand the concept of an under-resourced school environment.
The following are a reflection of how they refer to an under-resourced school context:

> *"An under-resourced school is the one that does not have some resources... in my previous school, we didn't have equipment at all. We used to improvise a lot, to an extent that when I came here, I felt that this school is far better. I haven't been here long enough to notice the extent of lack of resources in this*

school. Perhaps someone from a well-resourced school, might feel that this school is under-resourced."

" An under-resourced school is the one that does not have enough resources. For instance, a school may have a laboratory, but the laboratory may turn out to be small in terms of accommodating all the learners. On the other hand, there may be certain apparatus, others not being there, especially, for the fact that those that are not available cannot cover up the whole syllabi."

" Under-resourced schools are schools that don't have enough apparatus, chemicals, and so forth. If the staff is not qualified too, the school becomes under-resourced. You'll find that when a Physics teacher leaves school, a Maths teacher or any other teacher is immediately put in that space to teach Physics...because they are not employing new teachers who actually know the subject. The Maths teacher might have studied science as a second subject, but you'll find that he hasn't been teaching it for years."

"Under-resourced schools are having it tough, because the world is in competition. We are being compared with the schools that are resourced, those that have everything. On the other hand, we do not have anything, but we are doing something. And at the end of the day, when children pass, they are going to be on line with the ones that were resourced."

"Under-resourced schools are schools that are needy in terms of resources, infrastructure, e.g. the buildings, computer centers, home economics centers, libraries."

" Looking at the atmosphere that I'm currently at, I believe that being under-resourced has to be something that poses as a problem, because of the fact that as educators, we have to improvise. For instance, when one does not have a beaker, one can use a bottle of coke, and cut it. So, at the end of the day, a lesson is not affected by the lack of resources as such. But the level of participation and innovation of the teacher, how actively he or she is involved, so that at the end of the day, the objectives of the lesson can be met."

"Under-resourced secondary schools mean that we have some of the equipments, and only to find that we cannot use some of those equipments properly. At the same time, it can also mean that we have run out of, or we do not have, other equipments."

4.9 Laboratory experiments and usage

Whether or not the educators made use of the laboratory resources on a regular basis, most of them were positive about the value of learners doing practical work. Some of them conceded that, in practice, they do not conduct experiments as regularly as they might, regardless of resources. Only Educator B complained about the size of the laboratory in his school and highlighted the usage of the laboratory in other science subjects, which include Biology. In his school, he said, the lab' is being used at all times: "We actually fight for the lab' space, but first priority is always given to Grade 12 learners." As a result, the usage and consumption of resources and apparatus becomes high. All the educators said they had to prioritize in deciding whether or not to do practical work. Under pressure of time as well as equipment, sometimes the teacher had to demonstrate experimental tests to the learners. Smaller groups meant more usage of chemicals and other resources, and took more class time. All teachers noted the problem of having to chase against time in order to cover the year's curriculum. Thus they made their decisions on four grounds: the availability of equipment, the costs of consumables, the time required for practical work, and judgments about cost effectiveness.

While the educators all would have liked more resources and better conditions, they were clear that they would not wait for unavailable resources to become available. There were always alternatives, even if it meant relying on the textbooks and worksheets for much of the time. In most instances, improvisation of equipment and chemicals was part of the solution. Other alternatives were to purchase supplies themselves, or have learners bring materials from home.

For the purpose of improvising, educators referred to different types of materials which they usually make use of. One of them strongly expressed views such as Educator B's, that "*there is a lot of chemistry that takes place in the households*" on a daily basis. Most educators take into consideration the fact that many households have common chemicals and materials that are less harmful which are usually used on a day-to-day basis. Household chemicals and materials they suggested included vinegar for acetic acid; Jik or bleach for chlorine-H_2O; surge laxative for phenolphthalein; potassium permanganate; table salt; fruits or vegetables that have got certain sugars or acids; and glass containers of different shapes to serve as beakers and test tubes. One of the educators said that sometimes she found herself having to go back to narrating to the learners, since improvising with alternative materials consumes too much teaching time.

Just above half of the educators said that sometimes they purchase apparatus out of their own money. One of the main reasons for this was not that the school had no money to allocate to such supplies, but that the process of purchasing took a long time – months or even the entire year in some cases. In some schools, educators felt that the school managers didn't understand the demands of Physical Science, and did not take this learning area as one of the major priorities in their schools. In contrast, they gave examples of schools where school managers are also Physical Science/Chemistry teachers, where the situation was different. Within this study, the educators who said that it never occurred to them to buy materials out of their own pockets proved to be in schools where managers and HODs played active roles in making sure that most of the necessary materials were available.

Asking learners to provide materials from home was also problematic. While a few learners were always willing to bring materials, others seemed not to be interested. At the same time, it was difficult to gauge whether the learners were covering up for financially struggling families, or whether they were uninterested

One of the educators said that her school goes 'an extra mile' of requesting previous learners to donate or sell their old Physical science/Chemistry textbooks at lower costs.

4.10 Teacher and school support

4.10.1 Parental Support

As noted earlier, the schools are generally in poor areas, and homes are often distant from the schools. Most educators complained of lack of parental participation, explaining that parents usually don't pitch up when they are called for meetings, and do not seem to show interest in their children's education. Educator C and D saw reasons for this. Some of the learners do not live with their parents. Parents are far away, and the learners stay with a grandparent, who might be very old, and not physically fit. Other learners stay alone without their parents, in rented houses or rooms in the village.

Unlike the above cases, Educator B complimented his learners' parents for giving their full support to his school most of the times. As both a school principal and a science teacher, he saw the parents as dynamic in the school affairs and activities, and involved in their children's learning. They came to the school for meetings and for appointments when learners were problematic at school. Educator B argued that through parental support and learners' co-operation, learners can do well in their studies regardless of whether they come from rich or poor families. He described the situation in his school, where the community was very poor, and yet the pass rate was high: treating the parents and community as a resource to be fostered and supported was an important idea for Educator B.

4.10.2 Support provided by the NGOs

Educators reported that NGO's such as their local Impala Platinum Mines (Amplats), Lesedi Project, Thintana by Wits University, and Protec, as well as Department of Education Science subject advisors, provided workshops in the area. They stated that attending such workshops had been to their advantage because they learned new skills, better methods of teaching, and deeper understanding of Physical Science concepts. The workshops helped them conduct lessons within the learners' comprehension and link related topics from Grades 10, 11 and 12. Educators believed that working together at the workshops increased their understanding, and served as a model of OBE for the learners in class. Educators pointed out that some teachers understand certain Physics sections better, while others understand some Chemistry sections more, so working together enabled them to share their knowledge.

Educators who become friends through the workshops were not only resources for each other, but also helped each other out with equipment and supplies. As well, Physical Science equipment and materials were often provided as part of the workshops. For example, the RADMASTE micro-kits were provided as part of the Thintana workshops. Some of these schools also received help through donors. For instance, school B has been presented with a television. Teacher E and his colleagues are able to borrow resources from a nearby college of education.

4.10.3 Support within their schools

The majority of teachers reported that they met regularly with other teachers in their schools, to discuss problems, coordinate programmes, and plan together. The meetings also enable teachers who have attended science-related workshops to report back, and to use resulting networks for assistance with resources and ideas. In some instances, teachers from these workshops provide support for other schools. For example, teacher F said she and her colleagues often work with science teachers from the nearby Junior Secondary school, which is about eight minutes walking distance away.

4.11 What happened in the classrooms?

When talking with teachers about the ways they teach, it is always difficult to know whether they are talking about ways they would like to teach or might teach, or ways they do teach. Observing classrooms provided some check on this: as part of preparations for the school visits, all teachers were informed that I would be watching them teach, with a view to how they managed in under-resourced situations and large classes.

In the lessons I observed, teachers had clearly planned their lessons and topics and their classroom management was generally good. They were able to maintain order and discipline, and engage the learners in the lessons (though on a few occasions, some learners would whisper in the background). In most of the schools, the sitting arrangement was in the old style with learners seated systematically in three to four rows parallel to each other, except for school A, where learners were seated in desks arranged in a "U-shape".

At some stages, learners in all the classes engaged in 'group work'. Towards the end of most lessons, there was whole-class question and answer time. Learners in school B seemed quite competitive when responding to questions, especially when they were required to provide reasons for answers that they had given. Nearly everyone had his or her own ways of reasoning.

Most of the educators seemed to know the content of their lessons well. In school D, the teacher often referred back to previous lessons. Most of the educators had compiled notes that they used often. The teacher in school B was the only one who came to classes without notes, working with confidence, and seeming to know everything from the beginning to the end.

General communication between the learners and teachers varied. In schools B, E, F, and G, learners felt free to ask questions and were able to relate their classroom learning with their domestic lives. The teachers encouraged these links: as teacher B commented: "chemistry happens everywhere". In the other schools, a few learners asked questions at some stages, but they seemed unwilling to open up.

During my presence in school A, no experiments were conducted, and no one used kits such as the RADMASTE microscience materials that had been made available during workshops. Learners did not have enough books, but they shared with those who had books. The teacher would ask them to refer to certain pages of the books, whereby they would read short sections for themselves, and she would give clarifications. Their sharing of books compelled them to discuss the answers in groups of two to four. Instead of giving them class-exercises, she preferred to give them homework. She wrote questions on the chalkboard, which they copied onto their books to answer at home. Teacher A said that most of the time, she preferred not to give her learners written class-exercises because they are time consuming. She said that she would rather use that limited time for teaching.

Schools B, E, and G were similar to each other, with learners and teachers all active in the classroom. Experiments were conducted, such as: *1.* Testing exothermic and endothermic reactions; *2.* Roles of temperature and concentration in a reversible reaction; as well as *3.* Measuring reaction rates and products. In these schools, learners brought materials from their homes or equipment they had developed themselves. They brought materials such as old transparent glass containers of different sizes, that served as beakers and test tubes; a small old paraffin lamp, which served as a burner, as well as a candle; an old home-based medicine dropper, as well as a thin hard plastic straw that also served as a dropper; 30cm rulers; and a few thermometers that were brought by a learner whose mother worked as a nurse in one of the nearby hospitals.

Learners in schools B and E were more actively involved in conducting experiments, than in school G, where learners were involved, but the teacher did most of the work, demonstrating to the whole class, with the help of three learners. The teacher said that she was doing so in order to save time. She said also that having all the learners involved in "hands-on" experience was not cost effective: the school would run out of materials quickly if everyone was to be directly involved in experiments all the time. The strategy that she put into place was to carefully rotate the learners' direct "hands-on" involvement.

The situation in schools C and F directly compared to school A. The difference was that in schools C and F, some of the textbooks that learners used were tattered and had loose pages. The teachers in these schools said that they usually encouraged previous learners to donate books to current learners, or to sell them at very low prices.

In school D, learners did not participate actively except when their teacher asked questions. Much of the work done in my presence turned out to be revision work. Learners were given worksheets to answer as individuals. On a different visit, they were given worksheets, which they answered in groups.

4.11.1 Opportunities for learning

Notwithstanding complaints expressed earlier that many learners were not motivated, most of the educators described their learners as people who are willing to learn regardless of the conditions they find themselves in. Learners were regarded as taking active roles in classroom activities and laboratory experiments. Educator F described his learners as people who openly comment during lessons and easily relate most of the lessons with their daily lives.

Group-work was one of the strategies most educators said they favoured. Most of them said that they always encouraged learners to work in groups, as group-work is an efficient way of helping learners to understand concepts. For instance, Educators C and F commented that even after they have tried repeatedly to explain an idea, some learners still couldn't understand or relate to what the teacher was saying. Those learners were often helped by group discussions. On the other hand, Educator A feared that sometimes learners rely too much on others, and end up being "spoon-fed". She said that in such cases, she needs to be careful to monitor their group-work. Educators B and D similarly were concerned that some learners did not take group-work seriously, and had to be followed around to make sure they were progressing. Most of the teachers felt that part of the teaching and learning in their classrooms was learner-centered, especially in that learners come up with solutions to problems. In spite of these professed commitments to group-work, as noted earlier, in the lessons I observed, group work was often limited to discussion a piece of text or a standard problem– not planning activities, exploring relationships between ideas presented and their own experiences, or shaping the development of the lesson.

In these schools, educators affirmed that they use English as the medium of instruction because the text is written in English, and they believe that they have to do so in order to meet the suitable standards of science. Educator A was confident that her learners learn science terminology in English and use it correctly. She felt that they encounter language problems but not with science terminology. Educator B outlined that he always starts the topics by first explaining most of the terminology before dealing with the main contents. Other educators generally said that the most important thing for the learners is to understand what they are learning. They believe that the issue of science concepts and misconceptions is not determined by the English language, but by the learners' conceptual grasp of what they learn.

Among the aims of Physical Science are the development of process skills, and methods of science. Educators expressed different feelings about these aims, based on what they felt was practical. Some educators felt they were addressing these aims while others felt it had not been possible for them to do so. Those who believed it was not practical pointed to constraints of time and resources. Others felt that as long as a teacher is committed, he or she would always find ways to deliver effectively.

The general view was that Physical Science teachers need more continuous support. Some of these educators emphasized that even though they improvise, it is not always effective because some learners have difficulties understanding the relationships between improvised and actual materials, as well as concepts thereof.

To guide the classroom observations, a rating scale developed by the Centre for Education Research, Evaluation and Policy (CEREP), at the University of Durban Westville was used, with modifications. It has items that fit under three broad headings:

- Classroom management, Orderliness, Goal direction and Plan, Teacher's content knowledge, Learners' engagement.
- Outcomes and opportunities to learn – especially conceptual knowledge, problem solving and critical thinking, systems thinking and metatheory, teamwork and inclusivity, lesson connections
- Assessment and monitoring

The results are summarized in Table 4.3, and reflect the discussions of classrooms provided above. All the educators scored well on general management and monitoring. With the exception of Educator B, the rest of the educators generally scored poorly on opportunities for outcomes such as problem-solving, systems thinking, teamwork and lesson connections. The emphasis in their classrooms was on the transmission of knowledge and conceptual understanding, and they generally did this in traditional ways.

Table 4.3 Rating scale: 1 (low) – 5 (high), *therefore 1=unsatisfactory, 3=average, and 5=excellent*

CATEGORY	TEACHER						
	A	B	C	D	E	F	G
Classroom management, Orderliness, Goal direction and Plan, Teacher's content knowledge, Learners' engagement	4	4	4	4	4	4	4
Outcomes and opportunities to learn:							
Conceptual knowledge	3	5	3	3	4	4	3
Problem solving and critical thinking	2	4	3	3	3	3	3
Systems thinking and metatheory	2	3	3	2	2	2	2
Teamwork and inclusivity	2	4	3	2	4	3	3
Lesson connections	2	4	3	3	3	3	2
Assessment and monitoring	3	3	4	3	3	4	3

4.11.2 Assessment methods

Comprehensively, the educators preferred to use standard methods when assessing their learners: class exercises; homework; class tests; oral questions; worksheets; follow-up experiments and demonstrations; individual and group assignments, and projects. These choices are consistent with the exams that the Provinces conduct. Teachers were well aware of this, and the emphasis such exams place on knowledge, rather than process skills. Most educators said that they did not choose approaches such as peer assessment because sometimes learners undermine each other's performance. Most of the educators simply said that they practice these assessment methods in order to keep track of their learners' progress. In my observations of classrooms, only one teacher made effective use of assessment as feedback to students, asking them to justify their answers, explain relationships they saw, predict the consequences of their ideas.

4.12 Some of the attitudes developed by teachers

Educators were also asked about the attitudes and morale of teachers who teach Physical Science in rural secondary schools. Most of them expressed feelings of demotivation and frustration. Even though they had previously stated that they always try to find alternative ways to make their teaching possible they still need a lot of support and courage.

Educators also felt that the time factor was an issue of concern, the time allocated to teach Physical Science was not enough, especially while Physical Science will remain to be a learning area with continuous demands and challenges. One of the educators felt that other educators have a negative attitude towards the subject. That is, they always give learners the impression that Physical Science is difficult, that such educators do not motivate the learners at all. The educators also felt that not enough is being done to show the correlation amongst Physics, Geography, Biology, Mathematics, Agricultural Science, and Language subjects. This would encourage teachers of these subjects to work together most of the times, and the Physics teacher would not feel isolated from the others.

They complained of little or lack of enough support from other stakeholders, such as their school managers; parents; and regional offices. Their rationale behind such thinking was that as Physical Science is one of the most challenging learning areas, at least parents (who are the most reachable stakeholders) needed to be actively involved in their children's learning processes, whether the school has resources or not. They felt that lack of some resources was stressful enough, and without enough support from the stakeholders, the whole burden of dealing with Physical Science and learners was left upon their shoulders. During this time, I could clearly see the silent expression that said, "I'm really tired of this situation". These educators said that when learners fail exams, parents always say that teachers don't do their job. This makes them feel that they get a negative reputation from the society.

A few educators agreed that they would definitely accept new jobs in other schools that are well resourced if they were to be offered. They said that the situations in their current schools concerning Physical Science/Chemistry resources were highly discouraging. On the other hand, the majority of educators felt that regardless of the conditions in their schools, they would not intend to abandon their current schools for better and well-resourced ones. They explained that even if a school can have all the teaching and learning resources, there will always be other demanding responsibilities to face. They said that they would not leave their current schools as they felt they still have important roles to play in their learners' lives. Whether their learners are not doing well academically, these educators felt that they are the ones who understand them very well. They said that going to well-resourced schools would not necessarily guarantee the best academic performance of learners. One of these educators frequently mentioned the fact that he felt very comfortable in his current school, and that if he were to go to a new school which is well-resourced, he would be under a lot of pressure to make sure that everyone there had to pass. If learners failed their exams, parents and other teachers would highly scrutinize his teaching methods.

When given the choice of answering with: **SA** for (Strongly Agree), **A** (Agree), **D** (Disagree), and **SD** (Strongly Disagree), the following responses were given by the educators to item number 2.3 on the questionnaire:

Table 4.4 ***A table to show how educators felt about the conditions of teaching Physical Science in their schools***

Statement/Question	**Number of educators per Response:**			
Educators:	**SA**	**A**	**D**	**SD**
-Honestly felt that their schools are under-resourced	2	3	2	-
-Conduct experiments on a regular basis	3	4	-	-
-Regular usage of laboratory resources, i.e. chemical, electric circuits	2	3	2	-
-Mostly find themselves without necessary Physics teaching materials	1	3	3	-
-Nothing can be done when there are no resources	-	-	-	7
-Buy resources out of own money	1	3	1	2

-Feel like moving to a school that has got better Physical Science resources and conditions		2	-	4	1
-Problem of resources deeply affect the academic performance of learners, especially those who are in Grade ten		2	2	3	-
-Learners are willing to take initiatives to cooperate when they are told to bring resources from their homes, in order to improvise		1	3	3	-

...Table 4.4 continued.

CHAPTER 5

5. DISCUSSION AND CONCLUSIONS

5.1 Introduction

This chapter brings about a discussion that takes the study back to where it began, right through to the end. It begins by summarizing the study: its aims, critical questions, literature review and methods, which all lead towards the end results, concerning how teachers go about their work when finding themselves in multi-dimensional rural school contexts. It extends this discussion by encompassing broader issues on under-resourced nature that are experienced by learners, originating from outside the school contexts.

5.2 What the study covered

The aim of the study was to investigate the meanings of 'under-resourced schools' that teachers in rural secondary schools face, and how the teachers respond to the challenges. The study was shaped by the following critical questions:

- How do physical science teachers in rural secondary schools define 'under-resourced' in their schools?
- How do Physical Science teachers in rural secondary schools deal with an under-resourced teaching environment?
- What beliefs do such teachers have about effective Physical Science teaching and learning, in these contexts?

The sample of teachers consisted of one Physical Science teacher from each of seven schools in a particular district in the Bafokeng area.

The study provided a general description of the area(s) where the schools are situated. This included the different villages, which collectively form a single Bafokeng district.

It offered a depiction of the demography of population that is found in the area, as well as its socio-economic status. This aided in giving a picture of not only where the schools are located, but also the kind of people who live around the area, as their children are the ones who form the majority of the learner population in the schools.

The type of *traditional* leadership that the Bafokeng fall under was explained, and this refers to the leadership of King Molotlegi. The context of the study partially looked at the fact that the Bafokeng are an independent community, which has developed itself progressively over the past decades. The achievements and the ways in which the Bafokeng have maintained their educational infrastructure is further explained in Chapter 4. And the nature of this study does not under any circumstances undermine the *(educational)* achievements of the Bafokeng people. It tries to give a reflection of the kind of situation that *(science)* teachers *(and others in general)* are normally faced with.

The study also described the school environments, whereby focus was laid on what the schools already had in terms of the (basic) resources and needs for teaching and learning. This refers to things such as the infrastructure, electricity, water supply, furniture, and so forth. In addition, the study gave attention to how the schools cater to learners, in terms of classrooms and seating, libraries, laboratories and equipment.

The teachers are the most important resource for learning available to the learners. The study, through interviews, questionnaires and observations, obtained detailed information on the teachers' qualifications and experience, their understandings of their schools and communities, their beliefs about teaching and resources, the resources they had and did not have, and the strategies they used in the face of lack of resources. As well as asking them to explain their beliefs and strategies, I observed their lessons, to see what they actually did in their classrooms.

5.3 Under-resourced communities

During the interviews with the teachers, it became clear that they thought of 'resources' more broadly than equipment and laboratories and libraries. All of the teachers showed great concern, though often with some confusion, about the effects of poverty, unemployment and community disruption on the learners, and how the learners' backgrounds affect their learning.

Different teachers had different views. It was due to what they had observed when looking at their learners over a continuous period of time, as well as particular experiences that they had encountered. For instance, most of the teachers gave a reflection that their learners generally come from poor family backgrounds, and some of them had sad but distinctive stories to tell. The stories ranged from learners who used to sleep, even in class, with empty stomachs; poor health due to undernourishment; learners who suffered from parental negligence and abuse; learners who had to face cold winters without warm school clothes; and learners who lived alone at home, or with their very old grandparents.

While some of the teachers could only go as far as narrating and feeling sorry for the learners, others explained how they always go an extra mile, making a combined effort with their colleagues and some of the community members, to make sure that such learners were taken care of in possible ways. This was not only for the sake of filling the learners' stomachs and helping them with other such problems, but also to making attempts for proper learning to take place. One such example was a teacher who went out of her way to convince previous learners to donate or sell their old books to those who are still at school. These teachers tried to put such learners on the same level as others whose family backgrounds were of a better nature. The teachers tried to make sure that these learners, from poorer family backgrounds, would be able to focus in class, just like others who came from better family backgrounds.

On the other hand, some teachers were able to notice other learners whose versions were different, such as learners who did not consider their educational needs as their first priorities; and negative influences outside school. They referred to learners who would rather buy fancy clothes with the little money that they had, instead of buying proper school cloths; and learners who would rather use their money for extreme entertainment purposes, such as going out at night to drink. These instances, in some ways, seemed to have had a huge impact on how some teachers viewed the learners generally from different background. Perhaps it was true that some learners were more interested in spending their money on non-academic activities, but the possibility is that it may be unfair for those who really struggled financially, as they seemed to have also been generalized with the ones who cared less about their educational needs.

Learners were also affected by other issues such as limited access to transport. Some usually had to find themselves having to walk for long distances to school. This could be due to a variety of reasons, such as that they missed their transport, they could not afford to pay for transport on a daily basis, or their homes were far from the routes where transport was available. Also for different reasons such as maintaining discipline and safety in the most of the schools, and encouraging learners to arrive at school on time, the gates usually were locked for the day.

The complex nature of the community as a resource showed up also in the teachers' views about the commitment and motivation of learners and their families. Some teachers complained that their learners and the learners' parents were not motivated about the value of education, and pointed to the problem that learners saw their older brothers and sisters complete school but then not get jobs, or the problem that their guardians (whether one parent, two parents or grandparents) were themselves poorly educated and did not properly motivate and support the learners. At the same time, some teachers (often the same ones who complained about their learners) said that their learners were highly motivated, and worked well in class. Clearly different learners are differently motivated and face different problems, and their motivation changes from one week to another. Some schools (especially School B) went to a lot of trouble to involve parents, and to build a strong sense of community and commitment within the school, in something of the same way that Malcolm et al (2000) describe in their report on schools that are highly successful in spite of the poverty of their communities.

5.4 The usual experiences in teaching science

The teachers' strategies in teaching Physics showed some unique as well as common creative methods of teaching under the set conditions. In all that I witnessed, heard, and commented on, I tried by all means not to judge their actions, but in some ways, school B seemed to be different from the other schools, as became evident in chapter four.

In talking about their schools, the study revealed that participants understood the concept of being *"under-resourced"* in different ways, mostly due to their teaching experiences over the past years. For instance, even though they explained this concept in nearly the same manner, the illustrations that they gave were unique. One participant's example was that the school was always running short of some apparatus, such as chemicals, while the other teacher's focus was more on the number of learners as compared to the space available (which also affected the teacher-learner ratio). Most of the other participants said that they always have a problem of outdated resources, and lack of Physics teachers. These different problems are not separate and independent: they come in combination, making some schools quite harder to work in than others.

The study revealed that the teachers' content knowledge in the Physical Science learning area contributed a lot towards the development of different teaching strategies. Content knowledge was important not only in actual teaching, but in identifying alternative resources. For instance, when the participants in the study talked about improvising materials and apparatus by encouraging learners to bring from their homes or to create whatever they could, it showed their knowledge of science in the daily living of their learners as ordinary people. They tried to encourage their learners by making them aware that science does not only happen at school. In this instance, it showed that curriculum goes beyond the classroom. According to Putsoa and Maphalala (1999), involvement in the construction of teaching/learning materials should generate a sense of meaningfulness in the teaching.

Some participants believed that for as long as they mastered the content of their learning area, they would always make sense out of whatever they teach, with or without resources. This they saw not only in terms of set exams, but in identifying resources in the community and making links between the science in the syllabus and the science in learners' lives.

5.4.1 Activities...

For most participants, it was easy for them to admit how problematic it was for them not to have some or most of the resources that are required to teach Physics/Chemistry.
The study revealed that, even for those participants who initially said that they did not have much of a problem with their resources, some of the chemicals in their laboratories were outdated, probably more than ten years old. Some of these participants said that they still made use of such chemicals during experiments, but the results were sometimes unpredictable.

For participants who said that they could no longer make use of old chemicals and equipment, another problem that they faced was how to dispose of such chemicals safely. They could not do so themselves, as they were afraid that they could endanger the environment.

During the interviews and in the questionnaires, the teachers had many ideas and examples of how they try to overcome resource problems – for example, by doing demonstrations with equipment they had, improvising equipment, getting learners to bring things from home (such as bottles and other containers, household chemicals, and fruits with particular properties), buying materials with their own money, borrowing from other schools and a college of education, using kits such as the RADMASTE micro-science kits, and recycling and sharing text-books. At the same time, some teachers were cautious about these strategies: the strategies were a lot of trouble and the results often not convincing. Especially, they took a lot of time, and teachers felt the pressures of the timetable (often with short periods), exams, and covering the syllabus.

My classroom observations showed that, even though the teachers are thoughtful of possible solutions to their dilemmas they usually face, and knowledgeable about teaching techniques and ways to surmount equipment problems, sometimes their beliefs and claims do not match what they do. In spite of my making clear to them my interest in the ways in which teachers managed a lack of resources, none of the lessons I observed, for example, involved improvised equipment or kits, or had some learners do experiments while other learners did something else. For instance, during the observations at School A, it was not clear as to what actually initiated group-work – whether it was done because of its potential for discussion and bringing in learners' ideas, or the simpler need to share text-books. In some ways, it seemed that learners who did not have books were simply forced by circumstances to share with those who had books and, as a result, they had to sit together and talk together. Generally, the teacher was the one who dominated the lessons, and learners were not actively involved most of the times.

On the other hand, some teachers are always more creative than others, less inclined to make 'resources' an excuse. For example, participants such as teacher B met most of the challenges. In spite of being the one with the highest number of learners, this school proved to be outstanding. Besides being overloaded with more school commitments as a school principal, teacher B managed very well. The (large) class did experiments, and when conducting experiments, there seemed to be a lot of mutual understanding between the teacher and the learners. Learners played major roles in their learning, as they were always active participants. Amongst other learning areas in this school, Physical Science was ahead in terms of learner enrolments.

When looking carefully at chapter four, the roles of other participants and their schools in this study are greatly recognized. The reason why I am highlighting the above two schools, A and B, is that out of all the schools and participants in the study, these two seemed to be the most extreme. So, it is suitable in this case to make comparison with them.

5.5 What the study displays

The study tried to look at what defines under-resourced schools, and the challenges that educators are faced with in under-resourced schools. The shortage of teaching and learning materials in the rural schools is usually compounded by lack of resources in the surrounding communities, which limit active support from the communities, which themselves are generally poor. In this context, teachers and school management are important in ways that go beyond classroom teaching and efficient administration. Their roles are complicated. On the one hand teachers and school managers are faced with problems they feel they can do little about (such as poverty and social problems in the community, or lack of equipment in the school) but on the other hand they are drawn into these situations, and do things they can do – perhaps small, such as improvising equipment, or providing food for a hungry learner, or larger, such as recycling books, organizing a school lunch programme, and working to build the school itself as a strong and active community.

Some of the teachers, together with their schools and the community members, were very considerate about their learners' needs. They could link the relationship between classroom learning and the negative effects of learners' home backgrounds. These teachers realized that for learners to be able to concentrate in class, someone had to make sure that the learners' stomachs were not empty. Several examples were provided in chapter 4 of teachers who brought lunch boxes for needy learners. Also in one of the schools, there was a van that brought food for these learners. Some teachers were also able to spot learners who had different kinds of serious problems in their homes, such as fear of a dominant father, as well as learners who were neglected by parents. These teachers found ways to support such learners.

The findings of this study encourage an insinuation that resources have to be considered more broadly than the teacher and his/her equipment, books, and other materials. It is highly due that other factors that directly and indirectly affect the teaching and learning in the rural schools are considered on a serious note. For instance, in the schools that were studied, the conditions in the communities are critical dimensions of resource levels. This implies that we have to think about education and resources more expansively than the common focus on what teachers and learners do in their classrooms. The findings of the study provide a reflection that shows that the issue of resources goes beyond the classroom setting.

Support and co-operation within and outside the school from different stakeholders does have an impact towards teaching and learning, whether directly or indirectly. Aspects outside the school that affect the teaching and learning are: learners' access to transport; parental involvement and domestic living arrangements (some learners staying alone or with their very old grandparents, because parents have died or work far from their homes); learners' interest and cooperation in their learning in the face of outside (peer) influences, competing demands on their energy, and their limited prospects of finding employment or entering tertiary education when they finish school

Beyond describing the broad and complex nature of the situations these teachers, school managers, learners and communities face, and the ways the teachers tackle resource issues in their teaching, the study raises the following:

- The level of school management systems' interest in the science learning area can play a vital role towards how science in the schools is maintained. The head teachers' knowledge and interest for science enables them not to treat science like any other learning areas where the resource requirements are different. Instead the school heads are able to realize the unique needs and requirements that physical science poses.

  In most schools, head teachers generally have a lack of science background. Given that they are still generally the ones who make major decisions for science, just like for any other school subject area, they have to have systems in place to support and promote science education. For instance, in this study, some of the educators complained that when science resources are required, some of the school principals do not understand why this has to be the case, since other learning areas do not demand as much. Sometimes it takes a very long time for the schools to purchase or receive science materials.

In this study one science teacher was a school principal. He had a clearer understanding of the requirements in the science learning area, and the demands thereof. As a result, he played vital active roles in the due process. As a consequence, teachers in his school generally tried to go an extra mile, because he made sure that the demands for science learning were attended to properly. The level of learner activities, involvement and performance in science seemed to be outstanding in this school as compared to other schools.

- Pena (2000) supports parental involvement in school education. His study showed that schools with a higher parental involvement outperform those with little parental involvement. In my study, data collected from school B as compared to other schools clearly puts this into detail. The school principal said that even though the community surrounding his school was generally poor, parents usually played active roles in the school affairs. In the other schools, where the communities seemed not to be greatly different, most participants said that it seemed to be a norm for parents not to be involved into schools' activities.

Participants gave a broad-spectrum of reasons for lack of parental involvement, and they are explained in chapter 4. Literature also reveals that parents do not participate who have limited education. Even if communities in the rural areas are willing to contribute, they themselves are victims of poor education, unemployment and general poverty. Based on such factors, Mathonzi (2001) explained that it is problematic to compare physical indicators of poverty with social indicators in rural areas. For instance, the construction of a new school does not in a way change the profile of the community that surrounds the school, and need not in itself result in improved education.

- Reports by the Department of Education (2001), as well as George and Kaplan (1998), suggest that improvement in science largely depends on the competence of science educators, and the educator's performance and practices. The Department of Education also addresses issues concerning the ongoing professional development of in-service educators. Higher education institutions as well as the non-governmental organizations are encouraged to play active roles in improving the knowledge and skills of educators, develop new programmes for educator preparation, strengthen subject matter and content knowledge. Naidoo (1997), for example, outlines the contributions that NGOs can make. Through current teacher education programmes, more focus is laid on: teacher capacity development, curriculum reform and outcomes based activities. All the teachers in the study are already involved in teacher development workshops that are offered by different sectors, such as the Education Department and NGOs, often with support from private industry. The teachers seemed to be really happy with the knowledge and skills that these in-service development sessions provide, and the networks of teachers that are established. From that point, it has to be up to the educators to extend their skills and to bring their new knowledge into their schools and classrooms. Some teachers in the study seemed to be more creative than others, by going an extra mile, making use of ideas and materials they had obtained through workshops.

- According to Naidoo and Savage (1998), pupils can be creative in identifying and collecting materials and resources for activities. Through improvisation, local resources can help in that they can be used to represent unavailable resources and materials. Rijsdijk (1997) noted that equipment used for demonstrations could be made up from scraps and other odds and ends, and other different materials that are within reach for the learners and teachers. Some of the teachers in my study encouraged their learners to collect materials, or bring from their homes the things that could be used for their learning. Teachers' perception was that this made it easier for learners to understand the relevance of the set curriculum towards their daily lives. However, such improvisation was often difficult to organize, and the results often not as effective as had been hoped.

- Rivard and Straw (2000) report on the value of learners using group discussions as part of learning – a technique that might seem especially appropriate in large classes, where individuals have limited access to the teacher. Rivard and Straw (2000) suggested that peer talk is important for distributing knowledge, and can enhance student understanding by extending available knowledge. This claim is also supported by Naidoo and Savage (1998) and Bianchini (1999). However, Bianchini also warned that group-work needs to be carefully managed; otherwise its benefits would not be reached. Some of the participants in the study used group-work effectively, by actively involving their learners in the classroom activities. Others were less successful: instead of learners being actively involved in groups, groups-work appeared to be mostly a process of sitting together when reading a book or doing a problem.

- Much of the literature explains how it is not easy to move teachers away from traditional methods of teaching. This can be due to lack of enough resources, lack of proper training towards the usage of available resources, teachers' workloads, knowledge, or motivation and resistance to change. In this regard, my study seemed to raise several contradictions. For example, some of the participants provided outlines of the alternative ways that they employ when teaching in under-resourced classrooms, but what I observed was different from what I was told in the interviews. Meanwhile other teachers displayed what they said in the interviews during the lessons

- Several researchers (such as, Baeta and Machado, 1999, Gadelha and Schall, 1999, Henriksen and Jorde, 2001, and Lucas, 1983) have supported the need for learners to visit science-related centers as well as field trips. They see this as part of the non-formal education, but enriching the learning experiences at school, and providing motivation for the learners in the field of science. Most of the participants in the study agreed that they 'sometimes' take their learners out to visit areas related to science and technology, especially to motivate the learners about the importance of science, mathematics and technology, and possible futures careers.

- Questions of motivation – and even the relationships between motivation and achievement are complex. For some learners, the teachers said that no matter what was done in the school, it was very difficult to motivate these learners. The main reason the teacher suggested, was that because the community was generally poor, the learners' older siblings who had finished Grade 12 could not afford to go to tertiary institutions to further their studies. They could also not find work. So some of the learners who were still at school could not see the importance of taking their education seriously. Instead, they would opt for outside entertainments and peer activities.

5.6 Some more positive outcomes

Participants said that they always look at the problem of lack of enough resources as a challenge that empowers them in a sense that it leaves them with no other options, and as a result, they must come up with creative methods in order to survive. The impression that I got from some of the participants was that if a Physical Science teacher is not willing to go an extra mile, s/he wouldn't cope with the given conditions of resources. "Going the extra mile" had a number of aspects – working with learners, working with other teachers, attending workshops.

Participants explained how their local Platinum mines (AMPLATS), as well as other NGOs and companies such as Thintana, Protec and Lesedi have come to their support in the most tremendous ways. Support varied from teacher-training workshops to the supply of inexpensive and 'easy to use' resources such as micro-kits. The micro-kits the teachers saw as flexible for teaching in and outside of the classroom/laboratory situation. The outside support systems have supported teachers' development and confidence to teach. Most of the participants felt that they have learned a lot from the workshops, such as new problem solving skills for their teaching. Also importantly, they gain ways of knowing how to cope with curricula demands in science. Since this kind of support has led to teachers meeting on a regular basis, they are now able to network with each other in order to come up with different problem solving strategies.

Discussions among Physical Science teachers themselves seemed to be something that has become a norm, just as teachers also try to encourage their learners to practice group-work and peer-learning. They said that discussions with other teachers increase their content knowledge and their confidence. Some of the participants also found it very useful to borrow apparatus and other Physical Science/Chemistry equipment from their neighboring schools.

Most of the participants also give credit to the significance of field trips or trips to the science related centers. They said that sometimes they take their learners to visit the mines, airports, the SABC, the Planetarium, as well as other centers that are directly related to science and technology. Participants who take their learners for such visits, said that the major purpose was to encourage learners as to where science and technology can take them in the future.

5.7 Important aspects to be considered in future

Teaching science in a rural school is not easy for the teachers. They are faced with challenges that can persuade them to be creative in different ways, or they may lose their passion for teaching under such demands. Based on my study, it is essential to take the importance of the following inter-connected aspects into consideration:

- Teachers are not always *"the know it all"* in the classroom. In other words, active participation from the learners can play a vital role in the daily teaching and learning processes. Activities in the classroom are also important, as learners will not always be in the receiving end.

- *Parental and community involvement* not only in the general school activities, but in the classroom situation is important. This makes it easy for the teachers not to feel that all the classroom teaching responsibilities are left on their shoulders alone. It is also vital that parents are encouraged to be directly involved in their children's education.

- It is important for Physical Science teachers to be directly involved in the *decision-making* processes, as they are the ones who know the actual needs for Physical Science, and they have direct and intimate knowledge of their learners.

- *Teacher-Development* and Support Mechanisms play a very positive role towards the way teachers look at the complicated process of teaching. Such mechanisms serve as direct support to the teachers, as they deal directly with the teaching of Physical Science. It also highlights the important roles of NGOs towards education.

- Learners as well as teachers must be encouraged to *improvise* for unavailable science materials. In this manner, they will know that there must not be an excuse for not having quality education, even if they do not have high class learning materials. This also helps in bridging the gap between classroom learning and people's normal daily living. Learners would also know that they have to take initiatives for their own learning.

- *Group work* provides an important purpose towards diverse learning, as long as it is properly managed and not looked at as just a period of time when learners are seating together. Through group discussions, learners can acquire more knowledge and ideas from each other, and the teacher gets a reflection of the learners' ways of critical thinking.

- It is necessary to send learners to science and technology-related places, as this may serve to encourage or motivate them in seeing the importance of science careers.

- One of the most important aspects to be considered, not only in under-resourced schools, is to make sure that some of the learners' primary needs are catered for. This directly refers to the issue of learners who come from poor family backgrounds. As it has already been explained in the study, some schools, teachers, and/or community members, took initiatives of ensuring that learners who came from extremely poor family backgrounds had food to eat for lunch, like other learners. As writers such as Adler (1979), Tuckman and O'Brian (1969), and Ruch (1963) point out: poverty affects mental health, and may lead to depression and low self-esteem. As compared to children from middle class families, children *(learners)* experiencing poverty tend to communicate less. Resources and the improvement of education are not only about what happens in classrooms, and are not only the responsibility of teachers.

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APPENDICES

A questionnaire to study the ways in which Physical Science teachers in rural secondary schools conduct their teaching process, as well as their views on teaching in an under-resourced context.
Region: North West, South Africa
Area: Bafokeng, Rustenburg.
Researcher: Kgomotso Legari
Institution: University of Durban~Westville

March/April 2002

***Please note that if you do not wish to include your name in this questionnaire, your confidentiality will be highly respected.**

Name of School: ____________________
Name of teacher: ____________________
Date: Day/ Month/ Year

SECTION~A

1. BIOGRAPHICAL DETAILS & TEACHING PROFILE

***Please mark with a cross "[X]" on the appropriate answer/box.**

1.1 Gender: [Male] [Female]

1.2 Age Group: [18-25] [26-35] [36-45] [46-55] [56 >]

1.3 Are you a fully qualified teacher? [Yes] [No]

1.4 Which qualifications do you currently have?
[Diploma only] [Degree & Diploma] [Degree only] [Degree & over]

1.5 Have you done a special method course in Physical Science in the above qualification?
[Yes] [No]

1.6 For how many years have you been a teacher?
[0-4] [5-10] [11-15] [16-20] [21 >]

1.7 Which Grade[s] do you currently teach?
[8] [9] [10] [11] [12]

1.8 How many Physical Science teachers do you currently have in your school?

[1] [2] [3] [4 >]

1.9 What is the average number of Physical Science learners per class in your school?

[Below 15] [Below 20] [Below 25] [Over 25] [Over 30] [Over 40]

SECTION~B

2. THE TEACHING ENVIRONMENT AND SCHOOL CONTEXT

2.1 Type of area in which your school is located:

[Rural] [Semi-Rural] [Farm]

2.2 Does your school have the following?:

	Yes	**No**
Electricity		
Sufficient water		
Library		
Enough books for Physics in the library		
All the learners in your classroom(s) have their own Physics Books		
Laboratory		
Sufficient laboratory/testing equipment		
Relevant Physics teaching aids		
Scientific models		

2.3 Please circle the most appropriate answer below
SA= Strongly Agree, A= Agree, D= Disagree, SD= Strongly Disagree

2.3.1 You honestly feel that your school is under-resourced especially in respect of Physical science	SA A D SD

2.3.2 During Physical Sciences lessons, you usually conduct experiments	SA	A	D	SD
2.3.3 You (and your learners) use laboratory resources such as - chemicals, test tubes, electric circuits, Bunsen burners, and other apparatus on a regular basis	SA	A	D	SD
2.3.4 In most occasions you find yourself being without necessary resources for Physical Science lessons/experiments	SA	A	D	SD
2.3.5 When there are no resources that you need for experiments/lessons, you stop work and wait until the school buys/receives them (even if that can take a week)	SA	A	D	SD
2.3.6 Sometimes you buy equipment with your own funds, if the school does not provide it	SA	A	D	SD
2.3.7 There are other alternative ways that you usually use when you run out of resources	SA	A	D	SD
2.3.8 Because of problems concerning the proper availability of Physical Science resources, you sometimes feel like you can go to a school which has got better resources	SA	A	D	SD
2.3.9 You feel that this problem of resources deeply affects the performance of learners, especially those who are in Grade 10	SA	A	D	SD
2.3.10 Your Physical Science learners (take the initiative to) cooperate when you request that they bring resources from their homes	SA	A	D	SD

A questionnaire to study the ways in which Physical Science teachers in rural secondary schools conduct their teaching process, as well as their views on teaching in an under-resourced context.
Region: North West, South Africa
Area: Bafokeng, Rustenburg.
Researcher: Kgomotso Legari
Institution: University of Durban~Westville

March/April 2002

SECTION~C 1

3. METHODS AND ALTERNATIVE WAYS OF TEACHING PHYSICAL SCIENCE

***Please answer the following questions in full, specify when necessary**

3.1 One of the aims of Physical Science is to develop in your learners the necessary skills, techniques and methods of science. As a teacher in a school that has limited access to Physical Science resources, do you think this is always possible in your own school? Why? (Explain fully)

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3.2 As compared to chemistry, some of the topics in physics can be taught without requiring special instruments. For example, one can demonstrate Newton's Laws of motion in or outside of the classroom, but chemistry lessons require equipment and chemicals. In the case where there is an absence of such materials, can you explain what other alternative ways you usually use?

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3.3 What attitudes do you think teachers in schools without proper resources develop? (You may state your own attitude concerning this, or attitudes that you may have observed from other teachers).

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3.4 If you had all the resources to teach Physical Science, how would this affect the performance of your learners? (Explain briefly)

3.5 Having the experience of working in an under-resourced school, do you honestly feel that even if resources may be available at some of the times, you do not/would not use them because you are able to conduct lessons without them? Explain

3.6 Do you usually attend sessions/workshops related to Physical Science teaching? (Specify)

3.7 What have you learned from workshops related to teacher development for Physical Science?

3.8 What are the constraints of obtaining resources?

3.9 Have you improvised equipment which was not available at any time? (Describe)

SECTION~C 2

4. EXPERIENCE WITH LEARNERS

4.1 At this point in time, you probably know most of your learners very well. Please give a brief explanation about their role during Physical Science lessons.

4.2 Are there cooperative learning strategies that your learners use to learn on their own? (Please specify)

4.3 Do you think their role(s) make Physical science to be regarded as learner centred in your school? (Why?)

4.4 How do you respond to some English Second Language learners when using western science terminology in Physical Science?

4.5 Based on your answer for the above question (4.4), do you think that at times there may be serious misconceptions?

4.6 Please explain the methods that you usually use to assess your learners.

4.7 Does this help you to keep track of their performance? (How?)

4.8 Do your learners practice peer assessment? (If the answer is yes, please explain how?)

4.9 Apart from being under-resourced, what other factors make the teaching and learning of Physical Science difficult to conduct in your school?

Kgomotso Legari: COMET 2
Dissertation,
University of Durban~Wstville

INTERVIEW SCHEDULE FOR PHYSICAL SCIENCE TEACHERS IN RURAL (UNDER-RESOURCED) SECONDARY SCHOOLS

✓ **All the questions below are based on the following Critical Question:**

1. **How do Physical Science teachers in rural secondary schools define 'under-resourced' in their schools?**
2. **How do Physical Science teachers in rural secondary schools deal with an under-resourced teaching environment?**
3. **What beliefs do such teachers have about effective Physical Science teaching and learning, in these contexts?**

***[For each of the following questions, the subject will be asked to explain briefly or give specific examples if possible.]**

CATEGORY 1: PHYSICAL RESOURCES	PURPOSE:
1.1 How can you explain the notion of "Under-resourced Secondary Schools"?	**-To look at the way Physical Science teachers understand the concept of being "Under-resourced", as well as how they this concept.**
1.2 Do you think that most of the schools in your area are under-resourced, especially when looking at Physical Science?	
1.3 How is your school as compared to others in this instance?	
1.4 Do you see being under-resourced as a serious setback during the process of your teaching?	
1.5 Does your school have any Physical Science materials that you find irrelevant/not useful/outdated?	**-To get an overview of the usage of available resources, as well as to know about any irrelevant materials + extension of the research questionnaire.**
1.6 Do you have a laboratory?	
1.6.1 How often do you use it?	
1.6.2 What other Physical Science resources do you have in your school?	

1.7 Did you find the need to improvise when equipment was not available?	

CATEGORY 2: STRATEGIES	PURPOSE:
2.1 What are the major strategies that you usually apply when teaching without proper resources?	**-To look at different/alternative ways that a Physical Science teacher uses in an under-resourced school.**
2.2 What do you think can be a rapid solution to this problem?	
2.3 Don't you think that teaching in an under-resourced school is a challenge that equips you with a greater responsibility of initiating solutions under extreme conditions?	**- To see if anything constructive may arise out of this situation.**
2.4 Do you sometimes take your learners for field trips or perhaps visit places such as factories that are directly related to the actual practice of Physics/Chemistry?	
2.5 Can you please describe teacher development sessions/workshops that you may be attending. (if any).	
2.5.1 Do you find them useful/ Do you see the need for them?	
2.6 Are you able to meet with other teachers on your own in order to discuss about the teaching of Physical Science?	**-To know if the Physical Science teacher(s) practice team teaching as well as the reasons thereof.**
2.7 Do you teach your Physical Science lessons alone or do you use team teaching?	
2.7.1 Why?	

CATEGORY 3: AID/CO-OPERATION	PURPOSE:
3.1 Do you/your school sometimes borrow Physical Science	**- The main aim is to know about**

resources from other schools?	**the level of support that (Physical Science) teachers receive from different context.** **-Also to know if there is co-operation from stake holders.**
3.2 If so, what means of transport do you use to make this possible?	
3.3 Do you feel that the Department of Education provides you with proper support to enable the running of your lessons?	
3.4 What kind of support do you get from the community around your school, especially from parents?	

CATEGORY 4: **VIEWS ON: LEARNERS' BACKGROUND. : EXPERIENCES/EFFECTS.**	**PURPOSE:**
4.1 May you please tell me anything about your learners' background? For instance: does the majority of them come from middle/working class families, poor/rich families, different backgrounds, please specify if possible?	**-To get to know the Physical Science teachers' views on learners' background, and whether this may have any effect on their performance**
4.2 Being under-resourced, do you think that the performance of your learners is improving or deteriorating?	**- To get a picture of the experiences that teachers encounter based on the fact that their schools are under-resourced, and how this affects them and their learners.**
4.2.1 If it's improving, what do you think is the major reason behind the success?	
4.2.2 If it's deteriorating, what do you think can be done within your school?	
4.3 Looking at your learners as individuals, do you think that their home backgrounds may have certain effects towards their performance? Based on you experience as a Physical Science teacher, have you ever came across any exceptional cases?	
4.4 What are the negative effects that directly affect you	

personally since you are a teacher in such a school? (For instance, does this cause you stress at time?) Give other explanations if any.	
4.5 Personally, how do you feel about teaching in such a school? Can you please give a (major) reason.	
4.6 In a few words, can you please tell me about the experiences of teaching in an under-resourced rural school.	

APPENDIX C

The Principal

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Date

Dear Sir

Re: Request to conduct a research at your school

I am currently reading for a Masters Degree (in Science Education) at the University of Durban~Westville. My area of research is to look at "**The teaching of Physical Science in rural (under-resourced) Secondary Schools**". There fore, I would like to make a request to conduct a study in your school, which is amongst the ones below:

Names of schools

____

____

____

____

____

____

The intention of this study is not to interfere with the lessons at your school, since my Data collection will be based upon questionnaires, interviews with Physical Science teachers, as well as one-period observation per school. Due to time constraints, I will only be able to conduct interviews with one Physics teacher per school, as well as observations at the above-mentioned schools.

. Should my request be approved of, I will contact you again in order to agree on the date(s) on which I can come for data collection.

I hope this request reaches your full consideration.

Yours sincerely
Kgomotso Legari

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P. O. Box _____

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____

____

Cell: ________________
Tel (W): 031 __________
Fax (W): 031 __________
E-mail: ______________

APPENDIX D

INFORMED CONSENT OF THE SUBJECT

Participant's Name
Name of school
Address

Date: ___/___/___

Re: Informed Consent to participate in research

Dear Sir/Madam

As a follow-up concerning my request for permission to conduct a study at your school, I would like to request for your consent as a Physical Science teacher to participate in the stu.dy. Below, is an outline that identifies the details of the research:

Name of the researcher/investigator:	Kgomotso Legari (Mr.), B. Paed (Prim), B. Ed (Hons), M. Ed Student (Final Year) – (UDW).	
Current Research Title:	The teaching of Physical Science in rural (under-resourced) secondary schools.	
Statement of Purpose	Exploring the strategies/methods that Physical Science teachers employ in under-resourced school environments. The aim is not to assess or judge how teachers conduct their lessons, but to look at how they deal with their set environment, especially because there are different resource issues apart from the physical ones (such as the learners' backgrounds) that affect the teaching and learning process.	
Address and telephone number of the researcher's supervisor/s:	Mr. Allan Pillay University of Durban~Westville Dept. of Science Education School of Educational Studies Private Bag X54001 DURBAN 4001 Tel (W): 031 204 4586 Fax: 031 204 4594	Prof. Cliff Malcolm University of Durban~Westville Centre for Educational Research & Policy Development (CEREP) Private Bag X54001 DURBAN 4001 Tel: 031 204 4584 Fax: 031 204 4594 e-mail: cliffm@pixie.udw.ac.za
What is required of the subject?	Only the subject's co-operation to help the researcher with the following: - Allowing the researcher to be present in the classroom for observations during lesson/s, -Being involved in a 30-40 minute interview with the researcher and,	

	-Answering a questionnaire prior to- or -after the observation and interview sessions [and mailing the questionnaire back to the researcher in a self addressed fast-mail envelope provided].
Possible discomfort/ hazards/risks:	So far, there are no known negative effects that have been anticipated for this study. The researcher aims to try by all means to make the subject comfortable during the course of the study, including trying not to disturb the running of lessons.
Potential benefits from participating in the study:	The subject's contribution might be of great help to the Science teachers (and other teachers in general) who are battling with the disadvantage of lack of resources; As well as those teachers who have a problem with the performance of their learners, to adapt strategies that are practiced by teachers whose learners have a history of better performance under (nearly) similar conditions.
Payments and reimbursements of financial expenses incurred by subjects:	The subject is not expected to pay or be paid any amount of money (or otherwise), as there are no expected expenses from his/her party.
The use of audio recordings:	During the course of interview sessions, the researcher aims to perform audio recordings, as they will be of assistance during the writing of the research report, as well as to serve as evidence to the supervisors or the university Research Administration.
Confidentiality and anonymity:	The researcher assures that information provided by the subject in the questionnaire as well as interviews (audio recordings) will be treated confidentially, unless the subject allows permission for such information to be given to extra parties. The subject's wish to anonymity will be highly respected.

I understand the details and conditions stated above, and agree to be a participant in this study. I also understand that I may discontinue my participation if the researcher/ investigator's acts lead to my discomfort:

Signature of Participant:____________________

Date:_____/_________/______

Signature of Researcher/Investigator:____________________

Date:_____/_________/______

APPENDIX E

The Science Teacher

Dear Sir/Madam

I would like to express my appreciation for your permission of agreeing to participate in my study. At this stage, you may not be aware of the kind of contribution that you have given to my study, both as a human resource and as a source of information. Your knowledge and expertise in the Physical Science learning area plays a major role towards how one looks at state of education in the schools, especially in your area in general.

With these few words, I would like to once more thank you for your help.

Yours sincerely
K. Legari

University of Durban-Westville
Address_______________

Date