FACTORS ASSOCIATED WITH THE SHORTAGE OF PHYSICS TEACHERS IN SENIOR SECONDARY SCHOOLS IN SWAZILAND

by

ZEPHANIA TORCH DLAMINI

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SUPERVISOR: DR T I MOGASHOA

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DECLARATION

I, Torch Zephania Dlamini, declare that **FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS IN SENIOR SECONDARY SCHOOLS IN SWAZILAND** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

T.Z.Dlamini

DLAMINI, T.Z.

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Date

DEDICATION

This dissertation is dedicated to my wife, Thobile, and my three sons, Ardo, Imre and Zsabo, for their encouragement and support, and for the sacrifices they had to make during my studies.

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ABBREVIATIONS

ABC	Australian Broadcasting Corporation
AFCLIST	African Forum for Children’s Literacy in Science and Technology
APS	American Physical Society
CBET	Competency-based Education and Training
CCC	Curriculum Coordinating Committee
CPD	Continuous Professional Development
EFA	Exploratory Factor Analysis
EMIS	Education Management Information Systems
ESD	Education for Sustainable Development
EURYDICE	Education Systems and Policies in Europe
GCE	General Certificate of Education
ICT	Information and Communication Technology
IGCSE	International General Certificate of Secondary Education
INSET	In-service Education and Training
IOP	Institute of Physics
JMU	James Madison University
MoET	Ministry of Education and Training
NCC	National Curriculum Centre
NERCOM	National Education Review Commission
NGT	Nominal Group Technique
OECD	Organisation for Economic Co-operation and Development
PCK	Pedagogic Content Knowledge
PGCE	Post-graduate Certificate in Education
PGDE	Post-graduate Diploma in Education
REO	Regional Education Officer
SGCSE	Swaziland General Certificate of Secondary Education
SNAT	Swaziland National Association of Teachers
SPSS	Statistical Package for the Social Sciences
STD	Secondary Teachers Diploma

STN	Stimulating Physics Network
TDA	Training and Development Agency
TSC	Teaching Service Commission
TTCs	Teacher Training Colleges
UNISA	University of South Africa
UNISWA	University of Swaziland
UTEP	University of Texas at El Paso

SUMMARY

The shortage of specialist Physics teachers in senior secondary schools in Swaziland has, for years, been one of the nagging issues for the Ministry of Education and Training (MoET). This led MoET to exploiting the services of non-specialists, thus undermining the quality of learners who graduate from the system. Therefore, the study ascertained the causes of the shortage of specialist Physics teachers in senior secondary schools in Swaziland, how they could be retained and how their number could be increased.

A positivist-interpretive quantitative research approach was utilised to obtain reliable and valid results in this study. The quantitative research was a survey consisting of a questionnaire that was completed by Physics teachers in senior secondary schools. The data were analysed using descriptive statistics.

The study, based on the findings, concluded with some recommendations that could be used to retain and increase the number of Physics teachers in senior secondary schools.

KEY WORDS

Senior secondary schools, Physics teachers, specialist Physics teachers, teacher shortage, teacher retention, teacher increase, non-Physics specialists, gender disparities in Physics.

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CHAPTER 1

AN OVERVIEW OF THE STUDY

1.1 INTRODUCTION AND CONTEXT OF THE STUDY

One of the purposes of education is to develop the competencies within a learner and to enhance his/her knowledge, as well as to equip him/her with the skills that he/she could use while tackling challenges beyond the classroom setting. Central to the acquisition of knowledge and skills is the teacher who actively engages the learners, as critical co-investigators, in the teaching and learning processes (Gultig, Haodley & Jansen, 2002:56). Thus, a more democratic relationship is cultivated between the teacher and the learners. The knowledge and skills acquired by the learners are embedded in the subjects that they specialise in as they progress with their education. Some of these subjects are perceived as ‘sacred’ or vulnerable strategic subjects (Murphy & Whitelegg, 2006:282) since, as the learners progress with their learning, their numbers gradually decline, resulting in the pyramid pattern enrolments (Government of Swaziland, 2011:6). The natural sciences fall within the subjects that experience a decline in the number of learners who pursue them at tertiary level. In the researcher’s view, it is essential that educationists ascertain the reasons behind the decline in the number of learners who specialise in the sciences, in particular, at tertiary level, since this affects the availability of science specialists, for example, specialist Physics teachers.

The shortage of specialist Physics teachers is one of the nagging issues for governments and educationists alike globally (Rundquist, 2009:1; Boutelle, 2010:1; Mathews, 2011:1; Woolhouse & Cochrane, 2010:607; the Government of Swaziland, 2011:25). In Swaziland this shortage was echoed by the Ministry of Education and Training (MoET) (Government of Swaziland, 2011:25); Ministry of Education, 2004:43) In the same vein, the science panel members raised their concern in respect of issues emanating from the teaching and learning of Physics, and from examination reports on the performance of learners in the subject. The science panel members noted that learners performed poorly in Physics, and they attributed this to the shortage of specialist Physics teachers. Therefore, the panel sanctioned research that would investigate the causes of the shortage of specialist Physics teachers. The impetus of sanctioning research like the this one was that, among the natural sciences, Physics had been the hardest hit, since it was taught by teachers who had not specialised in Physics (e.g. Agriculture, Chemistry and Biology specialists) (Government of Swaziland, 2011:25). A synopsis of the teacher profile in schools around Mbabane city in Swaziland attested to the shortage of specialist Physics teachers. Apparently, the employment of specialist non-Physics teachers was partly due to non-efficacious initiatives targeted at addressing the persistent shortage of Science and Mathematics teachers in senior secondary schools.

Therefore, this study investigated the causes of the shortage of specialist Physics teachers in senior secondary schools in Swaziland, how they could be retained, and how their number could be increased.

The recurring adage posits that some teachers believe that not all learners can do science, since it is in the preserve of the intellectuals (Maqutu, 2003:97). In Swaziland learners who aspire to major or enrol in the Sciences at senior secondary and tertiary level are those who have performed very well (a credit C or better) in their Junior Certificate or Swaziland General Certificate of Secondary Education (SGCSE) examinations in the Sciences, including in Mathematics and English. English is regarded as a key subject for admission to tertiary institutions in Swaziland (Literacy and Numeracy Enhancement Programme – LaNEP Report, 2008:4). According to Murphy and Whitelegg (2006:287), within the Sciences, Physics is a subject where the number of learners who major in it gradually decreases as they progress within tertiary institutions, thus resulting in fewer Physics graduates. Reviewing the entry requirements in tertiary institutions and making them less demanding would probably attract more learners intending to do Physics. The shortage could also be addressed by reviewing the policy that sanctions better achievement in English as the determinant of admission to tertiary institutions.

The decrease in the number of Physics students within tertiary institutions is attested to by the statistics of graduates from the University of Swaziland (UNISWA) between the years 2000 and 2010 (UNISWA results 2000 – 2010, see Annexure J). A total of 79 students graduated between the years 2000 and 2010 with a Physics combination. It is apparent that after graduation, only a few took up teaching as a profession, as manifested in the persistent shortage. SHAI (2010:2) observed that some of the graduates choose careers in the private sector and not in the teaching profession, thus resulting in only a few specialist Physics teachers. In the researcher's view, it is essential that educators or policy-makers sanction more research at tertiary level that will examine the reasons why the graduates opt for other professions, since the current research focuses on the senior secondary level. Studies can also be conducted in Swaziland to investigate the views of Science specialists who opted to work in the private sector.

The existence of stringent selection processes require that teachers and tertiary admissions committees expend meticulous efforts to screen and select the group that is regarded as the 'cream' of the society. This stringent screening exercise undermines the aspirations of the Ministry of Education and Training (MoET), which aims to create a capacity for a 80% progression rate from senior secondary to tertiary education by 2022 (World Bank and MoET Sector Analysis Report, 2009:4). Nonetheless, on a yearly basis, teachers who major in Physics graduate from these tertiary institutions. It is apparent that these graduates cannot match the demand in schools. This necessitates the need to investigate the strategies employed by the tertiary institutions on prospective teacher recruitment and production, since this study interrogates the senior secondary level.

The educators should acknowledge the fact that there are some imminent challenges within the education system that need to be unravelled and addressed, since they affect the availability of specialist Physics teachers, hence the learners' performance in Physics (Sherriff, 2005:1). In the researcher's observation, the school is a conduit for some Science graduates *en route* for presumably 'better' professions. One wonders as to what specifically attracts them, and the challenges in the teaching profession that cause them to opt for other professions. Nonetheless, the current study avails an opportunity to determine the factors related to the shortage of Physics specialists within the teaching profession.

1.2 SIGNIFICANCE OF THE STUDY

The shortage of specialist Physics teachers is one of the nagging issues facing MoET. MoET noted that, currently, Physics is mainly taught by non-specialists (Government of Swaziland, 2011:25). This report also states that there are no measures in place to retain and increase the number of specialist Physics teachers. Therefore, it is anticipated that this study would provide some invaluable information to education stakeholders (MoET, education planners, administrators, inspectorate and science teachers) on the factors influencing the shortage of specialist Physics teachers. It is anticipated that they would collectively help find strategies on how to retain and increase the number of specialist Physics teachers. Since it is the learners who later become teachers, some of the strategies should focus on motivating the learners to take up the teaching of Physics as a profession later on in life. However, according to Murphy and Whitelegg (2008:299), research should examine teachers' perceptions on those learners who can and those who cannot do Physics.

The findings of this study are likely to:

- furnish the education stakeholders with the reasons behind the shortage of specialist Physics teachers in the schools;
- provide recommendations on how specialist Physics teachers can be retained in the schools;
- present some measures on how the number of specialist Physics teachers can be increased in schools; and,
- inform the stakeholders on the actual calibre of teachers that currently teach Physics in the schools.

It is also expected that

- the government of Swaziland will offer the anticipated and essential mechanisms and support required by the schools or teachers to address the factors that cause the teachers to leave the teaching profession;

- after some recommendations, the government will put measures in place for the services of specialist Physics teachers to be retained in schools in order to help the schools to achieve the desired outcomes;
- the pre-service and in-service teacher training centres will draw up programmes that will address the critical need for specialist Physics teachers.

The Swaziland Education and Training Sector Policy (2011) (Government of Swaziland, 2011:41) and the Annual Performance Report for MoET (2010/2011) (Government of Swaziland, 2011:27) acknowledge the absence of research meant to ascertain the causes of the shortage of science specialist teachers. This observation has been echoed by the science panel members. This indicates that Swaziland has not yet done research on the science teachers' opinions on the reasons behind the shortage of specialist Physics teachers in senior secondary schools. Most of the research that has been done on the reasons behind the shortage of specialist Physics teachers is based on the needs of other countries. Thus, the study aims to fill the gap of locally-based research on the reasons for the shortage of specialist Physics teachers. The study also aims to seek opinions on how specialist Physics teachers could be retained and how their numbers could be increased.

1.3 PROBLEM STATEMENT AND QUESTIONS

Among educationists, for example MoET, the Inspectorate, the Science Panel members, the William Pitcher College, the Swaziland National Association of Teachers, and UNISWA, and policy-makers there exists concern on the reasons for the shortage of specialist Physics teachers in the schools, especially since they have observed that the subject is mostly being taught by non-specialist teachers (Government of Swaziland, 2011:25). The shortage was acknowledged in the World Bank Sector Analysis Report (2009:7), which advocated for the recruitment of expatriate teachers as an immediate measure to teach Mathematics, science and ICTs, but this has not yet been realised due to challenges within the education system. The Report also noted that one of the challenges is that Swaziland does not have a human resources development strategy that could guide the supply of skills (World Bank & MoET Sector Analysis Report, 2009:10).

Ensuing from the above observation, the thrust of this study is to ascertain the reasons for the shortage of specialist Physics teachers, how they can be retained, and their number increased.

The study addressed the research questions listed below in order to achieve the goals of the study.

The primary research question of the study is:

What are the reasons for the shortage of specialist Physics teachers in senior secondary schools in Swaziland, and how can this shortage be reduced?

The research study also aimed to answer the following sub-questions:

- What are educationists' opinions on the reasons for the shortage of specialist Physics teachers in senior secondary schools in Swaziland?

- What are the educationists' views on how the number of specialist Physics teachers in schools can be retained, and also increased?

Furthermore, the study also advanced and addressed the following hypotheses and their alternative hypotheses.

HYPOTHESIS 1

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the shortage of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the shortage of Physics teachers in Swaziland.

HYPOTHESIS 2

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the retention of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the retention of Physics teachers in Swaziland.

HYPOTHESIS 3

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the increase in the number of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the increase in the number of Physics teachers in Swaziland.

1.4 AIM AND OBJECTIVES OF THE STUDY

1.4.1 Aim

The main aim of the study was to ascertain the factors associated with shortage of specialist Physics teachers in senior secondary schools in Swaziland, how to retain them, as well as how to increase their number in the teaching profession.

1.4.2 Objectives

The study is premised on the following objectives:

- to explore the factors associated with the shortage of specialist Physics teachers in senior secondary schools in Swaziland;

- to generate solutions on how specialist Physics teachers can be retained, and how their number can be increased in the schools;

- to determine if there is a statistically significant difference between the results of males and females Physics teachers in relation to the shortage, the retention and the increase in the number of Physics teachers;

1.5 RESEARCH DESIGN AND METHODS

A positivist-interpretive quantitative research approach was employed in the conducting of this study (Maree, 2007:21). The study also drew from applied research, and empirical quantitative research methods were employed to collect the data. *Empirical* means guided by evidence that is acquired from systematic research methods, as opposed to opinions, or to authorities (McMillan & Schumacher, 2010:9). Applied research encompasses the application and development of research-based knowledge that concerns a particular practice (McMillan & Schumacher, 2010:13). Applied research also generates knowledge pertinent to providing solutions to a broad spectrum of problems (McMillan & Schumacher, 2010:13). De Vos, Strydom, Fouché and Delport (2002:138) contend that quantitative research encompasses experiments, surveys and content analysis.

This study followed the cross-sectional design as a microcosm of the survey, since data was collected at a single point in time in a school setting (Ross 2005:23; Gay, Mills & Airasian, 2006:348). In short, the research method for this study is informed by the quantitative approach, encompassing the non-experimental design, which subsequently embraces the survey design.

The *survey design* is a microcosm of the quantitative non-experimental design (Maree, 2007:34). *Non-experimental research designs* describe things that have occurred, and examine the relationships between things without any direct manipulation of conditions that are experienced. Generally, surveys are usually quantitative in nature, since they generate numerical data (Cohen, Manion & Morrison, 2000:171). According to McMillan and Schumacher (2010:22), “surveys are used frequently in educational research to describe attitudes, beliefs, opinions, and other types of information”. Unlike qualitative research, where design elements are worked out during the course of the study, the advantage of surveys is that they specify in advance the hypothesis, measurement and sampling measures. Maree (2007:157) indicated that surveys are relatively cheap and easy to do. The respondents will usually complete the questionnaire at a time convenient for them (Maree, 2007:157; De Vos *et al*., 2002:174). The respondents also check personal records where such information is required.

In this study, the survey method was used to elicit the teachers’ opinions on the main factors influencing the shortage of specialist Physics teachers. The cost-cutting measures were realised through the utilisation of Regional Education Offices (REO’s) as distribution points, rather than using either private or hired transport. The question of convenience was manifested by the fact that the respondents were allowed sufficient time to complete the questionnaires in their own setting.

The survey method guarantees that information about a large number of people (the population) can be inferred from the responses obtained from a small group of respondents (the sample) (McMillan & Schumacher, 2010:236). In the same vein, Maree (2007:172) argued that surveys use information obtained from the sample to learn more about the population, in this case of Physics teachers in Swaziland. In other words, the survey provided a broad overview of a representative sample of a large population. Therefore, the sample for this study was drawn in such a manner that it is valid to generalise the results to the population, using relevant sampling procedures, which are outlined in one of the sections (section 3.5).

1.6 LIMITATIONS OF THE STUDY

The limitations of the design emanate from the factors listed below. The researcher ensured that the challenges emanating from these factors were minimised in order for the findings to be credible, as discussed previously.

- The size of the population and the sample
  The size of the sample was sufficient to generalise the findings to the population of all the Physics teachers.

- Selection bias
  The teachers from all the regions all had an equal opportunity to be included in the research, and from both the urban and the rural settings, as well as from government and from mission schools.

- Sampling procedures
  The selection of the sample was random to provide all the Physics teachers an equal chance to be selected.

- Measurement: validity and reliability
  The instrument was developed with the input from practitioners and experts in teacher education. The issues of validity and reliability were addressed, since the questionnaire was reviewed by experts, as well as piloted with similar respondents to the sample.

- Non-response from unit of analysis
  The researcher engaged in follow-up measures using short message services (sms) and phone calls to remind those who had not submitted their questionnaires.

1.7 DELIMITATION

The delimitation of a study encompasses the objectives, research questions, variables, theoretical objectives that the researcher adopted, as well as, the target population. The study focused on Physics teachers in senior secondary schools in Swaziland. These teachers had experienced challenges faced by Physics teachers when imparting Physics content to learners. The study explored the teachers' opinions using a questionnaire with four point close-ended Likert scale responses, which limited and focused the respondents' responses. The study aimed to ascertain the Physics teachers’ opinions on the causes of Physics teacher shortage, how they could be retained and their number increased in schools. The main aim of focusing on Physics teachers was to inform Government on the actual causes of Physics teacher shortage without relying on speculation, since there was no study in Swaziland that unravelled challenges faced by Physics teachers. It was essential that the population be Physics teachers, since non-Physics teachers did not have any experience on challenges faced by Physics teachers and had never taught Physics.

1.8 CLARIFICATION OF THE CONCEPTS

This section defines, in context, pertinent terms featuring in the study, namely Physics teachers, specialist Physics teachers, senior secondary schools, education stakeholders, teacher educators, prospective teachers, regions, and school codes.

1.8.1 Physics teachers

According to Berends (2006:625), *Physics teachers* can be perceived as teachers who teach a subject in which they were not trained or certified to teach. The term Physics teacher, is all-encompassing in its perception in schools, since it includes both specialists and non-specialist teachers. In this context, the term refers to teachers who have done at most one or two years of Physics at degree level. Physics teachers are referred to as non-Physics specialists and include specialists in agriculture.

1.8.2 Specialist Physics teachers

The Wikipedia defines a *specialist* as an expert in a particular profession, which, in this case is teaching. Specialist Physics teachers are teachers who have specialised in Physics (“Specialist”, n.d.). In the context of this study, specialist Physics teachers are regarded as teachers who have studied Physics for three years at diploma level and for four years at degree level.

1.8.3 Senior secondary level

The Wikipedia defines *a secondary school* as an educational institution where the final stage of schooling, known as secondary education and usually compulsory up to a specified age, takes place ("secondary school", n.d.). The secondary level follows elementary or primary education, and may be followed by university (tertiary) education. Furthermore, the Wikipedia states that some educationists use the term 'high school', which more often is associated with English-speaking countries, though the two terms, are far from synonymous ("high school", n.d.). In Swaziland, the term *secondary school* is conceived of as the level interfacing the primary level and senior secondary level. In fact, the Swaziland education system, prior to tertiary, is divided into three levels, comprising the primary level, the secondary level and the senior secondary level. In the context of Swaziland, the senior secondary level, on which this study focuses, consists of grades 11 and 12, or form IV and form V.

1.8.4 Education stakeholders

Bush and Heystek (2003:128) regard education *stakeholders* as all the people who have a legitimate interest in the ongoing effectiveness and success of a school. In this context, they are regarded as people who have a vested interest in the shortage of Physics teachers. They can also be perceived as people who have a direct experience of the shortage of specialist Physics teachers, namely MoET, teacher educators, principals and education planners.

1.8.5 Teacher educators

The Wikipedia defines *teacher education* as the policies and procedures designed to equip prospective teachers with the knowledge, attitudes, behaviors and skills they will require to perform their tasks effectively in the classroom, the school and the wider community ("teacher education", n.d.). Teacher educators are individuals employed to be in charge of teacher education. In this study, teacher educators are considered to be individuals who share their experiences with students at tertiary institutions, who are sometimes regarded as lecturers.

1.8.6 Prospective teachers

Prospective teachers are pre-service teachers who are engaged in pre-service training (SIL International, 1999:1). *Pre-service training* is instruction attained before a person begins a job or task. In this study, prospective teachers are those individuals who have enrolled in teacher training institutions and who intend to become teachers after graduation.

1.8.7 Regions

The term *region* is used by contemporary geographers to describe an area of land or water that is part of a larger whole ("region", n.d.). In Swaziland, regions are sometimes referred to as 'districts'. In this study the term *region* will refer to the four main sections into which Swaziland is divided, and these are, namely Hhohho, Manzini, Lubombo and Shiselweni.

1.8.8 School codes

In Swaziland, a school is identified by a name and a number. The name and the number are used for different purposes (Government of Swaziland, 2009). When a school registers with the Government of Swaziland, it is generally assigned a number referred to as a *school code*. The number acts as an identity for that particular school. In this study, the codes were used during sampling and the dispatching of the questionnaires at the Regional Education Offices.

1.9 CHAPTER DIVISION

The study is organised into five chapters, namely Chapter 1 to 5, according to Walonick's (2007:1) suggestion.

1.9.1 Chapter 1 provides the general overview of the study, including the introduction and context of the study. It also contains the significance of the study, the problem statement, the questions, hypotheses, the aim and objectives of the study, the research design and the methods, ethical considerations, limitations of the study, delimitation, the clarification of pertinent terms, and the chapter division.

1.9.2 Chapter 2 outlines the theoretical framework for the study and reviews studies that have been carried out to address problems similar to the current problem, embracing the nature and significance of Physics. Also international and local challenges and solutions to Physics learning, the provision for Physics in teacher training institutions in Swaziland, and Physics content from primary to senior secondary levels in Swaziland.

1.9.3 Chapter 3 provides an in-depth description of the research process, including the research design, and methodology followed in the study.

1.9.4 Chapter 4 presents the data, its analysis and interpretation.

1.9.5 Chapter 5 provides the summary of the research results of the study. Conclusions are drawn from the analysed and interpreted data. These are followed by recommendations for further research.

1.10 SUMMARY

In this chapter the introduction and context of the study were presented. The significance of the study was stated. This was followed by the problem statement, questions and hypotheses. The aims and objectives of the study were presented. These were followed by the research design and methods. The ethical considerations, limitations and delimitation of the study were outlined. Lastly, the relevant concepts in the study were clarified, followed by a presentation of the contents of each chapter.

The next chapter deals with the theoretical framework underpinning the study, as well as the literature that has a bearing on the study.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

In the previous chapter the context of the whole study was presented and it was demonstrated why the study was important and relevant. A summary of the literature that was reviewed and the theoretical framework that underpinned the study was also presented in the chapter.

In this chapter the researcher examines the studies that reported on the reasons for the shortage of specialist Physics teachers - that are an input at the school level -, how the teachers can be retained, and their number increased. The purpose of the literature review was to understand what contemporary studies regard as the reasons for the shortage of specialist Physics teachers, how their number can be increased, and how they can be retained. The literature that underpinned the study was first drawn from the studies that had been carried out in other countries, eventually narrowing them down to the local context (Maree, 2007:28). In this chapter the researcher specifically reports on what he investigated on what other researchers regarded as the reasons for the shortage of specialist Physics teachers, from the practitioners' and stakeholders' point of view, with the aim of deriving original and realistic solutions to address the shortage of specialist Physics teachers in Swaziland. The researcher investigated studies that had been carried out on the issues pertaining to the shortage of specialist Physics teachers emanating from policy, professional and institutional level.

Moreover, in this chapter the theoretical framework underpinning the study was also explicated. The framework was informed by Howie's (2003) model on school effectiveness. This model was investigated in conjunction with other associated models, namely the integrated model of school effectiveness (Scheerens, 1990), and factors that determine school effectiveness (Heneveld & Craig, 1996). In the section that follows the studies that had been done to ascertain the reasons for the shortage of specialist Physics teachers, how they can be retained, and their number increased in senior secondary schools and at tertiary level are discussed.

2.2 REASONS AND SOLUTIONS TO PHYSICS TEACHER SHORTAGE

The studies that have been carried out on the reasons for the shortage of specialist Physics teachers are all at an international level. No local studies exist that have reported on the factors contributing to the shortage of specialist Physics teachers, especially from the point of view of the Physics teachers (Ministry of Education and Training, 2012:1-122; Mathematics panel, 2012:1 and Government of Swaziland, 2011:27). Mathematics panel (2012:1) mentioned that the only study that was done focused on the challenges in Mathematics, science and ICT education at secondary level and teacher education. This study does not suffice, since it is not in-depth, but merely an overview. It is also not solely based on the opinions of Physics teachers who are practitioners, but of science teachers in general.

The main themes of the studies that have been examined on the reasons for the shortage of specialist Physics teachers, how they can be retained, and their number increased are policy, institutional and professional. A review of the literature indicated how the pronouncements or activities at each level influence the other levels in respect of the development of Physics teachers, since they cannot be treated in isolation. It also unravelled how the levels contribute to the shortage, and elicited solutions proposed at each level. Policy pronouncements are determinants of what occurs at professional and institutional levels. However, the silence of policy on certain issues does not imply their absence at the other levels. During the process of the literature review, some policy gaps and teacher education practices were identified that inadvertently contribute to the shortage of specialist Physics teachers.

The findings in the international literature were instrumental in the development of the questionnaire for this study. The literature review addressed the following sub-topics, namely the nature and significance of Physics, international and local challenges and solutions to the learning of Physics, the provision for Physics in teacher training institutions, and Physics content from primary to senior levels in Swaziland.

In retrospect, the literature review on the reasons for the shortage of specialist Physics teachers, how their numbers can be increased and retained is investigated at the following levels, namely policy, professional and institutional, as mentioned previously. The *institutional level* can furthermore be divided into tertiary, senior secondary, junior secondary and primary (Ministry of Education, 2004:8). *Education policy* refers to the collection of laws and rules that govern the operation of education systems ("policy", n.d.). The *policy level* regulates the practices on the professional and institutional levels. The *professional level* investigates and implements policy pronouncements. The *institutional level* is where policy pronouncements are put into practice. Physics teachers and lecturers operate at the institutional level through sharing their experiences with learners and students, respectively. The professional level and the components of the institutional level are closely knit in a complex relationship. Each level provides feedback to the other levels. If there is a discrepancy at one level, the operations of the other levels are affected.

The researcher started off by examining the nature and significance of Physics.

2.2.1 The nature and significance of Physics

Physics, like Mathematics, as a branch of science, not only represents a particular discipline having its own content, concepts and patterns of inquiry, but it also represents a special mode of thought – science (Slattery, 2006:86). Science is a fundamental form of human understanding, and as such, should be made available to learners. In this argument, Physics is a special case of a more general and powerful paradigm of human understanding that the school should foster (i.e. scientific reasoning). This paradigm reinforces scientific reasoning, especially, because an understanding of the concepts and procedures of Physics requires specialised forms of instruction, like conducting experiments with precision and detailed explanations. The curriculum, and subsequently the examination, should foster the teaching and learning of Physics for its sustenance in schools. It is apparent that the lack of scientific reasoning skills, and skills to engage in Physics content, like conducting experiments independently, contribute to the shortage of specialist Physics teachers. These skills should be reinforced by the curriculum. Thus, this study aimed to investigate if all the schools in the local context offer Physics as a subject. Physics, as a component of science, in schools, falls within the category of low performance subjects, including Mathematics and siSwati (World Bank and MoET Sector Analysis Report, 2009:6). This begs the question, namely how can the teaching and learning of Physics be enhanced in schools in order to improve learners' performance in the subject?

The Free Online Dictionary and Thesaurus ("Physics", n.d.) define *Physics* as the branch of science that deals with the properties of matter and energy, and the interactions between the two. This definition is shared by Rundquist (2009:1), who argues that Physics could be regarded as a natural science that entails the study of matter and its motion through space and time, along with associated concepts such as energy and force. The interaction between the two constructs (matter and energy) is embedded in traditional fields such as acoustics, optics, mechanics, thermodynamics, and electro-magnetism, as well as in modern augmentations, including atomic and nuclear Physics, cryogenics, solid-state Physics, particle Physics, and plasma Physics. In this context, Physics is regarded as a science that empowers learners with the skills to investigate the interactions between matter and energy, in order to come up with plausible conclusions.

On a broader perspective, Physics pertains to the general analysis of nature, conducted in order to comprehend the behaviour of the universe ("Physics", n.d.). Physics inter-connects with many disciplinary areas of research, such as Bio-Physics and quantum Chemistry. This inter-connection with other disciplines demonstrates that the boundaries of Physics are not rigidly demarcated, thus pointing to a weak classification (Sadovnik, 2001:3). According to Sadovnik (2001:3), *classification* refers to the nature of differentiation between the contents or the degree of boundary maintenance between contents. Physics is concerned with the modelling of the natural world with theory, which is usually quantitative ("Physics", n.d.). The knowledge of Physics, as embraced in Physics education, contributes to the development of an objective, realistic and scientific thought system (Güzel, 2011:1047). Physics education is the backbone of a first-class workforce in science, technology and Mathematics (Güzel, 2011:1047). Paramount in these definitions is the interaction between matter and energy in the universe that enables scientists to make postulates which are validated through empirical evidence. Thus, they develop scientific or natural laws. The empirical evidence, for this study, is essential in determining the opinions of Physics teachers on the reasons for the shortage of Physics teachers.

In the teaching and learning situation, the teacher and the learner are expected to first have an understanding of the definition and nature of Physics as entities of the Physics discipline. Thereafter, they will be able to manipulate its concepts with a deeper understanding. An understanding of the definition of Physics enables the teacher and learner to be aware of the content they will deal with that is entailed in the discipline. Moreover, the learner anticipates and appreciates the kind of knowledge he/she will interact with in the teaching and learning environment. The understanding of Physics also empowers the learner to relate it to other disciplines, like Mathematics, which demonstrates the permeability of the boundaries of the discipline.

Physics, as a component of science, in schools, falls within the category of low-performance subjects, including Mathematics and siSwati (World Bank and MoET Sector Analysis Report, 2009:6). Due to the lack of research in Physics education in the local context, it is unclear as to what other factors specifically cause the low performance in Physics (Examinations Council of Swaziland, 2011:2). It is apparent that some of the factors that contribute to the low performance are the shortage of specialist Physics teachers and the lack of pedagogic content knowledge, since most of the teachers are not qualified for the subjects they teach (Marope, 2010:36). According to Gess-Newsome (1999, in: Nilsson & Van Driel, 2010:544), it is vital that teachers understand the structure and nature of their discipline. They must be empowered with skills in selecting and translating critical Physics content into learning activities. The teachers should recognise and highlight the applications of Physics to the everyday lives of their learners.

Cornell University (2011:1) regards Physics as an essential subject. It is essential because its concepts are used as a basis for some careers. In fact, Physics is a prerequisite for the majority of careers in engineering, Chemistry, Biology, environmental and earth sciences, and the medical and veterinary sciences (Oon & Subramaniam, 2010:277). Learners who intend to specialise in these careers have to take some Physics courses. Physics also inculcates quantitative and analytical reasoning skills, more than the other subjects in the senior secondary curriculum (Cornell University, 2011:1). Physics is essential, because it equips the learner with specialised skills. These skills are unique to Physics, and are not promoted by the other subjects in the curriculum. Another reason that makes Physics essential is that the business community and politicians argue that a qualification in Physics is most desirable in the industries (Institute of Physics, 2010:1). Cornell University (2011:1) reports that there is a shift from Agriculture-oriented economy to a manufacturing-based economy, which requires a scientifically-educated and trained learner. The manufacturing-oriented economy emphasises the acquisition of knowledge and continuous innovation. The industries require a greater ability to invent, to improve and to adapt, and to see beyond the present problems to future opportunities (Cornell University, 2011:1). These skills are promoted by a profound knowledge of Physics content, which is made available by a qualified teacher at the school level. The acquisition of this content is supported by mathematical knowledge.

Mathematics acts as a significant tool for the manipulation of mathematical problems embedded in the Physics content (Murphy & Whitelegg, 2006:287). In other words, Physics makes Mathematics a "reality" (Rundquist, 2009:1). This means that Physics can be conceived of as Mathematics with real-life examples. Due to the decline in learners who specialise in Physics, some careers might lack specialists, as manifested in the teaching profession. Therefore, the shortage of Physics specialists must be urgently addressed, in particular in schools, through enhancing the learners' mathematical content knowledge. Some mitigating measures should also be put in place by policy-makers to ensure that the above careers do not deprive the teaching profession of qualified Physics teachers. These professions are considered to be well-paying. This begs the question, namely: How can the teaching and learning of

Physics be enhanced in schools in Swaziland, since the number of Physics specialists who graduate from the tertiary institutions is insufficient to cater for the needs of the teaching profession and industry? Some invaluable information can be obtained from the international solutions in order to respond to this question.

2.2.2 International and local challenges and solutions to the learning of Physics

It was imperative that the researcher investigates the reasons for and the solutions to the shortage of specialist Physics teachers at an international level as a basis for the analysis of the local context. The challenges facing the teaching and learning of Physics have been echoed at both international (Boutelle, 2010:1; Gold, 2006:1) and local (Government of Swaziland, 2010/2011:25) spheres. In Swaziland the different levels (primary, junior secondary, senior secondary and tertiary) must feed one another in terms of forming a foundation for prospective teacher preparation. The learners must be equipped with Physics content at each level that is a prerequisite for the acquisition of higher-order concepts at another level. Paramount is the development of a positive attitude towards the subject, in order that more learners would enrol in the sciences at tertiary level (Murphy & Whitelegg, 2006:290). Due to the persistent shortage of Physics teachers, the call to increase the number of Physicists has become a world-wide concern (Oon & Subramaniam, 2010:281; Boutelle, 2010:2; Rundquist, 2009:1; Volkmann, 2011:1). The issue of the shortage of Physics teachers must be addressed throughout all the levels of the education system so that the proposed solutions may help to reduce the shortage significantly. This calls for more relevant and teacher or practitioner-oriented solutions.

Apparently, the challenges emanate from policy, institutional and professional levels. Coupled with these challenges are some solutions that educationists have proposed. The shortage of Physics specialists has been reported at an international level in Australia, the United Kingdom (U.K.) and the United States of America (U.S.A.) (SHAI, 2010; Cartlidge, 2001; Sherriff, 2005). The shortage is manifested in situations where a larger percentage (90%) of the learners is taught by teachers who do not possess a Physical science qualification.

There is sufficient evidence pointing to the world-wide acute shortage of specialist Physics teachers as a result of various challenges (BBC News, 2008:1; Rundquist, 2009:1; Politis, Killeavy & Mitchell, 2007:39; SHAI, 2010:1; Oon & Subramaniam, 2010:277). The American Association for Employment in Education consistently listed high school Physics as one of the fields with severe teacher shortages (SHAI, 2010:1). SHAI observed that two thirds of the Physics teachers did not major in Physics (SHAI, 2010:1). As a mitigating measure, SHAI advocated for greater incentives to attract Physics graduates into teaching. This measure could be a challenge for developing countries like Swaziland, which are battling with corruption, mismanagement of their money, and the depletion of financial reserves (The Times of Swaziland, 16 May 2012; Marope, 2010:xxv; UNISWA student, 2012:21). This fact is well-articulated by Rogan and Grayson (2003:1172) who contend that a great deal of money could be wasted by government as high-quality ideas are never converted into classroom realities. The ideas remain on paper with no strategies on how to operationalise them, while the shortage of Physics teachers needs urgent and realistic solutions.

In Australia ABC News, reporting on a study of South Australian science teachers, found that only about half of the teachers teaching Physics had specialised in Physics (SHAI, 2010:1). The solution that some educationists and politicians propose is based on the three S's, namely salary, status and subordination. According to SHAI (2010:2), this means that the remuneration is not great, the teachers do not enjoy much respect, and they face increasing discipline problems in the classrooms. In addition to the three S's, Cartlidge (2001:2) argued that conditions, workload and technical provision deter graduates from becoming teachers. This situation is exacerbated by the fact that the recruitment of Physics teachers has to compete with financially rewarding career options in finance, software and the high-tech industries. Moreover, Physics is a challenging subject that requires a strong mathematical background. Improving science teachers' working conditions, empowering them in respect of Mathematics and Physics content knowledge and providing them with skills in classroom management would probably retain them in the profession longer. Also, making the working conditions better would probably attract more learners to do Physics-oriented teaching courses.

Since 1994 the number of universities offering degrees in Physics has dropped from 79 to 58 in the United Kingdom (U.K.) (Cartlidge, 2001:3). Cartlidge (2001:3) argued that the decline was due to the emergence of ‘deserts’ in undergraduate Physics teaching, i.e. regions of the U.K. not served by a local department. Drawing from a survey, the BBC News (2008:1) broadcast that almost one in four secondary schools in England no longer had any specialist Physics teachers. Also, in the United Kingdom, The Independent (2008:1) lamented the shortage of Physics specialists, which threatened the existence of the subject in schools. The Independent (2008:1) noted that there was a 27% drop of applicants for Physics training in tertiary institutions. The Independent (2008:1) also observed that the majority of Physics teachers were either retiring, or leaving the teaching profession for other professions.

Due to the shortage of Physicists, the learners were taught by non-specialist teachers and, as a result, were not performing well (Sherriff, 2005:1). Sherriff (2005:1) suggested that the government should provide ring-fenced funding and incentives to train and support non-specialist Physics teachers. Similarly, in Swaziland, most Physics teachers are non-specialists in Physics (Government of Swaziland 2011:25). The above authors unanimously acknowledge the shortage of specialist Physics teachers. The solutions they suggest cannot be attained without concerted effort by all the stakeholders, and the mobilisation of resources. A caveat should be raised that the tendency of sanctioning non-specialists to teach Physics undermines the quality of the learner that graduates from the system. Thus, Physics would not feature in the learner’s prerogative at tertiary level.

In the advent of Education for Sustainable Development (ESD) and advances in technology, a number of countries are experiencing strident calls to improve the quality of their teachers (SHAI, 2010:1). Within the context of this study, teacher-quality is enhanced through an extensive understanding of science content knowledge and strong pedagogical knowledge that facilitate the process of learning, a passion for Physics teaching, devotion to learners’ learning, and the efficient use of technology (Beese & Liang, 2010:267; Otero, Pollok & Finkelstein, 2010:1218). Teacher-quality is improved through enhancing the teachers’ understanding of the Physics content-knowledge and their pedagogic strategies. This understanding of the content of Physics would enable the teachers to keep up with technological advances and ESD (Darling-Hammond & Baratz-Snowden, 2005, in: Mokhele, 2011:33). Swaziland is no exception to this development. However, the quality of Physics teachers cannot be realised in the absence of dedicated and properly-qualified lecturers at tertiary level. According to Chodos and Ouellette (2012:1), teacher-quality is one of the paramount issues in science education. It rests upon in-service departments and tertiary institutions to improve teacher quality. The improvement of teacher quality calls for the mobilisation of resources that could be used in developing teacher-empowerment programmes. These programmes cannot be developed if the governments do not put in a great deal of effort towards teacher-development initiatives. The lack of relevant programmes for teacher-empowerment in respect of the Physics content is exacerbated by the mismanagement of funds that could be used to fund the programmes. Therefore, the enactment of teacher development programmes cannot be realised in the absence of funds.

The quality of teachers for science education is particularly important, because to be an effective science teacher requires a thorough and extensive understanding of the science content, strong pedagogical knowledge to facilitate the complicated process of learning, the efficient use of technology and other advanced devices, a passion for teaching, and a strong commitment to the learners' learning. These are some of the attributes of a Physics teacher. The efficient use of technology and other advanced devices requires a strong Physics background. The knowledge of technological advances cannot be attained fully in the current shortage of specialist Physics teachers.

According to the Organisation for Economic Co-operation and Development (OECD 2004), teacher-quality has received insufficient attention at policy level, which has impacted on the calibre of learners destined for Physics courses. Therefore, there exists a need to draft policy that would guide the enhancement of teacher quality, in particular, Physics teachers. Enhanced teacher-quality cannot be achieved if the governments do not unravel stifling challenges to the production of specialist Physics teachers at institutional level. Moreover, they have to put measures in place to address these challenges, like training the pre-service teachers to be abreast with the Physics content, ESD and technological advances. Such training would enable the teachers to meet the demands of lifelong-learning opportunities (Ministry of Education, 2004:1). Lifelong-learning equips the learners with the skills that would enable them to tackle the challenges they could encounter in the future, irrespective of the form these challenges take.

In order to mitigate these challenges so that the demands of the technological advances and learners' needs are met, it is essential that the preparation of the learners for such challenges starts at the primary level, and should be coupled with a relevant and efficacious curriculum. The curriculum should be shared with the learners by teachers who have had extensive training in specialised content (Physics content) or a strong conceptual knowledge (Nilsson & Van Driel, 2010:544). Central to the technological advances is the scientist or specialist Physics teacher. Educationists and policymakers alike have noted that the number of Physics specialists is decreasing, both at tertiary institutions and in some professions, especially in the teaching profession, which undermines their efforts of meeting the demands of these technological advances and ESD (Institute of Physics – IOP, 2002:1).

The above observations indicate that the shortage of specialist Physics teachers is not unique to Swaziland. Therefore, it is essential that the governments mobilise resources and commit themselves in the fight against the shortage by supporting programmes that are geared towards increasing the number of specialist Physics teachers in senior secondary schools. The teaching and learning of Physics in Swaziland is engulfed by numerous problems, ranging from the low input of trained graduates throughout all the levels of the education system, to insufficient programmes in tertiary institutions that could attract more potential Physics teachers (Government of Swaziland, 2011:42). The senior secondary level has been hardest hit. This level has been affected by a high turnover of teachers in the natural Sciences and an acute shortage of qualified Physics teachers.

The section that follows discusses the debates on how policies contribute to the shortage of specialist Physics teachers, as well as the proposed solutions at this level.

2.2.2.1 Challenges and solutions at policy level

Policy is a vital component in addressing the shortage of specialist Physics teachers. The policies should be explicit on how human resources should be developed to meet the demand for specialist Physics teachers. The manner of the enactment of policy and its pronouncements could contribute to the shortage of specialist Physics teachers. This means that policies, as guiding documents, are fundamental in the initiation, development and sustenance of educational programmes and human resources.

According to Woolhouse and Cochrane (2010:608), and the Education Journal (2011:1), the drives in respect of policy to recruit Physics and Chemistry specialists should be intensified. However, the IOP (2002:3) reports that the efforts geared towards improving the recruitment and retention of specialist Physics teachers have not been successful in delivering an adequate supply to meet the direct and hidden shortages in institutions, in order that the majority of learners may be exposed to good physics teaching, especially at the senior secondary level. Once the recruitment has occurred, the policy drives should serve as guides on how pre-service teachers may be empowered to handle the Physics concepts at tertiary level. But, the starting point is the availability of someone who could facilitate the handling of the concepts. The English government indicated that there was a shortage of specialist Physics teachers, and devised strategies to address the situation. It is not enough to merely acknowledge the existence of the shortage of specialist Physics teachers without ascertaining the causes. Woolhouse and Cochrane (2010:607) indicated that the English government, while operating at policy level, addressed the shortage of Physics specialists by means of a training and development agency for schools, which funded courses at tertiary institutions. These courses provided the necessary experience to pre-service teachers to teach the Physics and Chemistry content. Additional initiatives should be geared towards empowering the young novice Physics teachers.

The Institute for Statistics and Information on Education Systems and Policies in Europe (EURYDICE) reported that teachers in the developing countries were in general young and inexperienced (Güzel, 2011:1050). It follows that an inexperienced teacher will produce learners that are lacking in Physics content knowledge. The Institute for Physics and EURYDICE were in agreement that some teachers were in their youth, and reported that in most developing countries 30% of the teachers were under the age of 30 years. In some countries the number of young teachers increased to 50% (Güzel, 2011:1050). However, the developed countries portrayed a different picture. In the developed countries the number of the teachers who were 40 years and above was higher (Güzel, 2011:1050; Santiago, 2002:1). White and Tesfaye (2011:6) conducted a survey on the ages of Physics teachers. The results indicated that in 1987 the median age of high school Physics teachers was forty-one. In 2001 it rose to forty-six, and has held steady since. This indicates that many Physics teachers were older and were nearing retirement. This exacerbated the shortage. Nonetheless, the teachers who are in their youth have the opportunity to upgrade their Physics content knowledge through various initiatives that the policies offer.

Gold (2006:1) subscribes to the findings of the reports (Institute for Physics and EURYDICE) namely that some Physics teachers are inexperienced. He called for new scholarships, awards and legislation to encourage the learners to pursue careers in Science and Science education. The awards and scholarships can be issued in a stable economy. As a result of the economic meltdown and fiscal deficit, some countries have cut down their budgets and human resources to accommodate fiscal adjustment (Ministry of Education, 2004:6). In response to the unprecedented budget cuts, Cleveland State University, one of the U.S.A.'s teacher training institutions, had to reduce enrolments, increase tuition and make adjustments in its staffing (Mathews, 2011:1). Mathews (2011:1) observes that these changes detach potential Physics teachers from the pipeline, and weaken the training, monitoring and support of pre-service teachers as they begin their careers. Thus, the U.S.A.'s capacity to prepare Physics teachers was affected, hence the shortage. In the same vein, budgetary cuts by the government have affected enrolment in teacher training institutions in Swaziland. The budgetary cuts have also affected staffing in some departments. The repercussion of the reduction is manifested in the rate of teacher production, as well as in the replacement of deceased and retired teachers. Currently, the majority of Physics teachers are unable to upgrade their qualifications due to financial and various challenges.

Policy makers in Swaziland have not been silent in respect of the shortage of specialist Physics teachers. The shortage has been echoed by the Teaching Service Commission (TSC) (Magagula, 2010:15). Similarly, Ngozo (2012:9) reported that the TSC experienced difficulty in recruiting and retaining Science and Mathematics teachers, since they were locally produced in very small numbers. The Principal Secretary (PS) for Education subscribed to this and argued that MoET would be

> " deploying Home Economics and Agriculture teachers in schools to teach Mathematics and Science. This measure is adopted to try and address the shortage of qualified teachers for the Maths and Science cadre. When the university produces graduates, they are usually small in number and on top of that most of them do not continue with their education and do the Post Graduate Certificate in Education (PGCE) which qualifies them to be fully-fledged teachers. Government was losing these teachers to such sectors as Information and Technology, Engineering and a host of other fields…because of the huge financial benefit offered by the private sector. The ministry is…looking at introducing a retention allowance for these teachers … and this would involve government, in terms of requesting funds for this process" (Magagula 2010:15).

The deployment of Home Economics and Agriculture teachers to teach Mathematics and Science attest to the severity of the shortage of Physics teachers in senior secondary schools (Ministry of Education and Training, 2012:1-122). The Principal Secretary (MoET) mentioned that MoET was working with UNISWA to find strategies on how to increase the intake of Mathematics and Science learners to supply the noted gap in the teaching profession. Moreover, only a few locals were willing to take up teaching posts. Seemingly, for a number of years, government was not interested in finding solutions for addressing, specifically, the shortage of specialist Physics teachers, until only recently. This does not mean that the government was not aware of the shortage, but what is paramount are the measures that were put in place to alleviate the situation. It is apparent that there exists a gap, emanating from the lack of consultation with the relevant practitioners by the government. Another gap is the lack of specific policy documents indicating how the government aims to address the shortage of specialist Physics teachers, though the government claims to have developed a strategy or a plan. The existence of a plan is not sufficient, since it was not collectively developed. The researcher feels compelled, having observed the government's operations, to doubt if the plan will ever be implemented to produce the required results. This has led to non-governmental organisations 'rescuing' the government from challenging situations. A case in point is the African Forum for Children's Literacy in Science and Technology (AFCLIST) programme which was meant to empower girls in respect of Science.

The Swaziland Education and Training Sector Policy (2011) states that Swaziland has, however, by 2007, reduced the percentage of unqualified teachers by only about 8% at the primary school level and 2% at junior or senior secondary school level (Government of Swaziland, 2011:41). This indicates that, on average, the learner to qualified teacher ratio is 37:1 at primary school level and 19:1 at junior or senior secondary school level. There, nonetheless, exist acute shortages of qualified teachers for Mathematics, Science, Information and Communication Technology (ICT) and Prevocational subjects, including Design and Technology, and Business Studies (Marope, 2010:36). Comparatively, in 2005, the average learner to qualified Mathematics and Science teacher ratio was estimated at 84:1 (Marope, 2010:36). In subsequent years the teacher to learner ratio was reduced, so that in 2010 it was 19:1 (Marope, 2010:36). The reduction in teacher to learner ratio does not imply that there is an increase in the production of Science teachers. The urgency of teacher shortages cannot be easily met by the long-term introduction of Mathematics, Science and ICT programmes and so might require the short-term importation of qualified teachers in these fields (Government of Swaziland, 2011:41). In 2010 the government of Swaziland resolved to import Science and Mathematics teachers from Kenya, in line with the study by the World Bank (Magagula, 2010:15), but to date this has remained a dream. The shortage of teachers was echoed by Makhubu (2014:2), drawing on the pronouncement of the chairman of the TSC who noted that "…there was a challenge in finding qualified Maths, Science, French and IT teachers". The World Bank also noted that there was an acute shortage of Mathematics and Science teachers. In order to address the shortage of Physics teachers, the Swaziland Education and Training Sector Policy (2011) advocates for in-service supplementary training to improve the teachers' content knowledge and competency, but will require a continuing professional development (CPD) programme to make this viable (Government of Swaziland, 2011:41). There is also an urgent need for policymakers to provide accessible learner loan schemes to boost the intake into tertiary education programmes and other priority courses in order to increase the number of Physics prospective teachers.

In Swaziland other measures were proposed at policy level aimed at addressing the shortage of specialist Physics teachers. The Swaziland Education and Training Sector Policy (2011) (Government of Swaziland, 2011:41) reports that the government aims to increase the flow of pre-service teachers into the profession by revising teacher education and instructor curricula to prepare the teachers for Competency-based Education and Training (CBET). The same policy document indicates that the Government of Swaziland would train teacher instructors and prioritise the output of sufficient numbers of qualified Early Childhood Care Education, Mathematics, Science, ICT, Design and Technology and Business Studies teachers to meet the national requirements (Government of Swaziland, 2011:41). The government could also establish a Teacher Education and Training Curriculum Review Panel to prepare recommendations for the introduction of curricula to prioritise the teaching of Mathematics, Science, ICT, Design and Technology, and Business Studies (Government of Swaziland, 2011:42). Most of the above measures are still in the pipeline. It is unclear when the government would implement them. Therefore, there is a need for a strategic plan initiated by the government that would outline the commencement dates for these measures.

The Ministry of Education and Training (MoET) has been able to establish subject Panels for some of the new subjects (ICT, Design and Technology, and Business Studies) within the pre-vocational programmes, but not Teacher Education and Training Curriculum Review Panels (Government of Swaziland, 2011:42). MoET aims to achieve the establishment of Panels by means of the provision of the physical and human resource capacity to facilitate a 20% progression rate from senior secondary school to pre-service training. In the era of global recession and economic meltdown, the government is geared towards reforming the demand-based financing model for teacher training. This could be attained through increasing the number of scholarships available for pre-service teachers and for those students intending to upgrade their qualifications to Bachelor of Education (B.Ed.) or Post Graduate Diploma in Education (PGDE) (Government of Swaziland, 2011:41). MoET also promises to meet the demand for the up-grading of qualifications by providing capacity-building opportunities to lecturers who could deliver the teacher training curriculum (Government of Swaziland, 2011:41). One doubts the feasibility of this exercise, since the government has financial challenges, and has resolved to reduce the tuition fees for learners in tertiary education. It is unclear what measures would be directed towards the training of, in particular, Science or Physics teachers, though the government had acknowledged their shortage in schools.

MoET has realised that there is a need to enact policies that will retain and increase the number of Physics teachers, and these policies are not in existence, yet. This aspiration is encapsulated in the Swaziland Education and Training Sector Policy (2011) (Government of Swaziland, 2011:41). The policy document indicates that the government would engage in research to evaluate regional models for Science teacher environmental incentive schemes, career development, the promotion and retention of science teachers to guide the improvement of related conditions in Swaziland. The policy document also mentions that the government would create incentives for experienced Science teachers holding diplomas in education (Primary Teachers Diploma and Secondary Teachers Diploma) to upgrade their qualifications by:

- offering part-time studies that are partially funded; and/or,
- shortening the duration for B.Ed. studies for diploma holders.

The above initiatives are still in the pipeline, but MoET does not elaborate on how these would be attained, bearing in mind the urgent demand for human resources in the Sciences. The shortening of the duration for diploma holders for those who intended furthering their studies in the B. Ed. programme was implemented prior to 1991. This initiative was then dropped when the Secondary Teachers Diploma (STD) programme was transferred to one of the teacher training colleges (William Pitcher Teacher Training College). The STD programme now takes 3 years to complete in this institution. It is puzzling that graduates from this college who intend to further their studies with UNISWA are required to start from the first year, even though this institution accredits the programme. It is apparent that this is due to poor curricula articulation by pre-service teachers and the programmes they are exposed to, which undermine the quality of these teachers (Marope, 2010:xxv). According to Santiago (2002:1), teacher quality is a critical factor in determining learners' learning. Therefore, it is essential that the education authorities (policymakers) develop strategies that will guarantee an adequate supply of quality teachers, as some of the strategies have failed to yield the desired results.

The Annual Performance Report for MoET (2010/2011) (Government of Swaziland, 2011:25) indicates that the Government of Swaziland has developed a strategy for addressing the shortage of Physics teachers. The government does not specify what the strategy entails, and when it would be implemented. One shortcoming of the policymakers when developing the strategy was that they did not enlist the input from the teachers or stakeholders with vested interest. Apparently, the government has not learnt any lessons from the top-down approach to addressing issues as this had rendered some programmes less effective, for example, continuous assessment (CA). The policy level is crucial in the development and sustenance of human resources in educational institutions. The lack of explicit policies on the development of human resources affects the operations of the institutional level, which resorts to exploiting the services of non-specialist Physics teachers.

The proclivity of sanctioning non-specialists to teach Physics is not in line with the aspirations of the National Review Education Commission (NERCOM) (Government of Swaziland, 1985:33). This is also alluded to by the National Policy Statement on Education (1998) (Government of Swaziland, 1998:2). Both documents recommend that the education system should have adequately trained teachers to reduce the teacher-learner ratio. Having noted a shortage in some disciplines, the NERCOM Report encouraged teacher trainees to specialise in Mathematics, Science, English and Agriculture at primary level, which is not yet the case. On the contrary, the World Bank Report (2006:42) reflects that there are adequate teachers in Swaziland, and places the teacher-learner ratio at 32:1 and 13:1 at primary and secondary school level, respectively. However, the Education for All Plan of Action (2004) acknowledged a shortage of Science and Mathematics teachers, and for example, put the teacher-learner ratio at one Mathematics teacher to 84 learners at secondary school level (Ministry of Education, 2004:8). Even though the World Bank Report acknowledged the adequacy of teachers, it also noted that there was a shortage of Mathematics and Science teachers, and attributed the shortage to the low enrolment at teacher training institutions. The Report indicates that Science holds a 9% sector in the pie chart of the distribution of the coverage by subject at secondary education. This translates to 3% for Physics, when shared equally among the Sciences, which could not be the case, since practically Biology and Chemistry have a larger share. This indicates that there exists a low enrolment for Physics courses at tertiary institutions, as reflected in the UNISWA results (2010).

Then, the question may be asked, namely “What could the challenges be that emanate from the institutional level?”

2.2.2.2 Challenges and solutions at institutional level

The institutional level is where the shortage of specialist Physics teachers is eventually manifested. Educationists believe that there are a number of reasons for the decline in the number of Physics specialists and have proposed various strategies of retaining them, and of increasing their number at the institutional level (Education Journal, 2011:1). The senior secondary school level is a key determinant of how the selection of tertiary subject options of learners would be like. The laying of a strong Physics foundation at the secondary school level is very important if educators intend to increase the number of specialist Physics teachers.

The challenges to Physics learning at the institutional level are mainly based on the interaction between the level's attributes, namely the teacher, the learner, the resources and the content. According to Rosengrant (2010:281) and Beese and Liang (2010:267), the training of pre-service Physics teachers at tertiary level requires, *inter alia*, content knowledge, pedagogical skills, and pedagogical content knowledge (PCK), which could be enhanced by means of teacher-oriented research. Rosengrant (2010:281) observes that the success of pre-service teachers in teaching Physics content is hinged on the extent to which they were engaged in educational research. He advocates for programmes at tertiary level that would engage pre-service Physics teachers in action research. The benefit accrued is that teachers who are engaged in research eventually become critical and analytical thinkers and these attributes are fundamental in the Physics discipline. The teachers also become self-confident and self-directed. Their ability to be open-minded and flexible is enhanced. Research indicates that pre-service teachers who conduct science content-specific research augment their content knowledge (Rosengrant, 2010:281). The teachers also develop scientific skills and become more enthusiastic to teach Physics content *(Ibid* 281). It is essential that Physics teachers are encouraged to engage in action research that would inform their practice. Pre-service education should be strengthened in cases where it addresses the needs of pre-service teachers inadequately. Some forums should be made available to Physics teachers where they could share their findings with other Physics teachers.

However, Rosengrant (2010:281) argues that the curriculum at tertiary institutions has little if any, unused time to add more activities or courses to their programmes. The lack of time to engage in Physics-oriented activities is not unique to the tertiary level. The perception from head-teachers is that the senior secondary level has not been spared from an overloaded curriculum (Marope, 2010:38; Oon & Subramaniam, 2010:277). The overloaded curriculum does not allow for the addition of courses for wider choices for learners, thus limiting their pathways (Marope, 201:xxvi). Moreover, the learners have insufficient time to investigate their content, thus perpetuating the cycle. It is apparent that learners who aspire to become teachers and had been taught by teachers lacking in Physics content-knowledge would also be lacking in content-knowledge. The caliber of teachers who lack Physics content-knowledge in Swaziland is regarded as non-Physics specialists, for example, teachers of Agriculture. The education system exploits the services of these teachers to teach Physics at the institutional level.

The majority of schools in Swaziland rely on non-Physics specialists to teach Physics at senior secondary school level (Marope, 2010:36). It is likely that learners choose other subject combinations at tertiary level, because they lack Physics content-knowledge, and Physics role-models. There exists a need for local researchers to ascertain the actual reasons for these preferences. The shunning of the Physics choices at tertiary level could mean a pedagogical relationship between the teacher and learner during the acquisition of content was not cultivated. This pedagogical relationship between the teacher and the learner is perceived as *frame* by Sadovnik (2001:3). He defines *frame* as the degree of control the teacher and the learner "…possess over the selection, organisation, pacing and timing of the knowledge transmitted and received in the pedagogical relationship" (Sadovnik, 2001:3). The teacher, who is a non-specialist in Physics, does not have much control over what is taught, resulting in strong framing. *Strong framing* encompasses a reduction in options that the non-specialist can tap on during the teaching and learning processes.

The boundaries between one set of content and another set of content, and how it should be taught are blurred for the non-specialist teacher (Gultig *et al.,* 2002:99). Moreover, the non-specialist teacher, in some instances, has the challenge of distinguishing between what may or may not be taught. Since the non-specialist grapples with Physics content and lacks profound knowledge on what should be taught, subsequently the learners would be deprived of the opportunity to apprehend Physics content-knowledge. The learners who were exposed to poor initial Physics experiences are more likely to be demoralized, and thus be dissuaded to pursue the subject at tertiary level (Cornell University, 2011:1). Once these learners enroll at tertiary institutions, the Physics content they receive would be extrapolating onto a poorly structured foundation. Non-physics specialists might be versed with pedagogical skills, as they are generic, but will be lacking in Physics content-knowledge. The challenges that emanate from the inadequacy of the teachers' Physics content-knowledge constitute some of the reasons that compel prospective teachers to opt for other Science options at tertiary level. Then, the begging question is, "How can the Physics teachers be retained in the schools?"

Woolhouse and Cochrane (2010:607) suggest that one way of retaining specialist Physics teachers was that they should identify themselves as Physics specialists and integrate into particular communities of practice. This integration facilitates interaction and enhances subject content knowledge and pedagogic practice, as well as impacts on job satisfaction. These retention strategies are not compelling, since the teachers would subscribe to them out of their own volition. Unless these retention strategies are coupled with some incentives, they will also remain an aspiration. As an incentive, IBM paid private sector Physics employees to go back to teach, and public universities sent Physics majors to help teach high school Physics (Volkmann, 2011:1). Volkmann (2011:1) suggests that universities should be tasked with retraining the current Science teachers in night and weekend classes. Volkmann (2011:1) also proposes that universities should incorporate Science education in the four years of teacher training programmes. This initiative was adopted by UNISWA for a couple of years, but was later dropped, as the institution placed more emphasis on training scientists to satisfy the demands of the industries. UNISWA inadvertently contributed to the shortage of Science teachers, but later (2003) rectified it by introducing direct entry for school leavers. The direct entry programme has yielded very little results, since there is still a need for specialist Physics teachers in the schools, with two cohorts having graduated. Since the shortage is persistent, UNISWA could adopt the idea of offering weekend lessons to service non-Physics specialist teachers through its distance education programme.

The United Kingdom (U.K.) has not been spared from the shortage of prospective specialist Physics teachers at the tertiary level Physics courses (Barmby, 2006:247). The shortage of teachers was due to the declining interest in Physics (Oon &

Subramaniam, 2010:277). However, Oon and Subramaniam (2010) do not furnish any reasons behind the decline in interest. They observe that, as a result of the declining interest in Physics, between 1994 and 2004, Physics departments in the U.K. were closed down at a total of 24 universities. According to the Training and Development Agency (TDA), the teacher shortage was severe in Science, Mathematics and English (Barmby, 2006:247). A survey conducted in England and Wales involving 246 teachers produced some informative results on the reasons for the shortage of Science teachers. The results indicate that the teachers were discouraged to continue teaching on grounds of issues such as the workload and learner behaviour (Barmby, 2006:247). Barmby (2006:247) suggests that these issues should be tackled from the teachers' perspective as they are well-positioned to voice pertinent and relevant challenges, as well as invaluable solutions. This is in line with the thrust of this study which aspires to obtain the opinions of the practitioners. The above researchers (Oon and Subramaniam, and Barmby) point to interest, the workload and learner behaviour as some of the factors that demotivate Physics teachers. Therefore it is essential that these are also investigated within the local context.

The U.K. has reported a decline in the number of universities offering degrees in Physics (Cartlidge, 2001:3). The shortage of specialist Physics teachers at tertiary level in the U.K. was also noted by The Independent (2008:1). The repercussions of the shortage of prospective teachers at tertiary institutions are subsequently manifested at the senior secondary school level. The shortage has a negative impact on the learners' performance in Physics. The Independent (2008:1) and BBC News (2008:1) reported on the severe shortage of Physics specialists. For example, in London, 50% of the senior secondary schools were without a Physics teacher. The above statistics are indicative of a severe situation that needs urgent attention. Thus, the solutions must be developed with input from the practitioners.

One of the unifying forces in a school setting that catalyse the teaching and learning processes is the administration of the school. The purpose of the school administration is, amongst others, to support and inculcate the spirit of unity among the teachers and the learners. Physics teachers have raised some concerns in respect of the manner in which the school administration provides support. Boutelle (2010:1) argues that more that 40% of the teachers put the blame on the head-teacher as the main cause of their leaving the profession, and over 50% cite poor administrative support from the district. This observation is echoed by Gold (2006:1), who asserts that Physics teachers feel that they do not receive sufficient support from the school administration. The lack of support from the administration has a cascading effect, in the sense that the teachers tend to also develop poor interpersonal relationships with their fellow colleagues and, subsequently, with the learners. The poor interpersonal relationships, the lack of support and improvement opportunities, coupled with other challenges, make the teachers feel that teaching secondary level Physics courses lacks prestige (Gold, 2006:1; Boutelle, 2010:1). Güzel (2011:1050) accedes to this observation and contends that the teaching profession lacks development and improvement opportunities. The lack of improvement opportunities deprives Physics teachers of the chance to be abreast with contemporary issues, as well as with the skills to handle Physics concepts with a deeper and informed understanding.

The shortage of specialist Physics teachers is mainly manifested at the school level where their services are required. Smithers (in: IOP, 2010:1) examined the reasons for the Physics teacher shortage at school level. He reported that schools without Physics specialists had fewer learners progressing to A-level in the subject. SHAI (2010:1) concurs with this observation and reports that the reduction in the number of learners progressing to A-level is drastic. The reduction in learner progression is caused by the complexity of Physics and the shortage of specialist Physics teachers who can assist the learners. The IOP (2010:1) reports that about 500 state schools in England lacked specialist Physics teachers, and more than half of new Physics teachers are leaving the profession, having attained teaching experience of four and a half years. The IOP (2010:1) laments the attrition, while reporting that Physics teachers are frustrated by the lack of respect from both the learners and the school administrators, including the lack of discipline in schools. The lack of respect is manifested when the teachers are derided by the learners, thus subjecting them to physical assault. Having acknowledged all these challenges, the IOP provides a number of suggestions to the challenge. One of the suggestions is the creation of ‘supercentres’ aimed at training more Physics teachers, as well as mentoring in order to improve retention (Beese & Liang, 2010:268). Some benefits were accrued when the IOP was running the Stimulating Physics Network (STN), which is in resonance with Boutelle’s (2010:2) suggestions. The STN resulted in the schools taking part seeing a 30% increase in the number of learners taking their Advanced Subsidiary (AS) exams. It is unfortunate that there is no unifying body for Physics teachers in Swaziland where their challenges could be addressed at the institutional level.

Boutelle (2010:1) provides a number of suggestions for the institutional level on how to retain and increase the number of Physics teachers, which could be useful in addressing the current situation in Swaziland, namely

- offer incentives in the form of signing bonus;
- provide professional development opportunities to those already involved in science careers;
- make an effort to seek out learners immediately they enrol in their first year Physics courses to steer them into teaching careers;
- pay interns for candidates with Science backgrounds;
- offer attractive wage and benefit packages;
- motivate Physics teachers to engage in distance learning;
- develop methods to identify and motivate college undergraduates and high school learners who might not be considering teaching (Boutelle, 2010:1).

The suggestions by Boutelle are quite relevant for the local context, but most of them are hinged on the availability of finances. It stands to reason that the major challenge is sourcing finances to provide incentives to the Physics teachers. It would be much better if governments sanction Physics education as a priority area, but this is undermined by the fact that in some of the developing countries a larger proportion of the finances are channelled towards the activities of the security forces (Simelane, 2012:27). It appears that the government is not aware of the fact that these forces require the expertise of Physics specialists to develop the machinery for the Forces.

The research on the teachers' opinions on the reasons for the specialist Physics teacher shortage points to the primary level as one of the sources (Politis *et al.,* 2007:39). Politis *et al.* (2007) conducted a survey which revealed that a decline existed in the take-up of Physics within second-level education in Ireland. The survey included an analysis of the opinions of school principals, senior cycle Physics teachers and junior cycle Science teachers from 720 schools on the main factors influencing the take-up of Physics. According to Politis *et al.* (2007:39), the data revealed that most of the senior cycle Physics teachers did not possess a 'Physics-dominated' degree. The teachers were dissatisfied with the technical back-up available to them and their learners. They also argued that the majority of their learners lacked the basic mathematical skills needed to manipulate the Physics content, and believed that their learners were not adequately informed about career opportunities in Physics. The teachers felt that the learners were disadvantaged in regard to grade points in the leaving-certificate examination compared with most of the other subjects. Therefore there is a need for renewed urgency in respect of the implementation of a comprehensive action programme to reverse the decline in the Physics teacher shortage before it impacts negatively on the economy.

However, Oon and Subramaniam (2010) present suggestions that can be accomplished without sourcing a great deal of finances. Oon and Subramaniam (2010:281) conducted a survey to ascertain the teachers' views on how to encourage more learners to study Physics at tertiary level. They hoped that this initiative would increase the number of Physics teachers. They sampled 166 Physics teachers in Singapore schools and administered an open-ended questionnaire.

The teachers suggested that:

- the Physics curriculum should be reviewed;
- teaching Physics should be fun;
- the career prospects of Physics-graduates should be improved;
- the career opportunities available to Physics-graduates should be published;
- enrichment programmes should be conducted to promote Physics (Oon & Subramaniam, 2010:281).

The Physics curriculum should incorporate more courses when it is reviewed. These courses should not be complex but attractive so that learners could derive some fun. Moreover, the courses should be enriched to be more relevant to the learners' needs.

It is well-documented that Swaziland is currently faced with a shortage of specialist Physics teachers at the senior secondary school level (Government of Swaziland, 2011:25) This shortage is prevalent in both rural and urban schools (Government of Swaziland, 2011:25). A synopsis of teachers in senior secondary schools around Mbabane city revealed that three schools had Agriculture specialists teaching Physics, one school had Biology and Chemistry specialists teaching Physics, and another school exploited the expertise of an engineer. In some cases, Physics was taught by Bachelor of Science graduates who were without a teaching qualification. It is the learners who bear the brunt of being taught by teachers who have no Physics qualification. The academic incompetence of the teachers can be manifested in the poor performance of the learners in examinations that require certain standards of competence (Examinations Council of Swaziland, 2009:71 and Shongwe, 1996:217). Consequently, the learners lack the basic knowledge that would enable them to pursue challenging subjects like Science. Moreover, they would not feel confident enough to choose Science-oriented careers. Thus, the learners would regard Science as a 'sacred' discipline. This notion equates Science to a discipline designed for the selected few. Then, to what extent does the professional level contribute to the shortage of specialist Physics teachers and what solutions are proposed at this level?

2.2.2.3 Challenges and solutions at professional level

In retrospect, the researcher mentioned previously that the policy level influences the operations of the professional level. In the U.K. policy pronouncements affected the operations of the professional level. The shortage of Physics teachers in the U.K. was because of the failure of government's initiatives to recruit more Physics specialists (Sherriff, 2005:1). According to Robinson, of the Centre for Education and Research, 26% of the Physics teachers were either leaving the profession or retiring

(BBC News, 2008:1). Central to addressing the shortage is professional development in Physics for non-specialists. Similarly, in Swaziland, most Physics teachers are non-specialists in Physics (Government of Swaziland, 2011:25). Some of the above solutions to the shortage of Physics teachers' are long-term, but Swaziland needs immediate solutions, hence the need to ascertain these in the local context. The case of Swaziland is premised on access to programmes at tertiary level, which are currently markedly insufficient.

The professional development of teachers, as an initiative of policy, has been paramount in the improvement of Physics education in senior secondary schools in the U.S.A. (Woolhouse & Cochrane, 2010:608). Ross, Van Dusen, Sherman and Otero (2012:327) investigated how Physics teachers developed and implemented an inquiry-oriented curriculum in order to shift the teachers towards mastery in their fields. The results indicated that, as the teachers engaged in teacher participant-driven experiences, they became more expert-like in conceptions of inquiry teaching and learning. The method employed by these researchers is in line with the social constructivist theory, which advocates for a collective effort in meaning-making ("constructivism", n.d.). This social constructivist theory was manifested when the teachers were engaged in lesson-sharing reflections and discourse meetings. Woolhouse and Cochrane (2010:608) suggest that Physics teachers should be integrated into a community of practice, which could enhance their subject knowledge and pedagogic practice. The Physics teachers in Swaziland, once they become members of a community of practice, can initiate and exploit lesson-sharing reflections and discourse meetings in their clusters at regional level to augment their knowledge of the Physics content. Therefore, the need exists for policy to establish and support teacher cluster activities that promote Physics education.

Several researchers have reported that many pre-service teachers lack the most basic understanding of their disciplines when they begin training as teachers (Nilsson & Van Driel, 2010:544). Nilsson and Van Driel (2010:542) contend that often pre-service teachers lack the basic understanding of content knowledge. These researchers draw on a study that sampled 147 in-service junior secondary science teachers in Hong Kong, and examined their competence in the Physics content

(Nilsson & Van Driel, 2010:544). The findings indicate that the majority of the pre-service teachers are incompetent in teaching Physics content-knowledge, in particular in topics such as mechanics and electricity. They conclude that this is due to a disjuncture in the levels, i.e., a lack of connection between the concepts that the junior secondary pre-service teachers acquire and the concepts they are likely to teach (Nilsson & Van Driel, 2010:544). There exists the need for the harmonisation of the concepts from one level to the other for a smooth transition in Physics content. In other words, the learners should be assisted in how to make a connection between the Physics content-knowledge learnt at the different levels.

Contrary to the observations as indicated in the Education Journal (2011) on the duration of courses, in Swaziland the duration of the Physics courses is not a year, but three years at diploma level and four years at degree level. The duration of courses is sufficient to produce a well-trained Physics teacher, but this could be undermined by the recurrent class boycotts (Dlamini, 2012:4; The Swazi News, 2012:20). According to this newspaper (The Swazi News), the local tertiary institutions are regarded as 'war zones', since such boycotts are almost on an annual basis. The begging question is, namely "How do these tertiary institutions ensure that the learners have sufficient time to be able to manage the Physics content?" On a positive note, but for other countries, the Education Journal (2011:1) indicates that there was a rise (30%) in the number of Physics trainees in 2011. The increase was facilitated by initiatives geared towards recruiting Physics teachers, and the introduction of a Physics and Mathematics postgraduate certificate in education (PGCE). Moreover, there were commitments by the government to review the salary and conditions of service for Physics teachers, since they were paid less than other Science, technology and engineering professions (Education Journal, 2011:2, Volkmann, 2011:1; JMU Public Affairs, 2009:1). A review of the salaries and working conditions has recurrently surfaced in lists of teachers' demands from the government, which indicates that these demands are crucial for teacher retention. Another issue that has featured in one of the lists is special remuneration for Science teachers. The issue of special remuneration for Science teachers was contested in Swaziland by the Swaziland National Association Teachers (SNAT). SNAT argued that it was discriminatory, since all teachers served the same purpose.

Güzel (2011:1046) contends that some of the challenges related to the shortage of Physics teachers that emanate from the professional perspective are associated with the teachers, the learners and the content. The teaching methods employed by the teachers are passive, uninspiring and ineffective (Oon & Subramaniam, 2010:277). This points to the poor quality of Physics teachers; thus Physics teaching and learning would lack motivation for learners who intend to pursue the teaching career. According to Vegas (2005:17), motivation is one of the factors affecting the quality of teachers. The shortage of Physics teachers could be due to a lack of motivation. Williams and Williams (*s.a.*:1) note that there is very little learning, if any can take place unless the learners are consistently motivated. Also, the absence of self-motivation has a negative impact on the teaching and learning of Physics. The learners end up complaining that Physics is a collection of laws, and that the subject requires a great deal of formulae for mathematical calculations. These complaints by the learners emanated from the fact that they did not have sufficient knowledge of the Mathematical content, which is essential for the acquisition of the Physics concepts. Learners who feel that the content of Physics is less relevant to their needs tend to be unmanageable in class. This situation is exacerbated by the fact that the content is taught by teachers who have not specialised in Physics. Volkmann (2011:1) argues that it is a challenge to the learners that the majority of the Physics teachers did not major in the subject, and this does not inspire the learners to go into the teaching profession. Apparently the learners observed that the teaching profession did not reward teachers. Moreover, the teachers were also faced with disciplinary challenges, due to, for example, a lack of support from the school administration. In this argument, teacher and learner motivation are critical to the Physics teaching and learning processes.

In order to mitigate the shortage of Physics teachers at the professional level, Grosnick and Watson (2008: 1) use the analogue of a bucket that never overflows. They suggest that effective induction programmes should be introduced, and that these should be coupled with motivation. One way of motivating the teachers is through ascertaining and meeting their needs. It is vital that school administrators and policymakers know the teachers' needs and, for example, provide in-service training programmes that are school-based to augment their content knowledge

(Millar, 2006:39). These strategies are meant for professional teachers, but other strategies should be geared towards pre-service and prospective teachers. Gold (2006:1) and Boutelle (2010:1) suggest that the recruitment exercise should focus on undergraduates in the other sciences by providing incentive packages and attractive salaries to encourage them to consider teaching careers. They should not be recruited to teach just any subject, but specifically Physics, as the shortage of Physics teachers is severe.

The shortage of teachers within the sciences is hierarchical. In the U.S.A., Physics (2%) is leading in the shortage of teachers, followed by Chemistry (20%), with a relative surplus for Biology (25%) (Chodos & Ouellette, 2012:1). The few Physics teachers who are available are not trained to teach Physics. The majority of Physics teachers are under-qualified, with only 1/3 holding a degree in Physics or Physics education (Riordon, 2008:1; University of Texas at El Paso – UTEP, 2010:1; Cornell University, 2011:1; Physics blog on the World of Physicists, 2008:1; Chodos & Ouellette, 2012:1). Lindsey (2012:1) reports that more than half of all the Physics teachers do not possess a degree in Physics, whilst the American Physical Society (2012:1) reports that only 35% have a degree in Physics. Nonetheless, all the above publications agree that there is a shortage of qualified Physics teachers. One of the reasons why schools rely on under-qualified Physics teachers could be due to the teachers' demand in schools, inasmuch that other institutions that might be bogus take over the production of teachers with a limited duration of courses. It follows that the under-qualified teachers produce learners that are deficient in terms of the mastery of content. When the shortage is quantified it is obvious that a large percentage (90%) of learners is taught by teachers who have not majored in Physics nor have any certification to teach Physics. The statistics in New York indicated that more than half (52%) of the senior secondary schools did not offer Physics due to the shortage of specialists (Cornell University, 2011:2). As a result, very few learners enroll for senior secondary school Physics courses. Some initiatives should be geared towards empowering learners to enroll for Physics courses. Other initiatives should focus on the development of relevant training programmes that would empower under-qualified Physics teachers.

However, Ronald (2007:1) reported that a large number of learners were enrolled for Physics courses. Riordon (2008:1) agrees that there is a slight increase (1% a year) in the number of learners who take senior secondary school Physics. The APS (2012:1) reports that the rise for the past ten years was from 20% to 28%. However, this is fluctuating, compared to the findings of Cornell University. The few learners who enroll for the Physics courses emerge with skills and confidence to pursue tertiary education in the same discipline. Those who cannot make it, end up teaching the ‘softer’ Sciences like Biology and the Life Sciences. In New York teacher training institutions produced 52% of all qualifications, but only 16% with Physics as a major, and most of them were destined for other professions (Cornell University, 2011:1). The majority of students with Physics training go on to careers in finance, economics and management, and this sounds weird considering their major. Moreover, these careers are well-respected and well-paying, and historically have provided an upward path for the socio-economically disadvantaged, hence the current shortage experienced in the teaching profession. Therefore, educationists should develop strategies that could be used to attract graduates to the teaching profession, and also help to maintain the number of Physics teachers.

The shortage of Physics teachers is due to the fact that teacher education programmes do not attract learners who have a strong Physics background (Cornell University, 2011:1). This means that some of the teacher training programmes are irrelevant, do not have any appeal to prospective Physics teachers, and have little visibility to learners. The shortage is exacerbated by the fact that some tertiary institutions require that Physics teachers first earn an undergraduate degree in Physics or Physics education before obtaining teacher certification. In the same vein, the B.Sc. programme that UNISWA claims is meant for prospective teachers is ineffective for teaching purposes, since the graduates are required to enroll for a PGCE on completion of the four years of training. On certification, the prospective teachers take up the teaching profession, but this is a long and demotivating route. It would be better for UNISWA to integrate the education courses in all the years of the training programme, as advocated by Volkmann (2011:1), and Beese and Liang (2010:268). The option of integrating education courses in the B.Sc. programmes was echoed by His Majesty the King of Swaziland (King Mswati III) in his speech presented on the 20th of August 2012. The non-integration of education programmes in the courses at tertiary institutions reduces the overall output of Physics teachers. The reduction in the overall output in tertiary institutions deprives the senior secondary schools in Swaziland of qualified Physics teachers. This is indicated in the UNISWA results of 2000 – 2010. Therefore, UNISWA needs to integrate the education courses in the Science programme for learners who intend to join the teaching profession.

Cornell University (2011:1) paints another gloomy picture in respect of the production of Physics teachers in the United States of America. In one of the states, the top 10 institutions for training Physics majors produced 61% of all majors, but less than 4% of Physics teacher certifications. These statistics are alluded to by Gold (2006:1), who argues that subjects like English were better (70%) positioned to obtain certified teachers to teach the subject compared to Physics with a lower chance of only 33%, moreover, with full certification. Boutelle (2010:1) questions the quality of tertiary programmes and argues that these programmes under-prepare prospective teachers, since 35% of pre-service Physics teachers were under-prepared for teaching. Gold (2006:1) suggests that universities should work in collaboration with senior secondary schools and colleges to address the shortage by ensuring that their professional development programmes tap on what learners acquire at each level. It is essential that tertiary institutions play a major role in addressing under-preparedness of Physics teachers through developing relevant programmes. The programmes will then ensure a smooth transition in terms of the content acquisition by the learner, from senior secondary to tertiary level.

Marope (2010:36) indicates that the under-preparedness of Physics teachers is prevalent in the Lubombo and Shiselweni regions and in low-performing schools. Moreover, not all secondary school teachers are qualified to teach the subjects they currently offer (Marope, 2010:36). Those who are well-trained are attracted by more lucrative and less demanding careers, thus leaving the schools with under-prepared teachers (Boutelle, 2010:2; Rundquist, 2009:1). Some of the teachers retire (30%), while others abandon the profession altogether (Sherriff, 2005:1; Boutelle, 2010:2; Rundquist, 2009:1). Boutelle (2010:2) observes that some of the teachers are suspended, but does not furnish the reasons for their suspension. The suspension could be due to various malpractices in the profession, for example, the sexual abuse of learners. The Institute of Physics (IOP) (2010:1) notes that the learners sometimes fabricate accusations of sexual abuse against some teachers, thus totally ruining their careers. The shortage of Physics teachers is so severe that it cannot be contained. The IOP associate it to "…a bath with the plug out and the taps only half on" (IOP, 2010:1). In accordance with IOP (2010:1), teachers were leaving the profession at such a higher rate that only 19% remained in teaching, despite holding a Physics degree. It is apparent that there is no cohesion between the rate of teacher production and teacher retention in schools, due to various challenges. The abovementioned challenges that the teachers face have to be addressed through seeking their opinions, which is the thrust of this study.

The situation in respect of the Physics teacher shortage in the U.S.A. is severe, and bears some resemblance with the one in Swaziland (UNISWA results, 2000 – 2010). Some startling cases on the shortage of Physics teachers in the U.S.A. can be indicated. Rundquist (2009:1) reports that from 2007 to 2008 only one prospective teacher out of 955 graduated from one of the U.S.A.'s universities with a certificate to teach Physics. At another college only 40 Physics teachers graduated in a period of 12 years. The Department of Education in the U.S.A. issued 4050 certificates in 2008, but only 67 of the candidates were qualified to teach Physics. According to the National Mathematics and Science Initiative, only 5% of the U.S.A.'s undergraduates earned college degrees in Science and Engineering, compared to 42% in China. The statistics point to a dire situation, and raise questions on the measures being employed for the professional development of Physics teachers. Thus, the current measures should be reviewed at tertiary level.

The above statistics also provides enough evidence for the existence of a shortage of Physics teachers at the international level. But, what is paramount are the measures employed to address the shortage. In order to address the shortage of Physics teachers, Rundquist (2009:1) suggests that teachers who are holding other majors and are able to teach should be recruited to enroll in evening classes to learn the Physics content, rather than recalling those people working in the industries who have majored in the sciences. She also suggests that Physics teachers should enroll for intensive summer courses and on completion be awarded with some graduate credits points which are paid for by the government. These suggestions sound more relevant to address the situation in Swaziland, but the government should provide incentives, and the training centres should be easily accessible to the teachers. In the meantime, these centres could be utilised to augment the Physics content-knowledge of teachers of Agriculture while other means are being sought for training more relevant specialists.

Educationists and politicians argue that salary reviews can solve some of the challenges faced by the discipline. People are attracted to a particular profession by the amount of remuneration that is offered. Research suggests that unattractive salary scales, the lack of incentives and unfavourable working conditions compel Science teachers to leave the teaching profession for higher-salaried jobs in other occupations (Vegas, 2005:16). Physics teachers believe that the salary offered to them is meagre, which has declined considerably in the most recent years (Santiago, 2002:1). In other words, the salary is not equivalent to the effort they exert during the teaching and learning of Physics. Moreover, a culture exists that undervalues teaching as a profession and rewards it, both financially and sociologically, in the same manner (Boutelle, 2010:1). One useful way of addressing the shortage of Physics teachers in Swaziland is by means of offering attractive salaries to the teachers, since salaries are vital for the recruitment and retention of teachers (Beese & Liang, 2010:270). The teachers also complain that they do not get much respect from learners, and this undermines their integrity and status. Thus, the teachers face increasing problems of discipline in the classrooms. The Physics teachers should be assisted by the administrators on how to instil discipline in the learners.

The working conditions and workload are some of the deterrents for graduates who intend to be teachers (Cartlidge, 2001:2). This situation is made worse by the fact that Physics is a challenging subject that requires from learners to have a strong Mathematics background (SHAI, 2010:2). The lack of the learners' depth of mathematics knowledge was acknowledged by Sharp *et al.* (in: Murphy & Whitelegg, 2006:287). This lack of mathematics knowledge was noted by 25% of the Science heads in the schools, and by 45% of the Science educators, which made the study of Physics complex. It is vital that the mathematics background of learners is improved and reinforced by professional teachers for the acquisition of mathematics embedded in Physics concepts. Measures geared towards improving Science teachers' working conditions, the reduction of their workload, and the provision of support could retain them longer in the profession. A direct consequence of the overwhelming workload is manifested in the teaching load of Physics teachers in some schools in Swaziland. It is possible to come across a situation in a school where Physics teachers have more teaching periods than the other teachers, due to their shortage. A case in point, in one particular school in Mbabane city, the Physics teacher had 30 periods, while the other teachers (English and Religious education) had on average 20 periods (Mavimbela, 2012:3). This indicates that the few teachers who are available are overloaded.

The severe shortage of specialist Physics teachers in the United Kingdom at professional level was indicated by Woolhouse and Cochrane (2010:607), who attributed it to the structure of professional development programmes and also the recruitment and retention strategies employed by the different structures in the government. They noted that about 25% of English schools were in severe shortage of one or more subject specialists. This implies that the majority of the learners were not taught by specialists, which had a negative effect on their performance in those subjects. On the issue of professional development, the Education Journal (2011:1), reporting on a study of a one-year postgraduate course for secondary Science trainees, reflects that the main issue is the manner how trainees acquire content knowledge, as opposed to how they learn to teach it. The results indicate that there is a strong variation in the amount and nature of Science knowledge taught during the initial teacher training courses (Education Journal, 2011:1). Lock (in: The Education Journal, 2011:1) echoes the strong variation in the nature of the taught Physics content, and argues that the perceived 'shortage' is due to the fact that nearly 1/3 of the trainees who specialised in Physics, felt that their degree courses had little to do with Physics, thus discouraging them from engaging in teaching the subject. The irrelevance and inadequacy of the degree courses is manifested at the senior secondary school level where the prospective teachers start their teaching careers. Cornell University (2011:1) reports that 1/3 of all senior secondary school Physics teachers had taken less than three college Physics classes. Also, at senior secondary school, 1/3 of the learners took Physics courses (Cornell University, 2011:1). Drawing from the above argument, there is a need to review strategies employed for Physics teachers' professional development. The Physics content has to be harmonised in all the levels and has to be made relevant to the situation that pre-service teachers would encounter at the senior secondary school level.

Regarding the issue of Physics content-knowledge, it is the role of tertiary institutions to ensure that prospective teachers have sufficient content-knowledge to effectively teach the subject they specialized in, since studying has an identifiable impact on classroom practice (Supovitz & Turner, 2000, in: Woolhouse & Cochrane, 2010:607). The Physics teachers' content knowledge has been questioned, and found to be inadequate. The Education Journal (2011:1) points to the lack of subject content-knowledge as a reason for the shortage of specialist Physics teachers. The deficiency in subject content is attested to by the JMU Public Affairs (2009:1) and Cornell University (2011:1), which note that the situation is more severe in rural schools. The Education Journal (2011:1) confirms the deficiency in Physics content, and reports that the percentage (20%) of learners who intend majoring in Physics is lower than that in Chemistry (30%) and Biology (50%). The above statistics are alluded to by the number of graduates from UNISWA between 2000 and 2010 (UNISWA results, 2000 – 2010). The Education Journal (2011:1) also reported that prospective teachers felt that their courses included very little Physics content. Moreover, the duration of the courses was only a year (Education Journal, 2011:1), which is inadequate for training specialist Physics teachers. The inadequacy of training in Physics causes the prospective teachers to lack the confidence to handle the Physics concepts when their turn comes to teach the subject. Insufficient content and lack of interest towards Physics content eventually create attitudes towards the subject.

2.2.2.4 Gender disparities and attitudes towards Physics

Some subject preferences according to gender have been recorded by researchers (Murphy and Whitelegg, 2006; Politis *et al.,* 2007). According to Marope (2010:30), gender inequalities in enrollment manifest themselves at around the age of 16. Thereafter, between the ages of 17 and 20, the majority of the boys remain in the school system. Therefore, this observation partly answers the question why there are less female students in some courses at tertiary level. But the paramount question is, namely “Why does the majority of female students opt out of Physics courses at tertiary level?” Politis *et al.* (2007:42) mention that research indicates that female students are not eager to learn Physics, since they regard it as ‘sacred’ and abstract. It is apparent that the decline is caused by their attitudes towards Physics. Therefore, research should ascertain the root causes of the negative attitude towards Physics, and also the misconception that female students prefer not to learn Physics.

The notion of regarding some subjects like Physics as ‘sacred’, abstract and difficult is not easy to un-teach, since it is inadvertently promoted by the teachers and the parents, and has its roots in the lower levels of education, which is later manifested in tertiary institutions (Nilsson & Van Driel, 2010:542; Oon & Subramaniam, 2010:277). Thus, the prospective teachers will have an inclination towards majoring in the ‘softer’ sciences. Subsequently, these teachers will be comfortable with teaching Biology and Chemistry, even after doing a course in Physics (Rundquist, 2009:1). These subject preferences by teachers and learners are deeply entrenched in gender biases. Some gender disparities are manifested in subject choices among prospective teachers and learners. A survey by Warrington and Younger (2000) on subject preferences indicated that the majority (63%) of girls prefer Biology and Chemistry (37%) (Warrington & Younger 2000, in: Murphy & Whitelegg, 2006:289), whilst Physics (22%) and Mathematics were considered to belong to the males’ domain (Politis *et al.,* 2007:42). The notion of apportioning subjects according to gender is deeply entrenched in the pedagogues’ and parents’ beliefs about competence and incompetence, which eventually filter down to the learners (Murphy & Whitelegg, 2006:299). Bruner (1996) argues that this shared symbolism is conserved, elaborated and transmitted to succeeding generations who maintain the culture’s identity and way of life. It is apparent that the repercussions of this belief greatly affect the teaching and learning of the sciences in schools and deter the learners who intend to take up Science education as a profession.

Some gender disparities within the sciences contribute to the shortage of specialist Physics teachers (Danielsson, 2009:1). Gender disparities have been recorded in Sweden. Danielsson (2009:1) reports that in Sweden female students were greatly under-represented within university Physics courses. The argument posed is that Physics is symbolically associated with men and masculinity. The under-representation of girls in some senior secondary Physics courses is also documented in England, as reflected in the report by the Institute of Physics (Collins, 2012:2). Collins further notes that questions have been raised on the attitudes and treatment of girls by teachers at lower levels (Collins, 2012:2). Studies have been done on the attitudes of girls towards Physics, and have indicated that girls who studied A-level Physics in girls’ schools displayed a greater ability than boys, and this manifested a positive attitude towards Physics (Collins, 2012:2; Ghosh, 2012:2).

However, Ghosh (2012:2) observes that the number of girls who studied A-level Physics is smaller than that of boys. Murphy and Whitelegg (2006:287) concur with Ghosh in respect of the reduced enrolment of girls and attributed it to the learners’ declining liking for Physics. Contrary to this, in the local context, almost an equal number of girls and boys do Physics at senior secondary level and A-level, but as they progress to the tertiary level, the number of female students is greatly reduced (University of Swaziland Calendar, 2010). In the researcher’s experience as a Physics teacher, he observed that in some instances there were more girls in the Physics classes than boys. But at university more male students opt for Physics than female students. This indicates that there is an unexplained learner-attrition gap between senior secondary school and university. Further research should clarify why fewer female students opt for Physics than male students at local tertiary institutions. Educators should first ascertain the reasons for this anomaly. Then, put measures in place that would attract more female students to the Physics courses. This would probably increase the number of graduates who take up Physics teaching, since this is the aspiration of MoET. This would help eliminating non-specialist teachers from teaching Physics.

Contrary to the general observations from other countries on the under-representation of girls, Physics is very popular in secondary schools in Scotland, with large numbers of boys and girls studying the Higher Grade course (Reid & Skryabina, 2003:509). Reid and Skryabina (2003) explored the attitudes and perceptions of Scottish boys and girls towards Physics, ranging from 10-18 years old. They recorded positive attitudes towards Science for both boys and girls towards the end of the primary school level. However, the attitudes of the girls declined significantly at the end of the second year of the secondary school level. When the learners reached the Higher Grade course, the attitudes of the boys declined markedly compared to those of the girls. It is essential that the structure and nature of the Science course in the junior secondary level be revisited to attract more girls who intend to study Physics.

The number of girls who took Physics courses in the U.S.A. increased slightly in the year 2012. The increase in the number of girls was also observed by Ronald (2007:1) who mentioned that it rose from 39% in 1987 to 49% in 2007. The Physics Teacher (2012:90), while acceding to the rise, reported that in January 2012, in the U.S.A., 47% of the Physics learners were female. This figure indicates a slight increase since the dissemination of the 1997 statistical results. An examination of the female representation by type of class indicates a growth in the number of females who enroll for Physics courses, especially conceptual Physics courses (The Physics Teacher, 2012:90). It is, however, not yet time for the teaching profession to celebrate this increase. The local context at tertiary level attests to the contrary. This increase in enrolment does not imply that, after completion, the graduates would all assume teaching roles. Moreover, this increase will not benefit the local context, thus the need for locally developed solutions, as is the thrust of this study. Central to the increase in enrolment are learner motivation and a positive attitude towards Physics.

Nilsson and Van Driel (2010:541) investigated how pre-service teachers perceived the development of their knowledge and attitudes towards Physics. The results indicated that self-confidence and meaningfulness of knowledge were perceived as important factors for the development of Science pre-service teachers' subject-matter knowledge, as well as a positive attitude towards Physics. The development of the teachers' subject-matter knowledge is paramount, since it enables them to explicate the Physics concepts with understanding. Subsequently, the learners taught by this caliber of teachers accrue some benefits, as they also investigate the Physics content with understanding. Eventually they also develop a positive attitude towards the subject, since the teachers' mastery of Physics-knowledge stimulates the learners' interests and engagement in the learning process (Nilsson & Van Driel, 2010:542). The teachers who lack knowledge of the subject matter have limited alternatives on how to impart content to learners (Nilsson & Van Driel, 2010:542). It is apparent, that the situation in Swaziland attests to lack of alternatives, since the schools rely mainly on teachers who are not Physics specialists.

All in all, the literature review indicates that various factors contribute to the shortage of specialist Physics teachers at senior secondary level emanating from policy, institutional and professional levels. Nonetheless, the literature also provides some solutions which may be employed at these levels. It is, therefore, essential that these levels synergise their activities in order to address the shortage. The researcher would argue that a positive attitude towards Physics and its relevance to both the teacher and learner are critical for the increase in the number of specialist Physics teachers, underscored by some incentives, not necessarily financial inducements. Then, the begging question is, namely "What are the challenges faced by the local tertiary institutions not to increase the enrolment, and to attract more prospective Physics teachers?"

2.2.2.5 The provision made for Physics in teacher training institutions in Swaziland

There are only two tertiary institutions in Swaziland where one can enrol for the Physics teaching profession. These are the William Pitcher College, that trains teachers at diploma level (Secondary Teacher's Diploma) for junior secondary level, and the University of Swaziland (UNISWA), that awards undergraduate degrees

(Bachelor of Science – B.Sc. and Bachelor of Education – B.Ed.), of which some qualify the teachers to teach at senior secondary level. The Physics programmes in these tertiary institutions are insufficient to cater for the needs of all the schools in Swaziland. This begs the question, namely are tertiary institutions aware of the shortage of Physics teachers in the schools? If yes, then what resources could they mobilise to address the situation?

The above programmes were meant to increase the number of science teachers in schools, including direct entry for science education candidates, starting in the year 2006. The In-service Department (INSET) once proposed that UNISWA introduces an additional intake of candidates to help curb the shortage (Mavimbela, 2012:10). In fact, INSET had observed that the programmes in the university had failed to attract a reasonable number of candidates. INSET is based at UNISWA, and is the only in-service department with one Physics officer who provides in-service training in Physics to all senior secondary school teachers in Swaziland. It is apparent that the department cannot cope with the demand, due to the shortage of resources and the number of schools that need their services. Having exonerated the INSET department, then there is a need to ascertain why Swaziland's teacher training institutions are currently unable to meet the demand for Physics teachers in senior secondary schools.

One of the mandates of teacher training institutions in Swaziland is to train teachers who specialise in various fields, in order to meet the demands of the teaching profession and the economy. The various specialist fields should be coupled with a variety of programmes that will attract more prospective teachers. One of these areas of specialisation is Physics. Physics is taught at the two teacher training institutions as one of the subjects of the curriculum. The process of teaching is facilitated by the presence of a competent lecturer who is conversant with Physics content-knowledge. One of these institutions is the William Pitcher College that trains teachers at diploma level to graduate with a Secondary Teacher's Diploma (STD). The teachers from this institution are qualified to teach at junior secondary level. The other institution is the University of Swaziland (UNISWA), that produces undergraduate degrees, namely a Bachelor of Science (B.Sc.) and a Bachelor of

Education (B.Ed.), which qualify the teachers to teach at senior secondary level. UNISWA has three main faculties that train both in-service and pre-service teachers, namely the Faculty of Science, the Faculty of Education, and the Faculty of Humanities.

The researcher focused on the Faculty of Science and the Faculty of Education in this study, since they *inter alia*, produced Physics teachers.

The Faculty of Science at UNISWA has evolved considerably over the past decade, and now consists of the following departments, namely Biological Sciences, Chemistry, Computer Science, Electrical and Electronics Engineering, Geography, Environmental Science and Planning (GEP), Mathematics and Physics. All the departments present courses that lead to the four-year degree of Bachelor of Science, except for Electrical and Electronic Engineering. The five-year Bachelor of Engineering (B. Eng.) programme enshrines the Faculty's intention to widen the Science and Technology base in the country. The Bachelor of Science (B.Sc.) degree programme is meant mainly for the production of teachers, with a small proportion going on to study Medicine, Pharmacy, Engineering (UNISWA Calendar, 2012/2013:22).

The UNISWA Calendar (2012/2013:22) reflects that the B.Sc. programme is meant for the delivery of teachers, but the situation in the schools indicates that the majority of the graduates do not opt for teaching, but for other professions. It is apparent that only a small percentage takes up teaching as a career. The researcher would like to argue that the B.Sc. programme is inadequate for the training of teachers as asserted by the university. The prospective teachers who are produced by this institution within the B.Sc. programme are half-trained, since on graduation they have no education background or teaching skills. The programme can only be made relevant by introducing a concurrent certificate or diploma in education. Therefore, it is improper for the university to claim that it is training teachers with the B.Sc. programme. Graduates who intend taking up teaching have to enrol for an extra year in the Faculty of Education to graduate with a post-graduate certificate in education (PGCE).

The Faculty of Education trains teachers in respect of different specialisation areas. The Faculty trains mainly in-service teachers who intend to upgrade their qualifications to degree level. The Faculty has five departments, namely Adult Education, Curriculum and Teaching, Educational Foundations and Management, In-Service Education and Primary Education. Through the Department of Adult Education, the Faculty offers professional training in adults, as well as continuing education, and helps to increase the effectiveness of institutions, organisations and community-based groups which serve the adult population of Swaziland and beyond. Aspiring students are able to learn while keeping their jobs and performing other obligations, as the tuition is offered part-time. The university claims that the other three departments offer the pre-service and in-service training of teachers and have continued to meet the needs for educators and school administrators at all levels (UNISWA Calendar, 2012/2013:22). On the contrary, the university has not yet met the needs for educators in all specialisation areas, especially Physics teachers. It is true that it produces a surplus of graduates in the Faculty of Humanities, but this is not true of the sciences. Therefore, the above statement is not applicable in the case of the science specialists otherwise the schools would not be starved of relevant Science graduates.

The Adult Education programme could be relevant in addressing the shortage of specialist Physics teachers, since the courses are offered on a part-time basis, as mentioned before. The teachers would be able retain their jobs while upgrading their qualifications, since this is an era of high demand for qualified Science teachers. The other department that can act as a focal point for teacher professional development is the In-service department. This department was established with the sole purpose of the professional development of in-service and beginning teachers in the sciences (Physics, Chemistry, Mathematics and Biology).

The In-service department organises workshops for secondary school Science and Mathematics teachers. These workshops are subject-specific, i.e. Biology, Chemistry, Physics and Mathematics. The purpose of the workshops is to address the identified needs of the teachers arising from the changing nature of the teaching and learning environment, the high turn-over of Science and Mathematics teachers and the changing education policies and the expectations of the teachers. Some current and recurrent activities include the preparation for the practical examinations, laboratory management and use, curriculum change (GCE to IGCSE to SGCSE), schemes of work, and teaching methods.

The In-service department also offers the induction programme (IP) which helps beginning teachers to settle down quickly, or in the teaching profession with the hope that they would stay on in the profession. It involves UNISWA-based workshops and school-based activities carried out with the help of a mentor teacher. The IP is offered to Science, Mathematics and Geography teachers. Mavimbela (2012:3) argues that the IP is suitable for all new teachers and it should be expanded to include teachers of other subject specialisations in the future.

The In-service department also offers non-specialist workshops which are intended for the large number of teachers teaching Science and Mathematics in the schools without the requisite qualifications. As mentioned in previous sections, some of these teachers lack training in education while others lack training in the content areas.

The workshops consist of two parts:

- basic teaching methods for those with no education qualification; and
- basic science skills workshops for those with no content knowledge.

The workshops cannot be offered on a frequent basis due to insufficient human resources in the department, since he has to attend to other activities in the department. There are only four lecturers manning this department, one for each subject area, namely Physics, Chemistry, Mathematics and Biology. The small number of lecturers cannot provide close supervision and professional development at a regular basis to all the Science teachers in Swaziland. Therefore, the government should employ more lecturers to facilitate the work of the department for a better coverage of the schools in all the regions. UNISWA could probably empower the In-service education department by employing more lecturers to provide in-service training to non-Physics specialist teachers during vacations or weekends.

In UNISWA's quest to address the shortage of specialist Physics teachers the direct entry for those who intended to major in Science was introduced in 2003 (Magagula, 2010:15). This programme was meant to increase the number of Science teachers in the schools. It is worth mentioning that this institution has for some years been producing only a small number of Physics specialists meant to either take up teaching or be absorbed by the industry. The In-service Department (INSET) once proposed that UNISWA introduces an additional intake of candidates to help curb the shortage (Mavimbela, 2012:5). In fact, INSET observed that the programmes in the university failed to attract a reasonable number of candidates (Mavimbela, 2012:8). Therefore, there is the need to ascertain why Swaziland's teacher training institutions are currently unable to meet the demand of Physics teachers in senior secondary schools, with all these measures in place.

The following section examines if the curriculum for the primary, secondary and senior secondary levels contains Physics content which may form a basis for the tertiary content. The content for these levels is a determinant for specialisation options at tertiary level, thus the need for proper grounding of learners in Physics concepts.

2.2.2.6 The content of Physics from primary to senior levels

The three levels through which the learner passes prior to the tertiary level are the primary, the secondary and the senior secondary levels. The assumption is that the learners at these levels are sufficiently exposed to the concepts of Physics as entailed in the curriculum documents. The contents of the Junior Certificate (JC) syllabus accede to this observation. The policy document (JC syllabus, 2012 - 2014) for Science stipulates that Science must be included in the curriculum and also indicates that:

- Science should have a place in the education of all learners who are in the school system, whether or not they are likely to go on to follow a career in the science or technology field. Science and technology permeate almost every aspect of one's daily life. Each of us needs to be able to bring to bear on the practical, social, economic and political issues of modern life.

- Science education should be regarded as a continuum from grade 1 to grade 12. The course of Science education should form a coherent series of experiences for learners as they progress through the Science curriculum.

- The central objective of the National Policy for Science in secondary education (junior and senior) in Swaziland is that all the learners should be given a broad programme of Science well suited to their abilities and aptitudes for the full five years of secondary education. Full weight must be given to the development of scientific skills and processes, as well as to knowledge and understanding.

- The science curriculum should provide equal opportunities and balanced courses. Particular attention should be given to the expectations and attitudes of the girl-child when reaching decisions on style, teaching methods and curriculum content (Ministry of Education and Training, 2012).

The above policy pronouncements indicate that Science is a core subject in the curriculum from grade 1 to grade 10. Thereafter it is one of the options at senior secondary level (grades 11 and 12). It is only the learners who intend to pursue Science-oriented careers who study it at senior secondary level. The policy document for Science has placed the emphasis on paying attention to the needs of the girl child in decision-making processes and the selection of teaching methods. The UNISWA statistics in previous sections indicated that there were few female students who specialised in Physics at tertiary level. It is still not clear, in the local context, why the number of female students who pursue second year Physics tends to decline at tertiary level, having been catered for in the Science curriculum in the lower levels. The question that arises is, namely "Could it be the structuring of the teaching and learning materials, and some activities in the teaching and learning processes which exclude the girl-child?" Politis *et al.* (2007:42) contend that some of the sciences are perceived to belong to the male's domain. It has been noted in panel meetings, face-to-face discussions, public meetings and formal submissions that this misconception is perpetuated by the teachers who have not specialised in Physics, parents and the learners themselves, as well as the society at large. The teacher is faced with the object of developing strategies that could be utilised to correct this conception.

An examination of the syllabi of the primary and secondary levels reveals that both contain Physics topics. The topics that entail Physics concepts at the primary level are, namely safety, electricity, sources of heat, energy, sound, lightning, force, technological awareness, measurement, magnetism and electromagnets. The secondary level encompasses the following topics, namely measurement, electricity and magnetism, mass, force, energy, light and sound. This indicates that Physics is represented in these levels, as the policy document for Science (grade 1 to grade 12) dictates. If we assume that the learners are exposed to the Physics concepts at the lower levels (primary, junior and senior secondary) that would form the basis for Physics-oriented careers, then one wonders what really causes them to not opt for Physics at the tertiary level.

Apparently, the structure of the Junior Certificate (JC) examination also contributes to the shortage of Physics specialists. A scrutiny of the JC examination reveals that Section A comprises five compulsory questions on Biology, Chemistry and Physics concepts. Section B consists of four questions. Three of these questions are based on Biology, Chemistry and Physics concepts and the fourth one is a reading comprehension. The learner is required to choose any two questions. Dlamini (2011) states that often the learners do not choose the Physics question, but opt for the reading comprehension, and the one from either Biology or Chemistry. He also observes that during the moderation of these questions, Physics is represented by only one moderator, whilst Chemistry and Biology have at least two moderators. Apparently, this does not provide diversity of opinions for Physics, which might render it complex for the level of the learners. He reports that, during teaching practice supervision, he visited six schools in the Manzini region, and found that the schools had eighteen teachers who taught Science, altogether. Of these eighteen teachers, only two were Science specialists, and the rest had majored in Agriculture. The manner of content interrogation by the teacher and learners probably influences the question choices in the examination. The above observations attest to the dire shortage of specialist Physics teachers. Projecting this observation on a larger scale could produce some informative results on the salient causes of Physics teachers' shortage. Educationists should engage in research to ascertain why the learners do not respond to Physics questions in the examination at the JC level.

The section that follows discusses the theoretical framework that informs this study.

2.3 THE THEORETICAL FRAMEWORK

The framework depicts a graphical or narrative explication of the issues that the study focuses on. These issues are key variables, factors or constructs, and the presumed association between them (Merriam, 1998:45; Maxwell, 2005:33). The main framework that underpins the study is a conceptual model developed by Howie (2003) on school effectives. The framework helped explain factors associated with the shortage of specialist Physics teachers, how they can be retained and how their number can be increased.

2.3.1 Howie's model of school effectiveness

Howie's model is, to a greater extent, informed by the work of Shavelson, McDonnell and Oakes (1987). In this model the education system is presented in terms of "inputs (including contexts), processes and outputs" (Howie, 2003:4). Howie's model is discussed with the following associated models, namely factors that determine school effectiveness (Heneveld & Craig, 1996) and the integrated model of school effectiveness (Scheerens, 1990). Howie's model was used as a theoretical and conceptual backdrop in order to analyse the findings of the study.

In the ensuing discussion, the researcher explicated each facet of the model and then related it to the study, starting off with the inputs.

2.3.1.1 The inputs

Howie (2003:4) identified three main prongs (inputs, processes and outputs) that characterise school effectiveness. The inputs comprise policy-related contexts operational at the national, regional and local or school level that inform the design and development of the intended curriculum, which, in the case of Swaziland, is the responsibility of the National Curriculum Centre (NCC). The intended curriculum explicates what should be taught to and learnt by the learners at the local level. In this case, what is taught and learnt at the local level (senior secondary schools) are Physics concepts. The concepts are imparted by the human resource, namely Physics teachers. The policy pronouncements at national level should stipulate the role that should be played by the provincial level on Physics teacher training, recruitment and retention. This means that the national policies should guide the operations of the schools, teacher training institutions and professional development initiatives. It is essential that MoET supports these institutions so that they could provide a variety of programmes that would attract more prospective Physics teachers. The current situation on teacher shortage points to insufficient support from MoET. The lack of support from MoET undermines the initiatives at provincial level. Subsequently, the provincial level should regulate the operations of the school level through, for example, the distribution of bursaries for learners. The amount allocated by the government for each learner is a factor of the school level (Teodorovic, 2009:297). The other activity at school level is teacher empowerment initiatives. Physics teachers are retained and capacitated on Physics-oriented innovations through in-service training at the school level. After receiving these empowerment programmes, the Physics teachers subsequently share their experiences on Physics content-knowledge with the learners at the school level. This demonstrates that Physics teachers play a crucial role in learner empowerment. Therefore, policy initiatives should promote the retention of Physics teachers at the school level through the provision of incentives and support.

The policy-related contexts influence the design and development of the intended curriculum. The intended curriculum comprises what is taught by the teachers and what is learnt by the learners (Ornstein & Hunkins, 2009:14). The ‘what is taught’ and ‘what is learnt’ are facilitated by the Physics teacher, and all occur at the school level. According to Van der Sandt and Nieuwoudt (2005:109), teachers are the catalysts of the teaching and learning processes, thus they are essential in the education system in engaging learners in the ‘what is taught’ and ‘what is learnt’. The teachers must be equipped with both content knowledge and pedagogic knowledge to cater for the different needs of the learners. Since this knowledge is shared with the learners, therefore, the school should offer a variety of Physics courses to cater for the diverse needs of the learners. The challenge in the education system, in the local context, is that the content that is received by the learners at the school level is inaccurate, since Physics is mostly taught by non-specialists.

The policy contexts also comprise resources, namely economic, physical and human. The economic resources enable the supported curriculum. Subsequently, the supported curriculum facilitates the implementation and delivering of curriculum resources, such as textbooks (Ornstein & Hunkins, 2009:14). The economic resource determines the share that the government invests in the provision of these resources and the development of the human resource at the school level. In some instances there could be sufficient funds to support the development of the human resource, but due to misdirected priorities, the money is diverted to cater for other needs. In most cases these needs do not benefit the development of Physics teachers. The structures that the head-teachers erect with the support from the government and from non-governmental organisations are classified within the physical resources. The purpose of the physical structures is to support the teaching and learning processes. The absence of some of these structures is a hindrance in the acquisition of the Physics concepts. The aspects of the physical structure that are essential for the teaching and learning of Physics are materials (e.g. books), the laboratory and laboratory equipment. Reports from the inspectorate have documented that there is insufficient laboratory equipment in most government-owned schools (Inspectorate report, 2010:5). The Education for All Plan of Action (2004) (Ministry of Education, 2004:6) reports that there is a high demand for science laboratories and other education-related projects. The lack of equipment affects the teaching and learning of Physics, since some of the equipment is specialised and essential for the explication of the Physics concepts. Moreover, the equipment cannot be improvised, for example, the cathode ray oscilloscope.

Howie (2003:4) contends that inputs also encompass some antecedents comprising the economic, physical and human resources. The antecedent that the study focuses on is the specialist Physics teacher. The antecedents are supplied by different structures within the Ministry of Education and Training to the various levels of the education system, for example, the senior secondary level. It is a challenge to the education system that the specialised human resource supplied to the secondary level by Teacher Training Colleges (TTCs) is insufficient, and some are not specialised at all. Therefore, this raises the need to ascertain the causes of the shortage. The human resource, as an antecedent of the policy context, consists of the characteristics of the teachers and the learners' background (Howie, 2003:4). One conspicuous characteristic of the majority of the Physics teachers in Swaziland is the lack of Physics content-knowledge, since they specialised in Agriculture and other irrelevant disciplines for Physics teaching. The learners who are taught by these teachers do not develop to master the Physics content. The content the learners acquire is fraught with misconceptions, since their teachers never specialised in the Physics discipline. Consequently, the Physics content would not be easy to assimilate at tertiary level, thus the learners would try all possible means to avoid Physics-oriented majors.

This study focuses mainly on the human resource (the specialist Physics teacher) as an input that equips the learners with Physics concepts, and makes them available at the classroom level. In this case, the teacher who has specialised in Physics is considered to be one of the catalysts of learning underpinning the education system (Van der Sandt & Nieuwoudt, 2005:109). Following Shulman (1986), Van der Sandt and Nieuwoudt (2005:110) argued that it was essential that effective teachers were equipped with different kinds of knowledge, such as content knowledge (subject matter) and pedagogic content knowledge (specific teaching strategies) to be able to deliver with understanding the Physics concepts. The Physics content knowledge is transformed by means of pedagogical knowledge into representations for use in the classroom. The teacher plays a pivotal role in assisting the learner to acquire the

Physics concepts in the teaching and learning milieu. The mastery of these concepts enables the learner to employ them in the classroom setting, and at a later stage pursue careers that require their utilisation in the world of work. Therefore, both the teacher and the learner must be conversant with these concepts at their appropriate level which in this case is the senior secondary level. For a number of years the senior secondary level has experienced a shortage of specialist Physics teachers such that the expertise of other specialists, for example, teachers who have been trained to teach Agriculture, has been harnessed. This begs the question, namely "Are the learners exposed to accurate Physics concepts and science processes that would enable them to pursue science related careers?" The researcher's argument is that part of the constituent of the human resource that teaches Physics, as an educational practice, is not trained to handle the subject and this may affect the learners' performance.

The second facet of Howie's model is processes, which is discussed in the section that follows.

2.3.1.2 The processes

The second facet of Howie's model pertains to *processes* or educational practices that are affected by the inputs. The *processes* are considered as practices in education and relate to what is taught and how it is taught, and occur in the schools and classrooms in Swaziland (Howie, 2003:4). The 'what is taught' refers to what the learners actually learn as expounded by the curriculum, which is the Physics content (Ornstein & Hunkins, 2009:14). The content requires that the teacher be competent in its application to properly handle its concepts. The processes are linked to the inputs, since they also encompass the 'what is taught' and 'how it is taught'. Physics teachers are expected to share their educational experiences in respect of Physics with the learners by employing teaching methods that involve active learner participation. The teaching methods that Physics teachers employ, as a component of the 'how it is taught', are generic. No methods are unique to a discipline. Thus, teachers of Agriculture can claim that they have the ability to teach Physics, but the main challenge lies in the way they apprehend and explicate the Physics concepts. The lack of Physics content of Agriculture teachers undermines the ‘what is taught’.

The processes are operational at the district, school and classroom levels. In the classroom level, processes enshrine the ‘what is taught’, or the Physics content. The content is conveyed by means of the written curriculum. The written curriculum guides what is enshrined in the school district documents (Ornstein & Hunkins, 2009:14). In order to enhance the competency of prospective teachers in imparting the content, the pre-service teacher educators should properly structure and present the content in such a way that it enhances the acquisition of specialised competencies in the discipline. The prospective Physics teachers should also be equipped with relevant pedagogic content knowledge to handle the content that they will encounter at the local level with self-confidence. For example, a non-Physics specialist would have difficulties explaining most of the Physics concepts, like the principle that informs how an alternating current motor operates. Therefore the teacher must be conversant with the Physics concepts to be able to properly impart them to the learner in the classroom. The researcher would like to contend that it is the specialist Physics teacher who can handle with confidence the ‘what is taught’ and ‘how it is taught’ of the processes. Since Physics teachers are assigned by head-teachers to teach the subject, irrespective of their field of specialisation, this could make some of them feel incompetent and uncomfortable to teach it. This could probably be one of the contributing factors to their search for other professions.

The evolutionary model developed by Johnson, Scholtz, Hodges and Botha (2003:86) shares the same sentiments as Howie’s model and indicates that prospective teachers enter their training with different levels of competencies and experiences. The training shapes their beliefs, knowledge and skills to suit the level and content they will share with learners. The content that survives the challenges in the school becomes the teacher’s ‘pedagogic repertoire’ that is shared with the learners (Johnson, *et al*. 2003:86). Drawing from Cooney (2001), Van der Sandt and Nieuwoudt (2005:117) contended that the significant moral feature of teacher education is the challenge to enable the teachers to perceive the acquisition of knowledge as a power that may enable learners to acquire that same kind of power.

The legacy is perpetuated when the learners also become professionals and share their experiences with other learners, but this happens at a minimum in the case of Physics. It is possible that many of the learners who enrol for tertiary science courses lack the content knowledge, and as a result, are incompetent in Physics. In fact, they are compelled by the tertiary institution's requirements to study Physics in their first year of training. The incompetence of the learners may be due to the fact that they did not have enough exposure to the subject while at school. Sufficient exposure to the subject could enhance their knowledge and skills. The inadequate exposure to the content of Physics is manifested when the learners opt for other subject combinations in the sciences at tertiary (for example, Biology and Chemistry), once they move to their second year, resulting in few Physics graduates. Thus, in the end, the teaching profession has to compete for the few that graduate with other, or more paying Physics-oriented professions, and eventually rely on non-specialists to teach the subject.

An apparent hierarchy exists, as the influence from policy level could be top-down, starting from national to provincial, to district, to school and then to classroom levels. It is against this background that some education solutions become irrelevant if policy makers do not consult with the stakeholders. Ornstein and Hunkins (2009:25) advocate for a bottom-up approach where the teacher plays a major role in ensuring that the learners are provided with the opportunities to acquire the knowledge of Physics. The challenges that the teacher encounters during the acquisition of the Physics learning content and that cannot be solved should be relayed to higher authorities at school level. Similarly, innovative ideas emanating from the classroom level should be encouraged and supported by the higher authorities. Therefore, it is essential that MoET consult the teachers and engage in a survey with the learners to generate solutions that would help to address issues emanating from the teaching profession, and at the school and classroom levels.

Drawing from the bottom-up approach, in order that the solution for the Physics teacher shortage may be efficacious, the strategies must emanate from the classroom level and gradually progress to MoET. The thrust of this study is to generate solutions from the classroom level, which might guide policies meant to address the shortage of specialist Physics teachers. The district level has to offer guidance as to how the policies are developed and implemented. Subsequently, the school level must determine the activities essential for the district level. Monitoring departments are strategically positioned in the districts to liaise between the schools and the policy-developing departments within MoET. Thus, they are instrumental in sending feedback to the policy-developing departments on the Physics teacher shortage and other challenges that have a bearing on the teaching and learning of Physics. MoET receives monitoring reports from the inspectorate, but the recommendations in these reports are rarely put into action.

The classroom level comprises the implemented curriculum, teaching, instruction and teacher qualifications (Howie, 2003:4; Teodorovic, 2009:297). The implemented curriculum is synonymous with the curriculum that teachers attempt to implement (Ornstein & Hunkins, 2009:14). The curriculum enshrines what is actually being taught by the Physics or Agriculture teachers. Teaching, as a component of the classroom level, deals with the context and conditions under which Physics teachers work. The teachers work in different contexts depending on their locations. Some work in rural areas and others in urban areas. Their conditions expose the teachers to different challenges. The rural areas are deprived of properly qualified teachers for Physics teaching (Jibowo & Sikhondze, 2012:2; Marope, 2010:38). These teachers are responsible for sharing the Physics content with the learners. Such content might not be clearly understood by the learners as it is articulated by teachers who are deficient in Physics content knowledge. Research indicates that learners' learning is attributable to classroom and school factors, for example, structured lessons, maximum communication between the teacher and learners, and intellectually challenging teaching (Teodorovic, 2009:299). Reynolds *et al.*, 2002, in: Teodorovic, 2009:299) argues that the teachers should provide positive feedback, check for learner understanding, and motivate the learners to take part in the learning of Physics. Positive feedback spurs the learner on to engage in Physics tasks in the teaching and learning milieu. Learner motivation should be both intrinsic and extrinsic for the attainment of outputs or learning outcomes. The begging question is, "How can the teacher motivate the learner to learn Physics to attain the learning outcomes when he/she is not also motivated?"

In the section that follows the researcher discusses the last facet in the model, namely outputs. Some of the challenges the learners face in the learning of Physics which affect their attainment of the learning outcomes, are also examined.

2.3.1.3 The outputs

The third prong in Howie’s model is ‘outputs’, which can be regarded as learning ‘outcomes’ that eventuate in learner achievement in specific subjects, which, in this study, is Physics (Howie, 2003:4). The other outputs are learner participation in class activities, their attitudes towards some subjects, and future aspirations. The achievement of the learners in Physics is undermined by both the manner in which they acquire the content and the methods employed by the facilitator. The reports from the inspectorate have indicated that teaching strategies affect learner performance in the sciences, which is influenced by the lack of specialists. The reports pointed to weak teacher skills and competencies in handling the Physics concepts (Marope, 2010:37). The non-specialist teacher has limited alternatives of explaining the Physics concepts to the learners. The teacher is compelled to embrace the content in the manner in which it is presented in the textbook. Thus, the learners will end up ‘parroting’ the content without any meaningful understanding. The lack of the understanding of the content deprives the learners of the opportunity to utilise the Physics concepts in various contexts to attain the learning outcomes.

It is essential that the learner participates in meaningful school and classroom activities to achieve the desired learning outcomes. In the context of this study, the essential classroom activity that the learner is expected to participate in is the acquisition of the Physics content. It is not just a matter of participating in the activities, but meaningful engagement with the activities is critical. This is in line with progressive education, which focuses on the learners rather than on the subject. Progressive education places the emphasis on relevant activities and learner experiences (Ornstein & Hunkins, 2009:47). The task of the teacher is to make the activities relevant to the needs of the learner. It stands to reason that the learners will not actively engage in the learning of Physics if they realise that they cannot derive any meaning from it. Thus, the teacher has to make the learning of Physics relevant, enjoyable and meaningful. According to Ausubel's meaningful learning model, learners learn meaningfully when they relate new concepts to what they already know (Mohammed, 2011:1). The learners must be motivated to actively engage in the Physics learning tasks, under the pretext that they will pursue it at tertiary level. In order for learning to be relevant, it must build on the learners' life experiences in respect of the Physics content.

The other aspect, in addition to motivation, that the teachers should be cautious of is the attitude of the learners towards some subjects, in particular towards Physics. The learners, especially girls, must be assisted to develop a positive attitude towards Physics. It has been noted that female students have a negative attitude towards Physics (Murphy & Whitelegg, 2006:289). Consequently, this attitude substantially reduces the number of female students who opt for Physics at tertiary level. Another significant aspect affecting the choice of Physics is the learners' attitude towards school. A learner who is demotivated within the classroom setting will develop a negative attitude towards school. It is the responsibility of the teacher to make school relevant to the needs of the learners. Research indicates that some practices within the school have a negative effect on the learners, thus depriving them of the opportunity to attain the learning outcomes. A case in point is corporal punishment.

According to Strauss (2009:4), corporal punishment increases anxiety, and decreases learners' motivation to actively take part in the classroom activities, and to achieve the desired outputs. Thus, the learner's cognitive development is affected, and the ability to reason out complex Physics problems is reduced. Poor cognitive development, combined with the lack of motivation, is a recipe for a bleak future. Howie (2003:4) notes that the learners' attitude towards specific subjects is a determinant of their future aspirations. It follows that if the teachers do not structure the learning process in a manner that the learners feel they are achieving something, then their efforts become futile. The main argument is that the teaching and learning process must engage the learners and encourage them to take responsibility for their learning to be successful in the learning of Physics. The glimmer of hope for the attainment of the Physics outputs lies within the synergy of MoET, the teacher and the learner.

A significant assumption in the learning of Physics is that learners learn both independently and through collaboration, for example by doing experiments. Collaborative learning requires that the learning environment accommodates the learners' active interaction with one another to optimise their achievement in Physics (Akinsola & Ifamuyiwa, 2008:83). Learners who are not properly grounded in the Physics content would perform poorly, be alienated, and not aspire to pursue this subject in the future. The learners' participation in the learning of Physics is enhanced when they feel that they are achieving something. But, how can the learner achieve or attain the outcomes if the teacher is also challenged by the subject? If the learner is not achieving anything that has to do with Physics in the class, then he/she will lack the motivation to participate in class activities, and his/her attitude towards the subject would be negative. This negative attitude becomes embedded to such an extent that at tertiary institutions the learner would try all possible means to avoid Physics. It follows that if the input in the Physics concepts is not properly grounded, then the teacher will not be able to properly impart these concepts, thus the learner would not achieve the Physics outcomes to a satisfactory level. The learner is then deprived of the opportunity to pursue the subject at tertiary level.

The discussion that follows is of models that are associated with Howie's.

2.3.2 Associated models of school effectiveness

Models that are associated with Howie's model are the integrated model of school effectiveness (Scheerens, 1990), and factors that determine school effectiveness (Heneveld & Craig, 1996). These models demonstrate how inputs, processes and outputs are associated, as well as how activities embedded in them, if not properly carried out, could contribute to the shortage of Physics specialist teachers.

The integrated model on school effectiveness by Scheerens (1990) shares the same sentiments as Howie's model, since it comprises the inputs, the process (school and classroom levels) and the outputs. This model is characterised by an interaction of specific school inputs and contextual factors, with specific school level and classroom-level processes, which, in turn, have an effect on learner achievement (Teodorovic, 2009:305). One of the attributes of the inputs is teacher experience, which is central to this study. The other attributes (per pupil expenditure, parent support, infrastructure, and materials) support the role that the teacher plays in the classroom. This study will shed some light on the relevance of the academic experience of the teachers who teach Physics in senior secondary schools.

The other aspect of the model is process, which examines issues emanating from the school and classroom levels. These are the levels where the acquisition of the Physics content by the learners should be promoted. At the school level, educational leadership, consensus, the cooperative planning of the teachers, and the quality of the school curricula in terms of the content covered and the formal structure, determine the quality of learner that the system will eventually produce. School leadership has been cited as one of the factors contributing to the shortage of Physics teachers. Some school administrators provide minimal support to the science department. They use the science fee to pay for other activities instead of purchasing laboratory equipment to be used for science practical activities (Ministry of Education and Training, 2010:4). At the classroom level, structured learning and the opportunity to learn facilitate the acquisition of Physics content and the realisation of outputs. The process, as entailed in the model, is provided for by the context, which could be incentives from higher administrative levels.

The process influences the outputs which is the third aspect of this model. The outputs embrace learners' achievement and are hinged on previous achievement, intelligence and socio-economic status. The researcher has argued that the achievement of the learner at the lower level is a determinant of his/her choice of courses at tertiary level. A learner who is not well-versed in Physics will opt for the other sciences.

The model that follows (Fig. 2.1) is the Integrated Model of School Effectiveness. As mentioned above, it comprises inputs, process linked to context and classroom level, and outputs.

The Integrated Model of School Effectiveness

(Scheerens 1990)

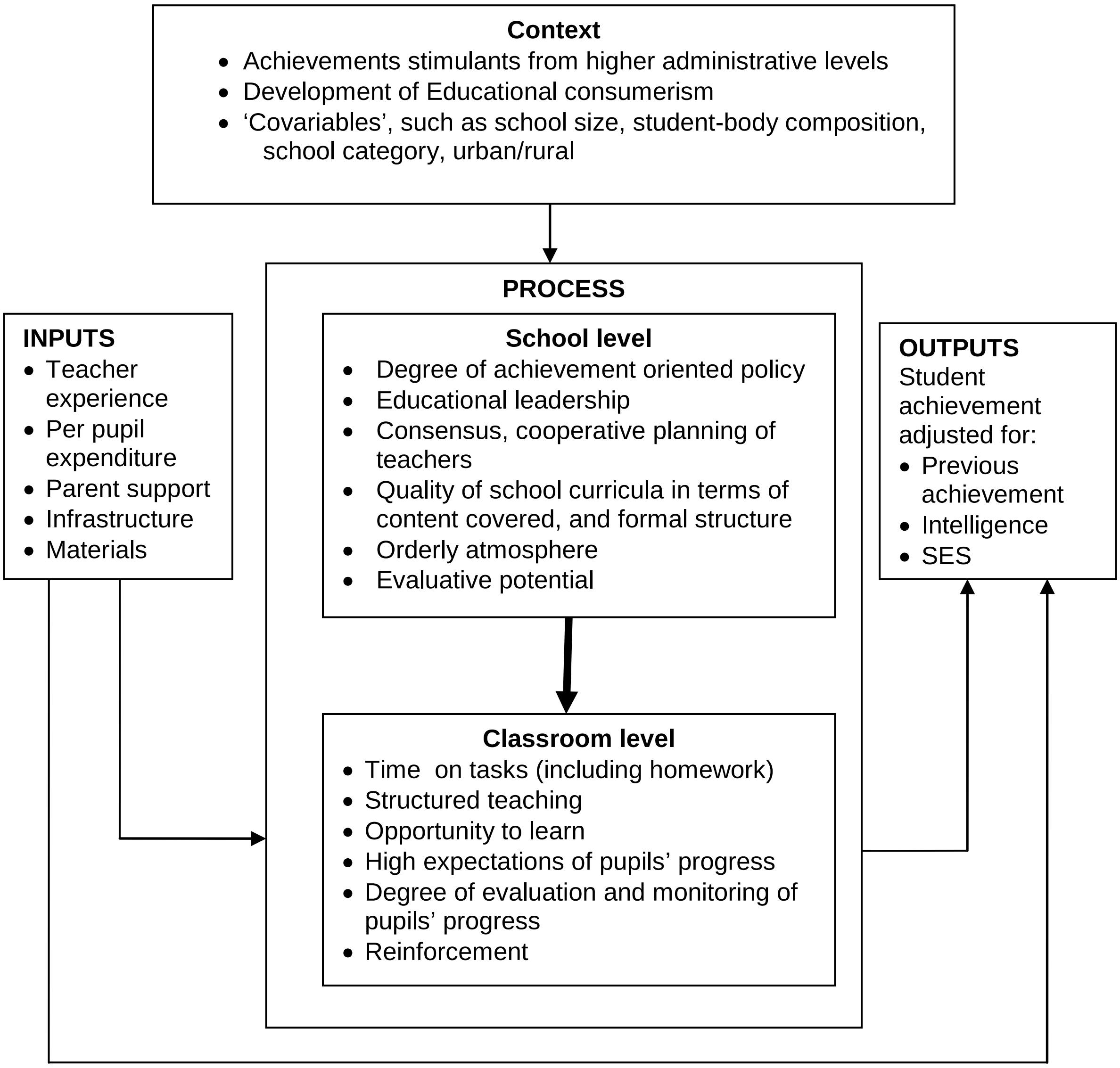

Fig. 2.1: **The Integrated Model of School Effectiveness**

The figure that follows (Fig. 2.2) shows another model that explicates factors that determine school effectiveness developed by Heneveld and Craig (1996), consisting of supporting inputs, enabling conditions connected to school climate and teaching or learning process, and student outcomes. These are foreground on conceptual factors (international, cultural, political and economic).

Factors that determine school effectiveness

(Heneveld & Craig 1996)

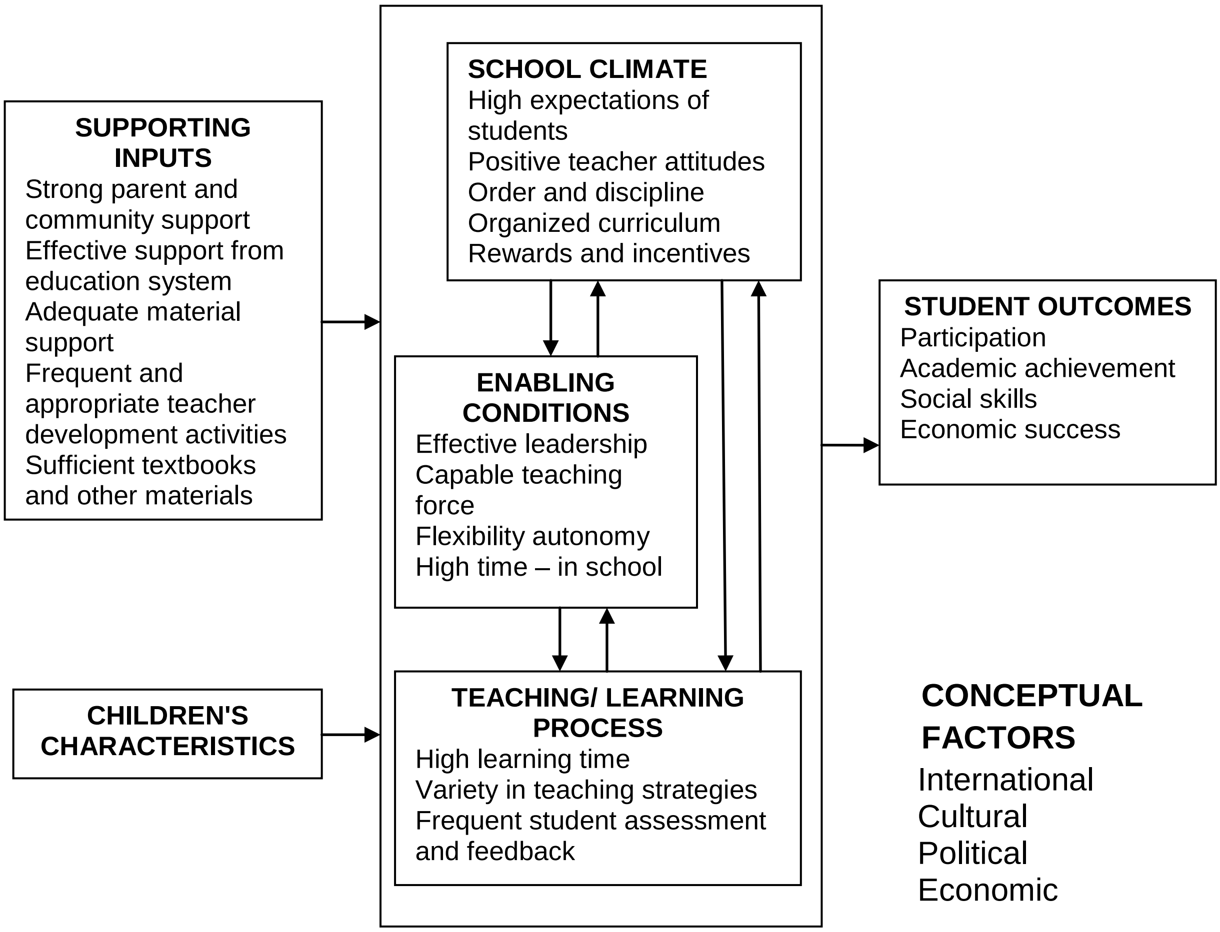

Figure 2.2: **Factors that determine school effectiveness**

The above model is based on the researchers' (Heneveld & Craig, 1996) literature review of school effectiveness studies undertaken in developing countries. Swaziland is a developing country; therefore, this model discusses pertinent issues for the local senior secondary level. The model is somewhat similar to the ones developed by Scheerens (1990) and Howie (2003). It is characterised by supporting inputs, enabling conditions, the school climate, the teaching/ learning processes and learner outcomes. The enabling conceptual factors are international, cultural, political and economic. In this model the school inputs and the learners' backgrounds interact with the school-level and classroom-level constructs to produce certain learner outcomes. Teachers of Physics have to plan learning experiences that will assist the learners to construct and appreciate an understanding of the natural phenomena, as well as the assessments that express evidence that learning has occurred. Physics teachers are also expected to assist all of their learners to acquire physics content through drawing effectively on the learners' diverse ideas, including those that are in discord with the normative science conceptions (Davis, Petish & Smithey, 2006:609). In accordance with the above model, the teachers must situate their learners' acquisition of Physics concepts within the broader context of their school, neighborhood, city, and the nation as a whole.

The thrust of this study is not to compare the models, but to demonstrate that they all accede that an effective school is characterised by the interaction of the models' attributes. The Physics teacher, as an input, should be supported with essential attributes or enabling conditions such as a conducive environment, effective leadership, support from the education system, a variety of teaching strategies, and active learner participation. The input and processes engaged with in the teaching and learning environment should assist the learner to attain the Physics outputs or learning outcomes.

The researcher aims to ascertain the challenges that the teachers encounter during teaching and learning that force them out of the teaching profession. In the researcher's view, if these challenges are not addressed, Physics will continue to be taught by non-specialist teachers, who may not be well-versed with the demands of its processes embedded in the content, and the manner that it is imparted to the learners. A lack of appropriate and competent input has a negative effect on the attainment of the outcomes that the learner intends to achieve in a learning course. The challenge to the learner who is taught by an incompetent input (Physics teacher) is that he/she is most likely to perform poorly in the final examination. This will result in few students enrolling for Physics at tertiary institutions, and they will, after graduation be shared between teaching and other professions. This eventually becomes cyclic, in the sense that the majority of the competent graduates opt for better-paying professions and thus starve the teaching profession of specialists. Eventually the expertise of non-specialists is harnessed in the teaching profession, thus producing learners who are inadequately exposed to the Physics content. It is essential that the ‘prospective input’ is supported to retain them longer in the profession in order for the appropriate content delivery, hence the better attainment of the outcomes by the learners, with the subsequent interruption of the vicious circle. The study aims to extricate strategies on how to retain the competent teachers for longer in the teaching profession.

2.4 SUMMARY

In this chapter the researcher examined literature that reported on the causes of the shortage of specialist Physics teachers in senior secondary schools, how they can be retained, and how their number can be increased. The researcher also discussed the causes of the shortage at an international level, eventually narrowing it down to the local context. The reasons, the retention strategies and how the number of Physics teachers may be increased were discussed at policy, institutional and professional levels. Research studies and reports indicated that practices at these levels contribute to the shortage of specialist Physics teachers in various ways. In addition, some solutions proposed at these levels were discussed. The literature review covered the nature and significance of Physics, international and local challenges and solutions to Physics learning, challenges and solutions at policy level, challenges and solutions at institutional level, challenges and solutions at professional level, gender disparities and attitudes towards Physics, and Physics content from primary to senior levels. Finally, the theoretical framework underpinning the study and associated models were discussed, namely the school effectiveness model (Howie, 2003), the integrated model of school effectiveness (Scheerens, 1990), and factors that determine school effectiveness (Heneveld & Craig, 1996).

In the next chapter the researcher discussed the research design and methods employed in this study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In the previous chapter the researcher examined studies that reported on the reasons for the shortage of specialist Physics teachers, how they can be retained, and how their number can be increased. In this chapter the researcher aims to describe and justify the research methodology selected to conduct the study to ascertain the teachers' opinions on the reasons for the shortage of specialist Physics teachers.

The research methodology can be regarded as a systematic framework for addressing an identified challenge with "…specific components such as phases, tasks, methods, techniques and tools" ("methodology", n.d.). Research methodology encompasses procedures utilised in making systematic observations (Glossary of Education). The research methodology embraces the research approach and design for this study, the data-collection instrument, the data-collection procedure, and validity and reliability. It also provides an explication of the sampling technique utilised in this study. In this chapter the researcher further elaborates on ethical issues that were taken into account in order to not cause any harm to the respondents. Since the data were collected from a larger sample of Physics teachers, therefore, the positivist-interpretive quantitative research methodology and survey design were employed.

In the section that follows, the researcher elaborates on the research method that was used.

3.2 QUANTITATIVE RESEARCH METHODOLOGY

McMillan and Schumacher (2010:8) define a *research method* as a way in which the researcher collects and analyses data. According to Cohen *et al.* (2000:44), *research* *methods* denote techniques related to the positivist model through which responses are elicited from predetermined questions, as was the case with this study. In this study, the quantitative research design involved the development of knowledge by collecting data by means of a predetermined instrument (Creswell, 2003:8). The quantitative research design places the emphasis on objectivity in the measurement and the description of the phenomena (McMillan & Schumacher, 2010:21). *Objectivity* simply means judgement based on an observable phenomenon that is not influenced by the researcher's emotions or personal prejudices. In this study, the quantitative research methodology encompassed statistical results that were analysed and interpreted. Numerical data refer to measurements consisting of rules for assigning numbers to objects in order to represent quantities or attributes in numerical form (De Vos, Strydom, Fouché and Delport, 2002:160). The statistical results were based on the opinions of the teachers on the reasons for the shortage of specialist Physics teachers, how they could be retained and how their number could be increased in schools.

The purpose of the quantitative research methodology was to provide a plan for generating empirical evidence that was used to address the research questions (McMillan & Schumacher, 2010:20). The methodology also provided a description of the procedures for conducting the study, including when, from whom, and under what conditions the data were obtained (McMillan & Schumacher, 2010:20). The methodology facilitated the drawing of valid and credible conclusions based on the responses from the respondents, as elicited by the research questions.

This study also employed empirical quantitative research methods as a means of collecting the data from the respondents. In accordance with empirical research, the researcher was guided by evidence acquired from systematic research methods rather than from authorities during the data-collection (McMillan & Schumacher, 2010:9). McMillan & Schumacher (2010:13) also argue that applied research is concerned with the production of knowledge appropriate for providing solutions to general problems or challenges. The general challenge was the shortage of specialist Physics teachers in senior secondary schools in Swaziland. Therefore, this study provided knowledge on the reasons for this shortage in order to generate solutions that would help mitigate the shortage. The main reason for employing the quantitative design was to obtain the opinions from a large sample for the purposes of generalising them to the larger population.

The quantitative research design employed encompassed a non-experimental design. The non-experimental design embraces the survey design, which was central in this study (De Vos *et al*., 2002:138). The survey design is a component of the cross-sectional design. According to Ross (2005:23), and Gay *et al.* (2006:348), the cross-sectional design prefers that data be collected at a single point in time which, in this case, is a school setting. The significance of the non-experimental research design is that it helped in ascertaining the factors associated with the shortage of Physics teachers that affect the teaching and learning of Physics in senior secondary schools in Swaziland. The ensuing section explicates the research design for this study.

3.3 THE RESEARCH DESIGN

Maree (2007:291, citing Bless & Higson-Smith, 1995:46) defines *research design* as a "...plan of how to proceed in determining the nature of the relationship between variables". In this study, the relationship was determined through the survey design. The survey design was utilised because of its quantitative nature. Thus, the survey design was used to generate numerical data that was processed statistically, which was the thrust of this study (Cohen *et al*., 2000:171). It was used to explain mainly the opinions and other types of information (biographical data) from the Physics teachers as reflected in the questionnaire (McMillan & Schumacher, 2010:22). It also specified in advance the type of instrument and sampling technique, as opposed to qualitative research, where the design elements are worked out while the study is in progress.

In chapter 1 (Section 1.5), the researcher indicated that surveys are inexpensive, and easy to do. In one respect that the survey was an inexpensive method is that the distribution points of the letters were centralised, namely the Regional Education Offices (REOs). This made it cost-effective, since the letters were not sent or mailed through the post to the individual schools. The level of demand was reduced since the Physics teachers referred to personal records in instances this information was required in the questionnaire. The manner in which the data was collected for this study enabled the Physics teachers to complete the questionnaire at a convenient time and place (Maree, 2007:157; De Vos *et al*., 2002:174). The above qualities of the survey were appropriate for the nature of knowledge that the study aimed to tap out, since the respondents reflected their opinions and completed the questionnaire without the researcher's interference.

Following Maree (2007:172) in a previous section (Section 1.5), the researcher argued that surveys make use of information obtained from the sample to learn more about the population. The information that the survey elicited in this study was what the teachers regarded as the reasons for the shortage of Physics teachers. By means of the survey a broad overview of a representative sample of a large population was attained. This study was designed in such a way that information on the Physics teachers in Swaziland could be inferred from the responses obtained from the sample (McMillan & Schumacher, 2010:236). The survey provided information on what the teachers regarded as factors associated with the shortage of specialist Physics teachers, how they can be retained and how their numbers can be increased. The researcher selected a population of teachers (Physics teachers) in the four regions, namely Hhohho, Manzini, Lubombo and Shiselweni of Swaziland, sampled the respondents and administered the questionnaire to collect the data.

The section that follows elaborates on the population of the Physics teachers selected for this study.

3.4 THE POPULATION

According to McMillan and Schumacher (2010:129), a *population* comprises a collection of elements or cases that conform to particular criteria and to which the results of a study may be generalised. In this study the group of elements consisted of Physics teachers, based in the four geographical regions of Swaziland. One of the reasons for drawing on the opinions of the teachers from the four regions is that they do not receive resources equally (Ministry of Education, 2004:37). Some of these regions are under-resourced, especially, Shiselweni and Lubombo (MoET Sector Analysis Report, 2009:3). The lack of resources may be a deterrent to some of the qualified Physics teachers to teach in under-resourced regions. Hhohho and Manzini have comparatively more resources, due to a hive of businesses. These regions have the potential of attracting the best teachers, since, due to technological advances; it is easier to access information or education resources, which are a catalyst in attracting the best teachers in the profession. Thus, the teachers from the different regions reflected what they experience in the regions in the questionnaires.

The population for the study comprised senior secondary school Physics teachers (N = 201) in the four regions of Swaziland, i.e. 53 (26%) from Hhohho, 43 (21%) from Lubombo, 56 (28%) from Manzini and 49 (24%) from Shiselweni (Government of Swaziland, 2011). The Swaziland Government School lists classify the schools according to the following categories, namely community, mission, government and private government-aided schools. This classification is in accordance with the type of organisation that initiated the school, as well as the type of grant that the government and other organisations provide. Some of the private schools in the regions were included in the population, since they obtained some support from government, hence private government-aided schools.

According to the Education Management Information Systems (EMIS) (2013), *community schools* are schools that were built by the community on Swazi nation land, and are managed mainly by the community. *Mission schools* are schools that were initiated by missionaries. *Mission schools* also have an input (to some extent) in the calibre of teachers that are recruited to the schools. Government owned schools are those that were built by the government, and some have boarding facilities fully supported by the government. The Education Rules (1977) (Government of Swaziland, 1977:1) define an *aided school* as a school that is in receipt of a grant-in-aid. *Private government-aided schools* are regarded as schools that are privately owned, but are supported by the government, by appointing the teachers. Moreover, private government-aided schools top up the salaries of the teachers. In fact, all the schools in the above categories are supported by the government, to some extent. The government appoints the teachers and pays their salaries. The number of private government-aided schools is insignificantly smaller (5 schools) than the schools in the other categories, thus they are classified as government schools. These different schools constituted the population for this study where the sample was selected. The section that follows discusses the sampling procedure.

3.5 SAMPLING

According to Maree (2007:79), *sampling* can be regarded as a process of selecting a portion of the population that would be used in a study. In this study, the probability sampling procedure, which is based on randomisation, was used to obtain the sample of senior secondary Physics teachers (De Vos *et al*., 2002:203). This means that the respondents were drawn from the large population (senior secondary Physics teachers) in such a manner that the probability of selecting each member of the population was equal. The probability sampling procedure efficiently provided estimates of what was true for the population of Physics teachers from a smaller group of respondents (Maree, 2007:172; Berends, 2006:625). Also, stratified random sampling was employed by dividing the sample into different strata (urban and rural). McMillan and Schumacher (2010:134) indicate that *stratified random sampling* is a variation of simple random sampling, while Maree (2007:172) considers it as a direct subset of the probability sampling method. However, they both concur that it is encompassed in the probability sampling methods. Stratified random sampling was employed in this study, since the population was based in urban and rural settings, as well as in mission and government-aided schools (De Vos *et al*., 2002:205). The different strata presented a variety of opinions.

Maree (2007:178) contends that when probability sampling is well-designed, larger samples would represent the population better than smaller samples, thus their findings render them more accurate. In this study, probability sampling provided equal chances to all the respondents of being selected through randomisation. As articulated by Maree (2007:172) and Berends (2006:625), the probability sampling procedure efficiently provided estimates of what was true for the population of Physics teachers from the sample of respondents.

This study employed a larger sample of Physics teachers in order to make the findings more realistic, representative and accurate. In order to sample the respondents for the study, schools were used. Pieces of paper with an inscription of the school's code were placed in a hat according to their locations, i.e. urban or rural, as well as the regions, in turn, as illustrated in Table 3.1. The papers in the hat were then shuffled. The required number of schools from each of the four regions, namely Hhohho: 53, Lubombo: 43, Manzini: 56 and Shiselweni: 49, was placed in the hat per region for sampling purposes. One piece of paper was picked at a time from the hat, without replacing it, until the required number of Physics teachers was selected as per the sample size. The Physics teachers received a questionnaire to fill in for each school selected.

Table 3.1: Type and number of schools in a stratum

Region	**Strata**						**Total per re-gion**
	Urban			Rural			
	Commu-nity	Mis-sion	Govern-ment	Commu-nity	Mis-sion	Govern-ment	
Hhohho	6	6	5	32	4	0	**53**
Manzini	3	10	3	33	7	0	**56**
Lubombo	1	2	3	33	2	2	**43**
Shiselweni	2	1	1	39	6	0	**49**
Total	**12**	**19**	**12**	**137**	**19**	**2**	**201**

Table 3.1 indicates that there are 201 senior secondary schools in Swaziland, excluding autonomous private schools. There are 53 (26%) in the Hhohho region, i.e. 17 (32%) in an urban setting and 36 (68%)in a rural setting; 43 (21%) in the Lubombo region, i.e. 6 (14%) in an urban and 37 (86%) in a rural setting; 56 (28%) in the Manzini region, i.e. 16 (29%) in an urban and 40 (71%) in a rural setting; and 49

(24%) in the Shiselweni region, i.e. 4 (8%) in an urban and 45 (92%)in a rural setting (Government of Swaziland, 2011). The 201 senior secondary schools represent the total number of Physics teachers.

3.5.1 The sample

The sample was drawn from the 201 (N = 201) senior secondary schools, i.e. one teacher in each school (Ministry of Education and Training 2011:4-5). The sample consisted of senior secondary school Physics teachers in the HHohho, Manzini, Lubombo and Shiselweni regions of Swaziland who are teaching in urban and rural settings. The Physics teachers participated in the study due to the fact that they were directly involved in the teaching and learning of Physics. They also had relevant experience pertaining to the teaching and learning of Physics, and the challenges facing their profession. The combined samples from these regions were sufficient to provide a representative sample to enable the generalisation of the findings to the larger population (Cohen *et al.,* 2000:94). When the population was subdivided into each stratum (region and location), it yielded a total sample consisting of 184.

The respondents in this study were selected from each region using the Krejcie and Morgan sampling strategy with a desired Confidence Level of 95% and a Margin of Error of 5% (Cohen et al., 2000:94). The schools were first divided into each stratum (region and location). Thereafter, the sample of Physics teachers was selected. The required number of schools from each of the four regions, namely Hhohho 49 (27%), Lubombo 40 (22%), Manzini 51 (28%) and Shiselweni 44 (24%), as drawn from the hat, formed the total sample of 184 Physics teachers, as reflected in Table 3.2.

Table 3.2: The sample per stratum and region

Region	Strata		Sample per region
	Urban	Rural	
Hhohho	16	33	49
Manzini	15	36	51
Lubombo	6	34	40
Shiselweni	4	40	44
Total	**41**	**143**	**184**

3.6 INTRUMENTATION

A structured (Likert-type) questionnaire scored across the responses, strongly disagree (1), disagree (2), agree (3) and strongly agree (4), was used to collect the Physics teachers' opinions (McMillan & Schumacher, 2010:198). The questionnaire was developed using the Nominal Group Technique (NGT), by means of engaging experts (Section 3.6.1). The NGT is a structured variation of small-group discussion methods in order to reach consensus. It is used for generating ideas, identifying issues, potential solutions, and for promoting consensus ("Nominal Group Technique" n.d.). After its development, the questionnaire was subjected to scrutiny by NCC officers, UNISA Ethics Committee and Science specialists.

Tague (2004) argues that the NGT is a structured process for group brainstorming that encourages contributions from those with relevant information and experience. It is a decision-making method that can be used among groups of different sizes with the intention of making their decision quickly, so that the participants' opinions are considered ("Nominal group technique", n.d.). In this study, the NGT was used to generate ideas from the experts where they identified reasons for the shortage of Physics teachers and suggested some solutions. The NGT balanced up participation between group members, enhanced the feeling of participation and satisfaction.

The instrument consisted of closed-form items (structured, selected responses, or closed ended), since they could be scored much simpler and it takes less time to answer them (McMillan & Schumacher, 2006:197). The instrument was divided into three sections, viz. section A contained demographic information, comprising sex, nationality, highest academic qualification, highest professional qualification, subjects majored in, teaching experience, experience teaching Physics, last year of studying Physics at tertiary level, level of specialisation, the type and location of the school where they were currently teaching, and the location of the school from where the teacher graduated. Section B consisted of the Physics teachers' opinions regarding the reasons for the shortage of specialist Physics teachers; section C comprised what the teachers regarded as possible retention strategies; and section D entailed strategies that could be used to increase the number of Physics teachers.
The Physics teachers entered their responses on the four point Likert-type questionnaire. The Likert-type scale provided an ordinal measure of their opinions. The teachers were asked to circle the response that best suited their opinions in the four-point scale. Some of the advantages of the questionnaire were that it was economical, had the same items for all the respondents and ensured anonymity (McMillan and Schumacher, 2010:195). The questionnaire also ensured that authentic and, to a lesser extent, some personal information was obtained from the respondents (McMillan & Schumacher, 2010:205).

There were processes that the researcher carried out to produce the final instrument before it was administered to the sample, namely development, pre-piloting, piloting, and expert scrutiny, at various stages. Therefore, these processes ensured that the final questionnaire was of high quality and efficacious.

3.6.1 Stages in the development of the questionnaire

The development of the questionnaire entailed a process, passing through six stages, with the input from the different officers or experts listed in the stages.

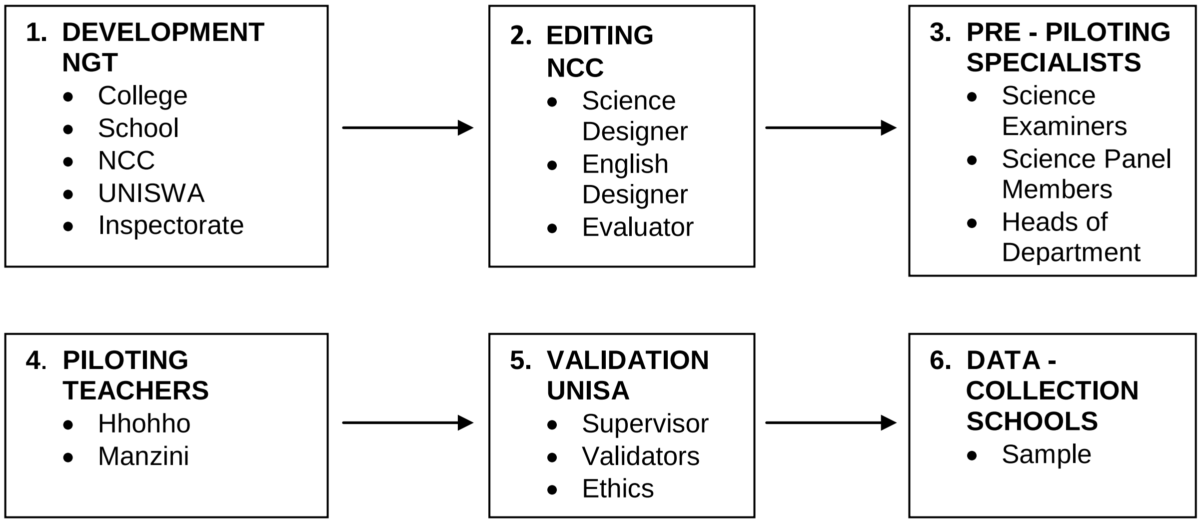

Figure 3.1: Stages in the development of the questionnaire

In accordance with the NGT, the items of the questionnaire were developed through sourcing suggestions from those who have experience in the teaching and learning of Physics, based in different settings, namely the school, college, curriculum design specialists, the inspectorate and the lecturers at the university. Some of the questionnaire items were also developed by means of the use of literature sources that had been reviewed. The suggestions from these experts helped to eliminate irrelevant items, as well as beef up sections that were not covered satisfactorily. After ‘cleaning up’ the items using the input of these educationists, the questionnaires were given to the smaller group in the National Curriculum Centre (NCC) for the final editing, consisting of a Science Designer, a Curriculum Evaluator and an English language Designer. The final questionnaire was then scrutinised by the Ethics Committee at the University of South Africa (UNISA) to ascertain if it addressed the research questions. The questionnaire was then piloted.

3.6.2 Piloting the instrument

Piloting can be regarded as a small-scale experiment to test, for example, a questionnaire, before it is administered on a large scale. According to Cohen *et al*. (2000:129), *piloting* is meant to refine the content, the wording and the length of the questionnaire. Piloting was critical in this study, since it helped to minimise factors that would have a negative effect on the data-collection. Piloting also helped to reinforce efficacious items. During the piloting, the researcher tried out the research instrument with a group of teachers similar to the sample used in this study.

Cohen *et al*. (2000:260) argue that piloting increases the validity, reliability and practicability of the questionnaire. In this study, piloting ensured the clarity of the items, the instructions and the layout of the questionnaire (Cohen *et al*., 2000:260). McMillan and Schumacher (2010:237) share the same sentiments, and contend that piloting provides feedback on the appearance or format of the questionnaire, and also on the length of the questionnaire, and time needed to complete it. The purpose of piloting the questionnaire in this study was to test whether the respondents interpreted the questions correctly, and whether the response-categories provided were suitable in addressing the research questions. Piloting the questionnaire enabled the researcher to ascertain ambiguity and biasness of items. During the piloting, the questionnaire was completed in the researcher's presence for the clarification of the items, where necessary, and for the timing of the response-rate.

A number of the items in the questionnaire that were developed through NGT were open-ended. The questionnaire with the open-ended items was pre-piloted with Examiners of Science, the Heads of Science Departments, and Science Panel Members in Swaziland, to ascertain if the questions were clear, sufficient and relevant in addressing the research questions. The results from the open-ended questions were used to develop the closed-ended items, to be used with the pilot sample. The questionnaire with the closed-ended items was then reviewed by Curriculum Designers and Curriculum Evaluators at NCC to ascertain the efficacy of the items. The questionnaire was also reviewed by other experts (lecturers in the

Department of Education in the University of Swaziland and a research officer in the University of South Africa) once more, to identify problems within the items.

The questionnaire was administered to a small group of respondents similar to the sample. The small group of Physics teachers was sampled from the Manzini and Hhohho regions (10 in each region) from urban and rural settings, as well as community, government-owned and mission schools. The main reason for selecting these regions was that they were easily accessible. The pilot group's opinions enabled the researcher to calculate the reliability coefficient and to generate the main factors (Maree, 2007:216). The feedback from the respondents in the pilot study led to some adjustments and modifications of the questionnaire items. The pilot questionnaire provided a space where the Physics teachers could write their comments about the individual items and the questionnaire as a whole.

In a nutshell, the following criteria, suggested by McMillan and Schumacher (2010:204), were used when the items were scrutinised at the various stages:

- Are the items clearly worded?
- Is the meaning of the items clear?
- Is there any difficulty in understanding the items?
- Are there any spelling or grammatical errors?
- Are the response scales appropriate?
- What suggestions are there for making improvements to the items?

The responses to the above items were essential for the revision of the instrument. The questionnaire was then sent to Physics specialists to enhance the evidence for validity. The specialists were requested to ascertain if the items addressed the stem question. The questionnaire was then distributed to the sample in all the four geographical regions of Swaziland, using the Regional Education Offices as distribution points.

3.7 DATA-COLLECTION

The data for the study were collected by means of a structured (Likert-type) questionnaire. The questionnaires, the information letters for the head-teachers and the Physics teachers, including a note on when to return the questionnaire were enclosed in envelopes. Berends (2006:628) called this mode of letter distribution as *mail survey.* One of the opportunities was that each month the head-teachers visited the Regional Education Offices (REOs) to collect the pay slips. Thus, the Curriculum Educators were requested to distribute the envelopes to the head-teachers at month-end, since Curriculum Educators were stationed at the REOs to liaise between the schools and the National Curriculum Centre. The head-teachers gave the Physics teachers the questionnaires and the questionnaire-return notes. It was stipulated in the notes that only the Physics teacher with more teaching experience (in case they were two in a school) should fill in the questionnaire.

The Curriculum Educators reminded the head-teachers during mid-month to return the questionnaires when they came to fetch the pay slips at month-end. Some of the head-teachers returned the questionnaires to the Curriculum Educators the following month when they fetched the pay-slips. Inspectors also assisted in collecting the questionnaires. They entered the school code on a sheet of paper for each questionnaire that they received. The process was catalysed by the fact that the head-teachers' cell phone numbers were available at the Regional Education Offices. Follow up measures that were put in place for unreturned questionnaires encompassed:

- reminding the head-teachers through phone calls after ten days to return the questionnaires (McMillan & Schumacher, 2006:239);
- visits to the school by the researcher and Curriculum Educators to fetch the questionnaires;
- requesting the inspectors and INSET officers to fetch the questionnaires on their way to conduct school-based workshops.

These measures increased the number of questionnaires that were returned.

3.8 DATA-ANALYSIS

The Statistical Package for the Social Sciences (SPSS) was used to analyse the data on the opinions of Physics teachers. In order to determine the significant differences by strata, a t-test was used which compared the means. The t-test was used on the strategies that could be used to address the shortage of Physics teachers, how they could be retained and how their numbers could be increased in schools. The mean, standard deviation, paired sample test were used to test the hypotheses on factors that influence the shortage of Physics teachers, as well as, in strategies that could be used to retain them and strategies that could be used to increase their numbers. The Pearson's Product Moment correlation was applied to factors that influence the shortage of Physics teachers, strategies that could be used to retain them and strategies that could be used to increase their numbers, in order to address the third objective of this study. Factor analysis was applied to strategies that could be used to retain Physics teachers and strategies that could be used to increase their numbers in schools, in order to address the second objective of this study.

3.9 VALIDITY AND RELIABILITY

This section explicates validity and reliability. These terms guided the development and implementation of the questionnaire. The terms were also essential in determining the generalisability of the results. *Generalisability* could be perceived as the extension of the research findings and conclusions drawn from the sample to the larger population.

3.9.1 Validity

Validity refers to the degree to which scientific explanations of phenomena match the reality, or the extent to which a test measures what it is set out to measure (McMillan & Schumacher, 2010:104; Maree, 2007:216; Handley, *s.a.*:1; Ross, 2005). This definition is shared by Tariq (2009:1), who also states that it approximates the truthfulness of the results. De Vos *et al*. (2002:166) subscribe to the above definition, and argue that a valid instrument does what it is intended to do. In order to enhance its validity, the instrument was subjected to content, face, construct, internal and external validity (McMillan & Schumacher, 2006:134; Maree, 2007:13; Tariq, 2009:2). Cohen *et al*. (2000:105) maintain that a valid instrument must demonstrate that it really measures what it purports to measure. According to Cohen *et al.* (2000:105), validity could also be improved through careful sampling, appropriate instrumentation, and the appropriate statistical treatment of the data. Sampling and instrumentation were discussed in the previous sections (Sections 3.5 and 3.6). The statistical analysis that was employed is reflected in a later section (Chapter 4) of the study. These were cautiously done to enhance validity. The questionnaire was validated by subjecting it to the different forms of validity which are explicated below. This ensured that the questionnaire covered all the important aspects of the issue under investigation. It was anticipated that if the items were properly constructed, they should elicit from the teachers the information required by means of the research questions.

To a certain extent, the questionnaire for this study was valid, since it elicited the opinions of teachers on causes of Physics teacher shortage. Validity in this study was viewed as the extent to which the questionnaire elicited what was essential to answer the research questions. The instrument had to be subjected to certain processes to ensure that it was valid, as elaborated on in the ensuing sections.

In order to ensure content, face and internal validity, the questionnaire was reviewed by experts through ascertaining if the items were properly constructed and if the questionnaire covered enough content (Maree, 2007:37). Maree (2007:39) and Handley (*s.a*.:1) contend that *external validity* refers to the generalisability of the results to other situations or groups of interest. External validity was attained through the use of rich descriptions of participants and their contexts (Maree, 2007:37). In this study, validity required that the data represent what it was intended for by properly engaging in the research processes and honestly reporting on the actual findings. Validity required that the researcher engages in rigorous sampling. In this study, when the data were analysed, the results were generalisable to the population of all Physics teachers.

In the discussion that follows, the researcher elaborated on each aspect of validity, and subsequently sated how each form of validity was addressed in this study.

(i) *Criterion validity*

According to Maree (2007:217), *criterion validity* pertains to structuring the instrument such so that it precisely measures what it is expected to measure. This form of validity requires that an instrument be correlated with an existing criterion. Criterion validity is manifested when there is a correlation between the instrument and the criterion. When there is a high correlation between the instrument and the criteria then the degree of validity is high, and the converse is equally true.

Following criterion validity, the questionnaire was structured so that it specifically extricated the respondents' opinions on the reasons for the shortage of specialist Physics specialist teachers, how they can be retained, and how their numbers can be increased.

(ii) *Construct validity*

Maree (2007:217) indicates that *construct validity* deals with "…how well the constructs covered by the instrument are measured by different groups of related items". The statistical techniques used for construct validity are factor analysis and item analysis (Maree, 2007:218).

McMillan & Schumacher (2010:115) further indicate that construct validity is closely associated with the generalisabilty of the findings. *Construct validity* can be perceived as the judgment about the extent to which interventions and measured variables actually represent the targeted theoretical underlying psychological constructs and elements (McMillan & Schumacher, 2010:115). Motivation can be regarded as one of the constructs central to retaining teachers in the profession, which is sustained by some incentives.

In this study construct validity involved the efficacy of employing a questionnaire as a measure of the opinions of the teachers of Physics, as also observed by McMillan & Schumacher (2010:115). Construct validity was addressed by ensuring that there were sufficient related items that covered the constructs featuring in the questionnaire (see section 4.2.2). The questionnaire was reviewed by different groups of experts whereby improving the construct validity.

(iii) *Content validity*

Cohen *et al*. (2000:109) declare that *content validity* requires that a questionnaire covers reasonably or comprehensively all the important aspects of the issue under investigation. In the same vein, Maree (2007:217) maintains that *content validity* refers to the degree to which the instrument covers the complete content of the particular construct that it is set out to measure. For example, if the instrument measures motivation, as was the case with aspects of this study, there should be items that cover the different aspects of motivation. In order to ensure the content validity of the instrument, it was presented to experts within the curriculum design cadre and UNISA (a research officer and lecturer) for their comments on content coverage before the final editing and validation.

(iv) *Face validity*

According to Maree (2007:217), *face validity* "…refers to the extent to which an instrument 'looks' valid". In other words, face validity requires that the instrument should appear to measure what it is designed to measure. McMillan and Schumacher (2010:175) state that *face validity* is a judgement that the items appear to be relevant.

In this study, face validity was concerned with the appearance of the questionnaire. In other words, each item tested the variable it was supposed to test. Since this type of validity cannot be quantified or tested, the instrument was scrutinised by experts in the field of Physics to ensure a high degree of face validity through employing the criteria discussed in section 3.6.2 on piloting the instrument.

(v) *Internal validity*

Cohen *et al*. (2000:107) state that *internal validity* concerns the degree of accuracy to which a particular event or issue can be explained by the data. McMillan and Schumacher (2010:264) indicate that *internal validity* refers to the "…judgment that is made concerning the confidence with which plausible rival hypotheses can be ruled out as explanations for the results". There are many factors that have a bearing on internal validity, but the researcher focused on the ones that had an effect on the study. These were, namely selection, pre-testing and instrumentation. *Selection* encompasses differences between the respondents (e.g. career paths) which could produce different results. In this study, the differences (in terms of level and subject taught) among the respondents were minimised by selecting only teachers who are engaged in teaching Physics at senior secondary level.

Pre-testing is the "act of responding to a questionnaire prior to the treatment" (McMillan & Schumacher, 2010:265). The questionnaire was pre-tested with two groups in two regions. The pilot groups had qualities similar to the ones of the sample, in order to eliminate the effects of pre-testing as a threat to internal validity. *Instrumentation* "…refers to the way changes in the instruments or persons used to collect data might affect the results" (McMillan & Schumacher, 2010:112). The structuring of response categories in the Likert scale of the questionnaire helped to minimise variations in the responses as compared to an open-ended questionnaire. In this study, the same instrument was used in the sample drawn from the four regions to collect the data, using the same data-collectors from NCC.

(vi) *External validity*

McMillan and Schumacher (2010:116) indicate that *external validity* refers to the extent to which the results of an experiment can be generalised to people and environmental conditions outside the context of the experiment. In this study external validity referred to the extent to which the results were generalised to the group of Physics teachers who were not part of the sample. Barret (2006:412-413) argues that one way of enhancing external validity is through ensuring that the collected data are consistent with what is known about the target population. What was known about the target population here was that they experienced challenges while teaching Physics which demotivate them, such that some contemplate leaving the teaching profession. Therefore, the study unravelled some of these challenges.

McMillan and Schumacher (2010:116-117) distinguish between two forms of external validity, namely population external validity and ecological external validity.

(vii) ***Population external validity***

Population external validity deals with the "…extent to which the results can be generalised to other people" who have similar characteristics to the sample (McMillan & Schumacher, 2010:116). Gall, Borg and Gall (1996:1) define *population validity* as the "…extent to which the results of a study can be generalised from the specific sample that was studied to a larger group of subjects". The results of this study were generalised to senior secondary level Physics teachers in Swaziland, as enabled by the sample size drawn from the four regions.

(viii) ***Ecological external validity***

Ecological external validity refers to the conditions of the study, and the extent to which generalising the results is limited to similar conditions which, in this study, are the teaching and learning environment (McMillan & Schumacher, 2010:116). Gall *et al*. (1996:1) point out that *ecological validity* is the "…extent to which the results of an experiment can be generalised from the set of environmental conditions created by the researcher to other environmental conditions (settings and conditions)". Shuttleworth (2009:1) defines *ecological validity* as a type of external validity that focuses on the testing condition and determines how much it influences behaviour. The ecological validity of this study was manifested when the methods and the setting of the study approximated the real world that was being examined as attested to by Shuttleworth (2009). One of the factors affecting the ecological external validity is the presence of the researcher. This effect was eliminated by distributing the questionnaires to the respondents, who filled them in at their own place and time, in the absence of the researcher.

In this study the validity of the data was manifested in the accuracy of the opinions of the Physics teachers that were tapped out obtained through engaging in rigorous sampling techniques, and carefully carrying out the research processes. The questionnaire was subjected to the various types of validity before seeking opinions of the sample of Physics teachers.

In general, during data-collection, the variation in instruments and data-collectors influences the results, hence validity. The validity of the data was enhanced by using the same questionnaire for all the respondents. The variation in the items of the questionnaire, hence the responses, was harmonised by eliciting responses through the Likert-type questionnaire for all the respondents and limiting the response categories. The tendency of engaging Physics experts to review the questionnaire at various stages of its development, enhances the validity of the output, which in this case, was the data collected from Physics teachers. Most of the experts were practitioners who had the knowledge of the possible challenges facing Physics teachers.

In the section that follows, the researcher discussed reliability and explicated how it had a bearing on this study.

3.9.2 Reliability

Reliability refers to the degree to which a measuring procedure gives consistent results (Ross, 2005:47). Ross (2005:47) contends that a reliable test is one which provides a consistent set of scores for a group of individuals when administered independently on several occasions. Reliability refers to the fact that the evaluation instrument gives the same results when administered and when inter-item correlation is calculated (Handley, *s.a*:1). De Vos *et al*. (2002:168) define *reliability* as the extent to which the independent administration of the same instrument consistently produces the same results under comparable settings. They (2002:195) suggest that in order to ascertain the reliability of an instrument, it must be subjected to test-retest reliability, parallel-form reliability and internal-consistency reliability. Internal reliability requires that, when a number of items are formulated to measure a certain construct, there should be a high degree of similarity among them, since they are supposed to measure one common construct (Maree, 2007:217). A measure of the degree of similarity is an indication of the internal consistency of the instrument. The results from piloting the instrument were quite vital in checking for the reliability of the instrument, since it was piloted with two groups from different regions. These results were analysed for the consistency of the instrument. The fact that the instrument was piloted in two groups from different regions enhanced the reliability.

Furthermore, r*eliability*, as perceived by Cohen *et al*. (2000:117), "…is essentially a synonym for consistency and replicability over time, over instruments and over groups of respondents". *Reliability* is, according to McMillan and Schumacher (2010:179) "… the extent to which measures are free from error". Pietersen and Maree (2007:215) define *reliability* as the ability of an instrument to produce the same results when administered to different respondents of the same population. *Reliability* is used to describe the overall consistency of an instrument ("Reliability", n.d.). One way of increasing reliability of an instrument is through eliminating errors. Scrutiny by Physics experts helped to eliminate errors in the questionnaire for this study. The reliability was concerned with the ability of the instrument to produce consistent or plausible results while administered to the pilot group and the sample. It was also concerned with the precision and accuracy of the instrument to extricate the opinions of the Physics teachers. Reliability is regarded as a necessary precondition for validity.

The coefficient that is used to measure the internal reliability of an instrument is Cronbach's alpha coefficient (p-value of 0.7), which provides a value for inter-item correlations (Maree, 2007:216). The reliability of the items of the questionnaire was manifested during piloting. Ross (2005:40) argues that the number of respondents in the piloting stage of the questionnaire should be reasonable to enhance reliability. The number of teachers selected for piloting in this study from the two settings was enough for the calculation of an estimate of reliability-coefficient.

In order to ensure that the items for the questionnaire were reliable, the researcher identified groups homogeneous to the major respondents for the study, and requested them to fill-in the validated and field-tested instrument of opinions (Maree, 2007:178). The responses were then subjected to the calculation of Cronbach's alpha coefficient (p = 8.0). The questionnaires were analysed and edited, based on the findings from the piloting. The responses from the two groups (Manzini and Hhohho) were nearly the same for each pair of items, and this indicated that the items were probably good. The responses from the two groups also provided an indication of variability in the answers to investigate various relationships. The reliability was enhanced by piloting the questionnaire through the identification of potential questions that elicited information relevant to the requirements of the research questions.

All in all, an instrument has "…high reliability if it produces similar results under consistent conditions" ("Reliability", n.d.). A study is reliable if demonstrates that it could produce similar results when carried out on a similar group of respondents (Cohen *et al*. 2000:117). The group of individuals in this study were Physics teachers, both in the piloting stage and the data-collection stage. The consistency of the results was ascertained through subjecting the questionnaire to piloting in two regions, and the actual implementation. The three main forms of reliability, as perceived by Cohen *et al*. (2000:117) are stability, equivalence and internal consistency. The researcher focused on the first two since they had a bearing on this study.

(i) *Reliability as stability*

Reliability as stability is regarded as a "…measure of consistency over time and over similar samples" (Cohen *et al*., 2000:117). In this form of reliability, the questionnaire yielded similar results in the groups of similar respondents. Similar results were obtained from the questionnaire during the piloting and data-gathering stages, and over time, similar results should be attained. If a questionnaire is administered to two groups that are similar, the probability is high that similar results could be obtained. In this case, it was the groups of Physics teachers in the different regions. Reliability as stability was essential during the implementation of the questionnaire where the correlation co-efficient was calculated, using the Pearson statistics. It was also possible to compare the coefficients from the groups to ascertain reliability.

(ii) *Reliability as equivalence*

Reliability as equivalence embraces two types of reliability. One of these types is when two forms of a questionnaire are used to gather data. If an equivalent form of the questionnaire is administered and yields similar data, then the questionnaire is said to be demonstrating reliability as equivalence. It is "…used to assess the degree to which different raters/observers give consistent estimates of the same phenomenon" (Trochim, 2006). Reliability as equivalence can be achieved through inter-rater reliability (Cohen *et al*., 2000:117). It is possible that errors are incurred when more than one researcher is gathering data for the same study. The errors are minimised by ensuring that all the researchers record the data in the same manner. For this study, the different officers in the regions were requested to only distribute and collect the questionnaires, thus this form of reliability was controlled, since the study was not qualitative but quantitative.

3.10 ETHICAL CONSIDERATIONS

McMillan and Schumacher (2010:117) indicate that "…ethics are concerned with beliefs about what is right or wrong from a moral perspective". Mauther, Birch, Jessop and Miller (2002:20) define *ethics* as the application of general rules and principles, and the internalisation of moral principles by the researcher. Schulze (2002a:5) shares the same sentiments and defines *ethics* as a set of moral principles that are adopted by the researcher as he/she carries out the study. According to Cohen *et al*. (2000:49), ethical issues emanate from the type of challenges being investigated, as well as the methods used to obtain valid and reliable data. The various stages in this study had the potential of incurring ethical challenges. The study was inclined towards the quantitative approach with its own requirements meant to address ethical issues, and the ensuing discussion addresses these challenges.

The researcher previously reported on the existing conditions of participants involved in the research. It was essential that he employs high standards of academic rigour, and behaves with honesty. This means that the data were strictly used for what it was intended. The report was based on the actual findings from the data without anything being altered. Therefore, the processes of obtaining informed consent, protecting the respondents from harm, and measures of ensuring confidentiality are discussed next.

3.10.1 Informed consent

De Vos *et al*. (2005:59) point out that *informed consent* entails an explanation to the respondents of the goal of the study, and all the possible advantages and disadvantages of engaging in it. The respondents in this study were provided with adequate information presented in a language and using terms that they could easily understand (Schulze, 2002b:17). The information comprised the aims of the research, the procedures to be followed, as well as possible anticipated advantages and disadvantages for the respondents. The researcher informed the respondents how the results of the study would be used in order for them to make an informed decision on whether or not to participate in the study. The language that the researcher used in the questionnaire was English, because it was understandable to all the respondents. English is also the medium of instruction in the schools, as well as the medium used by the learners when writing examinations.

It was imperative that the researcher first obtain the consent from the officers in administrative positions, and then from respondents. This signified the officers' willingness to provide the researcher with the permission to carry out the study and for the teachers to participate in it. In the observation of ethics, the researcher sent letters requesting for permission to collect the data to the following officers, namely

- the Regional Education Officers;
- the head-teachers; and
- the Physics teachers.

In short, protocol dictated that the researcher first informs the Regional Education Officers in the four regions about this study, since they have to be aware of all the activities undertaken in the schools. This information was then communicated to the head-teachers who assume supervisory roles in the schools. The communication (i.e., the request to conduct research) from the head-teachers was then relayed to the Physics teachers who experienced challenges during the teaching and learning processes. The Physics teachers then filled in the questionnaires and returned them to the head-teachers. Subsequently, the head-teachers submitted them to the Curriculum Educators and other officers at the REOs. The Curriculum Educators then submitted them to the researcher.

All in all, the researcher adhered to the ethical requirements by writing letters to the head-teachers requesting permission to do research at the schools. The letters were attached to the questionnaire (see Annexure C). Permission was sought from the Physics teachers by means of a consent form to complete the questionnaire (see Annexure E). The letter made it clear that the school and the teacher were not forced to participate, but at the same time the significance of the study was clarified to him/her to solicit his/her opinions, as well as the significance of his/her contribution. Permission was also sought from the Regional Education Offices to conduct the study (see Annexure A).

3.10.2 Protection from harm

As a researcher engages in a research study, the respondents may possibly be exposed to either emotional or physical harm. Schulze (2002b:6) argues that this should not happen during the data-collection processes. The questionnaire, for this study, was structured in such a manner that it did not extricate information that would expose the respondents to any emotional or physical harm. Also, in compliance with this condition, the questionnaire did not require any sensitive information.

3.10.3 Anonymity and confidentiality

Schulze (2002b:18-19) is of the opinion that the information obtained from the respondents should be regarded as confidential unless otherwise agreed upon through informed consent. The respondents have to be assured that no information that they presented will be exposed, and this includes their names and the names of their schools. In observation of the ethical requirements, the data collected in this study was kept in a safe and secure place, and the results were presented in an anonymous manner, so that the identities of the respondents were protected (Maree, 2007:299). Confidentiality, as part of ethics, was ensured through not revealing the particulars of the respondents. Moreover, pseudonyms were used to protect the identities of the participants during the pilot-testing. The researcher also made them aware that their participation was voluntary.

3.11 SUMMARY

In this chapter the research methodology encompassing the research approach and the research design for this study were described, as well as the justification for using the quantitative research methodology. The advantages of using a survey design and a questionnaire were explicated. The population for this study was described, including the sampling procedures. Strategies that were employed when developing the questionnaire were succinctly explicated, drawing on input from Physics experts, as well as by means of reviewing the literature sources. The data-collection processes and measures on how to maximise the return rate of the questionnaires by the head teachers were outlined. Piloting, its significance and how it was undertaken, was explained. Finally, validity and reliability issues including the ethical considerations were discussed.

In the next chapter, the researcher presented the data from the findings of this study, as well as the analysis of the data and the interpretation of the results.

CHAPTER 4

THE PRESENTATION AND ANALYSIS OF THE DATA

4.1 INTRODUCTION

The previous chapter mainly explicated the research method and design that were used in collecting the data for the study. The researcher also elaborated on the sampling technique used in the study and the questionnaire. The ethical issues that were taken into account in order not to cause any harm to the participants were clarified. The steps that were taken to ensure that issues regarding validity and reliability are addressed were outlined.

This researcher presents the data and its analysis in this chapter. The interpretation of the data was done concurrently with the analysis, as well as, in conjunction with the research questions, the theoretical framework and the literature review.

The opinions were obtained through a structured questionnaire focusing on the on the reasons causing Physics teachers' shortage, how they can be retained, and their numbers increased in senior secondary schools in Swaziland. In this study the researcher computed descriptive and inferential statistics, presented and analysed the data. The Statistical Package for the Social Sciences (SPSS) was used to analyse the data.

In Section 4.2.5.1, a t-test was mentioned as one of the statistical modes of data-analysis, thus the t-test was computed to compare the means regarding the factors associated with the reasons for the shortage, and strategies to retain and increase the number of Physics teachers (Bluman, 2006:448). The mean and standard deviation were applied to all items in the questionnaire in sections B, C and D.

In the section that follows, the descriptive analysis of the quantitative data is presented, together with its interpretation.

4.2 DATA-COLLECTION

As mentioned in section 3.7, the data was collected by means of written questionnaires, which were placed in an envelope at the Regional Education Offices together with a cover letter or letter of transmittal, outlining the study (McMillan & Schumacher, 2010:237). The envelopes were distributed to the head-teachers (mail survey) when they came to fetch their pay-slips from the Regional Education Offices (Berends, 2006:628). Also, an explanatory note was enclosed in the envelopes requesting the head-teachers to return the questionnaires when they came to fetch their pay-slips for the following month. During the middle of the month the head-teachers were reminded through phone calls (or short message service – sms) to return the questionnaires when they came to fetch their pay-slips at the end of the month.

The head-teachers who forgot to bring the questionnaires were reminded (after one week) by means of phone calls, to return them, in order to maximise the return-rate. The questionnaires were coded using the school codes, to ensure that follow-up measures were precise and focused. The school codes are readily available in the Regional Education Offices and in the Swaziland Government School Lists (2011).

4.3 DATA-ANALYSIS AND INTERPRETATION

According to Cohen *et al.* (2000:147), data-analysis involves the organising, accounting for and explaining of the data. In retrospect, the research approach for the study was quantitative. Quantitative research relies heavily on numerical data in reporting results (Maree, 2007:255). The study employed descriptive statistics to summarise and present the data. McMillan and Schumacher (2010:149) contend that "…the use of descriptive statistics is the most fundamental way to summarise data, and it is indispensable in interpreting the results of quantitative research". Descriptive statistics described the opinions of the Physics teachers in the sample and this is acceded to by Ross (2005:31). The Statistical Package for the Social Sciences (SPSS) was used to analyse the data obtained from the Physics teachers. In this study descriptive statistics was used to summarise, organise and reduce large numbers of observations extricated from the teachers' questionnaires. The statistics transformed a set of numbers or observations into indices that described or characterised the data.

Descriptive analysis encompasses univariate analysis (De Vos *et al*., 2002:225). Univariate analysis would be employed to summarise the data on a single characteristic or variable, which is the dependent variable, e.g. mean, median, mode, standard deviation, frequency distribution and percentages (McMillan & Schumacher, 2010:151; Ross, 2005:31). In order to determine the significant differences by strata, a t-test is used which compares the means (Bluman, 2006:448).

The following are some examples where descriptive data analysis was used in the questionnaire:

The t-test was used on the strategies to the shortage, retention and increase in the number of Physics teachers; the mean and standard deviation were applied to all the factors in the questionnaire for sections B, C and D; the Pearson's Product Moment Correlation Coefficient was used on the factors impacting on the shortage, retention and increase of the number of Physics teachers.

4.4 DESCRIPTIVE ANALYSIS OF THE QUANTITATIVE DATA

The descriptive analysis of data entails mainly expressing the results from the sample in numbers and percentages. A total of 168 (91.3%) questionnaires out of 184 were received from the sampled schools.

In this section the biographical data of the respondents, the reasons for the shortage of Physics teachers, the strategies that can be used to retain them, and the strategies that can be used to increase their numbers, including the statistical analysis are discussed.

In the section that follows the biographical data of the respondents was discussed.

4.4.1 Section A: Biographical data

Questions 1 - 12 are related to the personal particulars of the respondents, namely their gender, nationality, highest academic qualifications, highest professional qualifications, subject majors, teaching experience, experience teaching Physics, last year of studying Physics at tertiary level, level of tertiary education (primary or secondary), type of current school, the location of the current school and the location of the school where grade 12 was completed. The purpose of the biographical information was to gain insight into the biographical information of the Physics teachers in Swaziland. This data were used to ascertain if the teachers were really qualified to teach Physics in senior secondary schools.

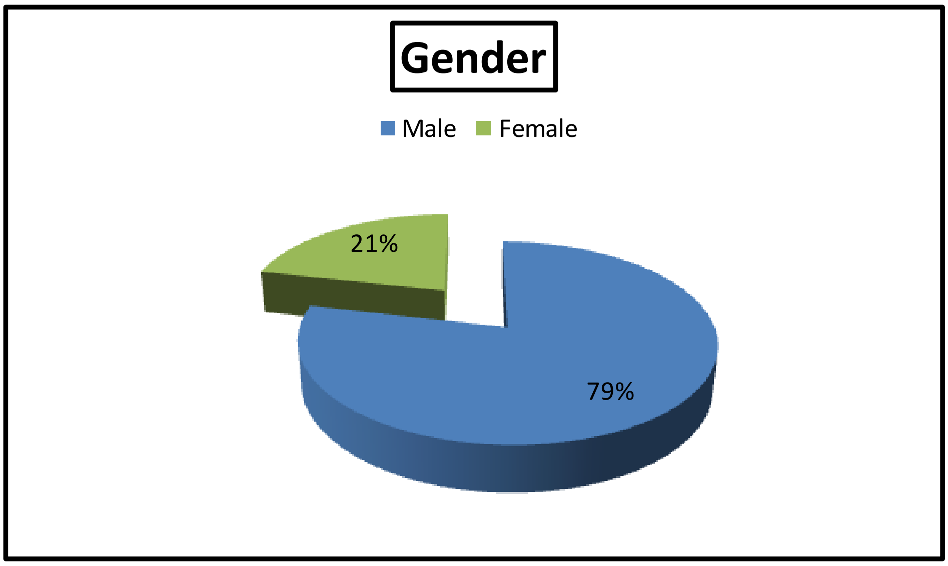

Figure 4.1: Graph of respondents by gender

From the graph (figure 4.1) it can be seen that the highest response to the questionnaire came from the male participants (79%), as opposed to the female respondents (21%) who teach Physics. This is in agreement with the belief that Physics is portrayed as a man's world (58.9%), as reflected in the statements on attitude (Table 4.11) being one of the reasons for the shortage of Physics teachers. The learners' attitude towards Physics is reflected in the outputs in Howie's (2006) model. The researcher observed that, during the setting, moderation and marking of

Physics examinations, the majority of the participants were male teachers. This is in line with the observation that the subject is dominated by male teachers (Politis *et al.,* 2007:42). Therefore, there is a need to ascertain the challenges faced by female students that discourage them to pursue it at tertiary level.

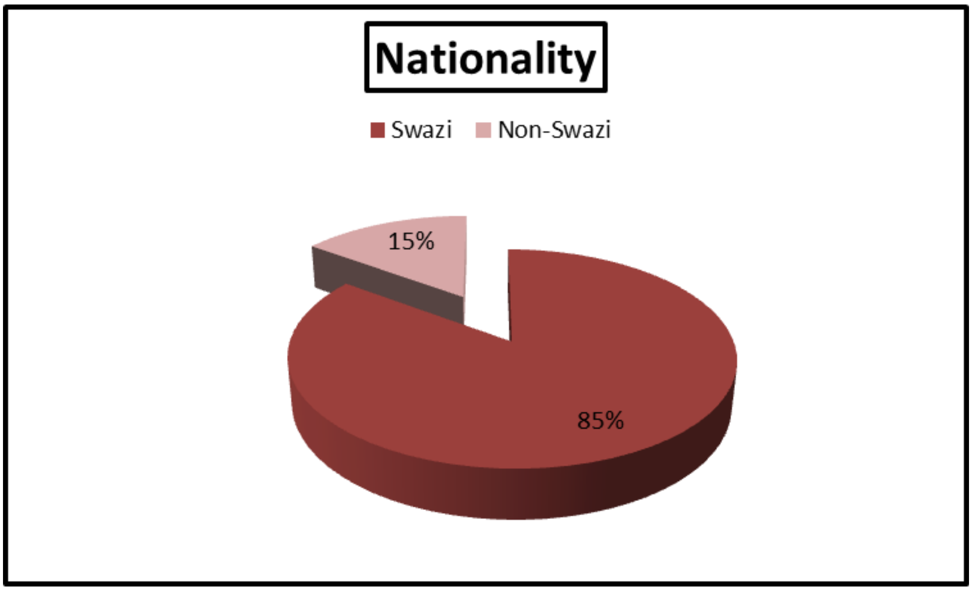

Figure 4.2: Graph of respondents by nationality

From the graph in figure 4.2 it can be seen that the highest response to the questionnaire came from the Swazi respondents (85%), compared to the non-Swazi respondents (15%) who teach Physics in this study. Thus, the majority of the teachers who teach Physics are Swazis. This does not mean that they majored in the subject (as reflected in Table 4.3), hence the government's initiative to recruit non-Swazi Physics specialists (Makhubu, 2014:2). The study indicated that some of the non-Swazi teachers are not specialists in Physics; hence the need to ascertain if the rest of the teachers, not included in the study, are really qualified to teach the subject. The Teaching Service Commission cannot shed light on this because they simply recruit teachers and are not aware of how they are deployed in the schools, since this is done by the head-teachers, according to the needs of the school.

Table 4.1: Highest academic qualification

Qualification	F	%
Certificate	0	0
Diploma	22	13.0
Bachelor's degree	135	80.4
Honours degree	3	1.8
Master's degree	8	4.8
Other (specify)	0	0

There is a distinction between the academic and the professional qualifications of the teachers, and Howie (2006), in the model on school effectiveness, regard these as inputs. Professional qualifications, in this context, enable the teachers to impart Physics concepts with a deeper understanding through employing various teaching methods. Politis *et al.* (2007:39) noted that Physics teachers did not have a 'Physics-dominated' degree. It was ascertained that the majority of the respondents (80.4%) possessed a Bachelor's degree as the highest academic qualification. In order to teach at the senior level, policy requires that the teachers should hold a degree. In the local context, the majority of the respondents hold a degree, but this does not imply that they have the relevant qualification to teach Physics, since MoET deployed non-specialist teachers to teach Physics (Magagula, 2010:15; Annual Performance report for MoET, 2010/2011:25). The percentage of diploma (13%) holders is somewhat higher, considering that they occasionally teach at this level, thus pointing to the shortage of Physics teachers with a Bachelor's degree in Science. In fact, diploma holders are trained to teach at junior secondary level only.

Table 4.2: Highest professional qualification

Qualification	F	%
Certificate in education	5	3.0
Post-graduate certificate in education	56	33.3
Diploma in education	25	14.9
Post-graduate diploma in education	3	1.8
Bachelor of education	21	12.5
Bachelor of Science (Agric.) education	17	10.1
Honours degree in education	0	0
None	20	11.9
Other (specify)	21	12.5

Chodos and Ouelette (2012:1), and Lindsey (2011:1) noted that most of the Physics teachers were not trained to teach the subject. It was ascertained that the majority of the respondents (33.3%) possessed a post-graduate certificate in Education as the highest professional qualification. This indicates that they are qualified teachers, since this qualification is attained by degree holders who intend to join the teaching profession (Magagula, 2010:15). The Bachelor of Education (12.5%) holders are qualified to teach at senior secondary level, which are inadequately produced by the local university (Magagula, 2010:15). It is a concern that there are only a few teachers with a Bachelor of Education degree, and are equal in percentage to those who hold other professional qualifications (12.5%). It is noteworthy and also another concern that quite a number of the respondents (11.9%) indicated that they possessed no professional qualification to teach Physics at school. This concern has been advanced by SHAI (2010:1), the NERCOM Report (1985) (Government of Swaziland, 1985:33) and the National Statement on Education (1998) (Ministry of Education, 1998:2).

It is also a concern that the teachers who are qualified to teach Agriculture (10.1%) are allowed to teach Physics. Moreover, the data indicated that other teachers who teach Physics majored in other qualifications, for example Economics, Electronics engineering, Computer Science and Home Economics and this was alluded to by Magagula (2010:15). The tendency by policymakers of allowing non-specialists to teach Physics lowers the standard of education and the quality of learners.

Table 4.3: Subject majors of respondents

Major	F	%
Mathematics/ Chemistry	16	9.5
Mathematics/ Physics	75	44.6
Chemistry/ Physics	5	3.0
Biology/ Chemistry	29	17.3
Other (specify)	43	25.6

This question was asked to ascertain the respondents' majors at tertiary level. Marope (2010:36) reported that schools in Swaziland depended on non-specialists to teach Physics. In this study, the majority of the respondents (44.6%) majored in Mathematics and Physics during their undergraduate level at university, and are qualified to teach the subject at senior secondary level. However, the World Bank Report acknowledged the shortage of Science teachers, attributing the shortage to low enrolment in teacher training institutions (2006:42). Some of the teachers who majored in Mathematics or Chemistry are likely to have done Physics in their first year, but this does not qualify them to be regarded as specialists in Physics. It is one of the requirements of the University of Swaziland that each student should do a minimum of three Science subjects in the first year, to be reduced to two in subsequent years. Biology and Chemistry (17.3%) specialists only tap on their senior secondary experience to teach Physics, which is very detrimental to the learners, since their subject content is not higher than that of the learners.

In his experience as teacher, the researcher noted that those who did not major in Physics were forced by circumstances to teach this subject, and they expended all effort to avoid teaching Physics. This indicated that they acknowledged their shortcomings. It is noteworthy and a concern that quite a number of respondents

(25.6%) indicated that their majors are other than expected majors to teach Physics. In short, the majority of the respondents (52.4%) did not major in Physics, and the teachers with other qualifications have been employed to teach Physics in senior secondary schools (Magagula, 2010:15). Engaging Mathematics/Chemistry, Biology/Chemistry and teachers with other qualifications to teach Physics attests to the shortage of specialist Physics teachers.

Table 4.4: Teaching experience (in years)

Teaching experience	F	%
0 – 5 years	43	25.5
6 – 10 years	37	22.0
11 – 15 years	31	18.5
16 – 20 years	26	15.5
Above 20 (specify)	31	18.5

This question was meant to ascertain the teaching experience, in general, of the respondents. It would also shed some light on whether they had enough teaching experience. Teacher experience is viewed as an input by Scheerens (1990) in the integrated model of school effectiveness. The advantage of an experienced teacher it that she/he has more than one way to share the Physics content with the learners. However, Güzel (2011:1050) observed that, in developing countries, the teachers were young and inexperienced. It may be indicated that the majority of the respondents fall in the bracket of 0-5 years' teaching experience (25.5%). It can be deduced that the majority of the Science teachers, in general, do not spend time in the teaching profession, since they are attracted by better paying jobs in the industry. In general, the data indicated that the majority (10 years and above, 74.5%) of the teachers have the required teaching experience.

Table 4.5: Respondents' Physics teaching experience (in years)

Experience teaching Physics	F	%
0 – 5 years	69	41.6
6 – 10 years	44	26.5
11 – 15 years	21	12.7
16 – 20 years	20	12.0
Above 20 (specify)	12	7.2

Paramount in this study is the teachers' experience teaching Physics. It can be observed that the majority of the respondents (41.6%) fall in the 0-5 years' bracket of experience teaching Physics, which falls short of the governments' policy of 8 years for one to be considered as an experienced teacher. Nonetheless, the majority of the respondents (in the bracket of 10 years and above, 58.4%) have sufficient experience in teaching Physics.

Table 4.6: Respondents' last year of studying Physics at a tertiary institution

Last year studying Physics	F	%
Year 1	57	33.9
Year 2	17	10.2
Year 3	33	19.6
Year 4	61	36.3

It can be seen that the majority of the respondents indicated that their last year of studying Physics at tertiary institution fell in the year 4 (36.3%) category, which is most appropriate for the senior secondary school level. It is anticipated that these teachers can confidently handle the senior secondary school level syllabus. However, the second category of year 1 that accounted for 33.9% is quite high for the senior secondary level. It stands to reason that these teachers will have a challenge handling some of the concepts of the subject, which has a negative effect on what the learners acquire. In his experience as a Physics teacher, the researcher observed that the teachers who studied Physics for one year at tertiary level tend to avoid teaching the subject and are more comfortable with Biology and Chemistry. This begs the question, namely “Is Physics more demanding than Biology or Chemistry?”

Table 4.7: Respondents’ level of tertiary education (primary or secondary Science education)

Primary/secondary science education	F	%
Primary science education	2	1.2
Secondary science education	112	67.1
Other (specify):	53	31.7

The purpose of this question was to ascertain if there were teachers who studied primary science at degree level who teach at the senior secondary school level. This constitutes the inputs as per Scheerens’ (1990) model. It can be observed that the majority of the respondents indicated that they studied towards a secondary Science education degree at tertiary level (67.1%). The data indicates that only 1.2% studied towards primary science degree in education, and these are not regarded as qualified to teach at senior secondary school level. The respondents who graduated with a primary science degree in education at tertiary level are those who did a secondary teachers’ diploma in Science at college, and those who did a primary teachers’ diploma in Science. These teachers take very few courses in Science at degree level.

It is worth noting and a concern that quite a number of the respondents (31.7%) indicated that they had neither a primary nor a secondary science education qualification at their degree level, but indicated that they teach Physics. It is unclear what these teachers possess. However, it can be noted that they have certificates that do not qualify them to teach at the senior secondary school level. Certificates in secondary school education which were meant to boost Science at the junior level were phased out in 1985. Currently, all the junior secondary school teachers are required to study towards a diploma before joining the teaching profession.

Table 4.8: Respondents' type of current school

Type of current school	F	%
Government	85	50.6
Mission	3	1.8
Private government-aided	41	24.4
Community	39	23.2

This question was meant to obtain the opinions from teachers located in different settings. The locations are regarded as 'co-variables' within context in Scheerens' (1990) model. The government-aided schools are supported far more than the others, inasmuch as that they are provided with cars, and auxiliary staff members who are included on the government's payroll. The support from government places the schools at an advantage over the other schools in terms of budget allocations. It can be seen that the majority of the respondents indicated that they are employed at government schools (50.6%). Private government-aided schools are semi-autonomous in the sense that they can recruit their own Science teachers with the government paying their salaries. All these categories of schools provided some invaluable information on the reasons for Physics teacher shortage, and the strategies to retain, and increase the numbers of Physics teachers.

Table 4.9: Respondents' location of current school

Location of current school	F	%
Urban	50	29.8
Semi-urban	40	23.8
Rural	78	46.4

School location, as part of the contexts in Scheerens' (1990) model, determines the extent to which resources are accessible. The Annual Performance Report for MoET (2010/2011:15) reported that the shortage of Physics teachers was prevalent in both rural and urban schools. In this study it can be seen that the majority of the respondents are located and teaching at rural schools (46.4%). These respondents have challenges accessing some of the resources essential for teaching in general. The urban schools (29.8%) have access to resources and technological innovations. It is anticipated that the learners will appreciate these innovations and utilise them during the learning process. Thus, the learners may be motivated to pursue Science-oriented careers, especially Physics, as they progress with their education. However, currently this is not the case. The argument, in this study, is that there are generally very few Physics specialists.

Table 4.10: Location of school where respondents completed Form V

School where Form V was completed	F	%
Urban	94	56.0
Semi-urban	29	17.2
Rural	45	26.8

It is well-known that one tends to opt to teach in an environment that is familiar to you. It can be seen that the majority of the respondents teaching Physics indicated that they were located in urban schools when completing Form V (56.0%). Apparently, they had sufficient resources, or else better teachers to motivate them to opt to pursue Science-oriented courses.

4.4.2 SECTION B: THE FACTORS THAT INFLUENCE THE SHORTAGE OF PHYSICS TEACHERS

In this part of the analysis of the descriptive data, statements were formulated regarding the factors that influence the shortage of Physics teachers. This was meant to address the first research question as reflected in chapter 1 of this study.

The respondents were asked to state the extent to which they **agree** or **disagree** with each statement listed in Table 4.11 which reflects their opinion according to the scale that follows:

1. SD = Strongly disagree
2. D = Disagree
3. A = Agree
4. SA = Strongly agree

Table 4.11: The shortage of Physics teachers (n = 168)

No.	The shortage of Physics teachers is due to the following factors:	Mean	Std. dev.	SD 1	D 2	A 3	SA 4
	Incentives						
1	The salary is not attractive.	3.50	.726	1.8	8.3	28.0	**61.9**
2	There are no incentives.	3.55	.608	1.2	2.4	36.5	**59.9**
	Support						
1	The support from the school administration is poor.	2.15	.701	13.7	**61.3**	20.8	4.2
2	The support from the science department is poor.	1.19	.691	24.4	**64.3**	7.1	4.2
3	There is no recruitment policy/strategy for the teachers of Physics.	3.25	.782	3.0	11.9	41.7	**43.5**
4	There is no retention policy/strategy for the teachers of Physics.	3.25	.829	2.4	11.9	**47.0**	42.3
5	The lack of Physics teaching resources	2.64	.762	8.3	33.9	**43.3**	14.3
6	Support from the inspectors is lacking.	2.41	.707	10.8	**43.7**	39.5	6.0
	Subject content						
1	Physics requires a strong	3.37	.686	1.2	9.6	40.1	**49.1**

	mathematical background.						
2	The content of Physics is not easy to teach.	2.26	.712	9.5	**58.9**	27.4	4.2
3	Physics has more abstract concepts.	2.59	.889	7.1	32.7	**54.2**	6.0
4	The Physics content makes use of males in its examples.	2.15	.654	26.8	**36.9**	30.4	6.0
5	Tertiary students lack knowledge of the content of Physics.	2.38	.729	7.7	**48.8**	41.7	1.8
6	The Physics syllabus at college is sub-standard.	2.28	.727	12.0	**51.8**	31.9	4.2
	Motivation						
1	There are few Physics role-models.	3.07	.677	4.2	10.7	**59.5**	25.6
2	Physics is boring to teach.	1.64	.749	44.6	**48.8**	4.2	2.4
3	The Physics teachers do not inspire the learners.	2.09	.641	20.2	**54.2**	22.0	3.6
4	Demoralising poor initial Physics experiences.	2.60	.768	3.0	39.5	**52.1**	5.4
	Attitudes						
1	The world of Physics is portrayed as a man's world.	2.95	.919	6.0	14.3	**58.9**	20.8
2	Teaching lacks prestige.	2.80	.815	8.9	27.4	**38.7**	25.0
3	The lack of respect for teachers among the learners.	2.24	.769	17.3	**47.6**	28.6	6.5
4	The lack of respect for teachers among the administrators.	2.11	.791	19.6	**54.2**	21.4	4.8
5	The learners have a negative attitude towards Physics.	3.08	.773	4.8	13.2	**51.5**	30.5
	Professional development						
1	Too few Physics courses at tertiary level to attract more learners.	2.81	.768	4.2	28.6	**49.4**	17.9
2	The drop-out rate in transition from	2.85	.734	3.0	28.9	**48.2**	19.9

	high school to college is high.						
3	There are very few training institutions for Physics teachers.	3.08	.783	4.2	10.7	**58.3**	26.8
4	Rigid entry requirements for Physics education at tertiary level.	2.90	.852	4.8	21.4	**52.4**	21.4
	Opportunities						
1	Physics has more opportunities than other subjects.	2.90	.747	3.6	31.0	**37.5**	28.0
2	The industries need more people with knowledge of Physics.	3.15	.715	2.4	14.3	**49.4**	33.9
3	Physics is not offered at all the schools.	2.06	.666	20.8	**54.2**	23.2	1.8
4	Inequality in access to opportunities in Physics education.	2.50	.746	5.4	43.5	**47.0**	4.2
5	Other lucrative career paths than teaching that attract Physics teachers.	3.36	.789	2.4	8.9	38.7	**50.0**
	Teacher challenges						
1	Inadequate learner discipline at school.	2.48	.760	10.7	38.1	**43.5**	7.7
2	The lack of learner discipline in school.	2.36	.611	12.5	**44.0**	38.7	4.8
3	Physical assault on teachers by the learners.	1.68	.651	38.1	**56.5**	4.2	1.2
4	False accusations directed to Physics teachers by the learners.	1.89	.849	26.2	**60.1**	12.5	1.2
5	Retirement of Physics teachers without being replaced.	2.79	.833	8.4	23.4	**49.1**	19.2
6	The workload is too much.	3.08	.608	2.4	23.8	**37.5**	36.3

The items in Table 4.11 were discussed according to the categories that follow:

- incentives;
- support;
- subject content;
- motivation;
- attitudes;
- professional development;
- opportunities;
- teacher challenges.

(i) Incentives:

Vegas (2005:16) and Santiago (2002:1) argue that Physics teachers leave the teaching profession because of other incentives and because of a meagre salary. The majority of the respondents (as indicated in Table 4.11, incentives) strongly agreed or agreed (96.4%) that there were no incentives to attract Physics teachers, nor attractive salaries (89.9%). Incentives for teachers were once proposed by the subject's senior inspector, but were rejected by the Teachers' Organisation (SNAT). They argued that it was discriminatory upon non-science teachers. It can be concluded that the lack of incentives contributes to the shortage of Physics teachers, since the majority of the respondents strongly agreed that there were no incentives to spur them on to teach Physics. Following this observation, SHAI (2010:1) argues for greater incentives to attract Physics graduates into teaching.

(ii) Support:

The support and rewards given to teachers, as achievement stimulants (Scheerens' 1990 model), are provided by, among others, the government, administrators and the inspectorate. Gold (2006:1) cited poor support from the administration as one of the reasons for the shortage of Physics teachers. The respondents (as reflected in Table 4.11, support) strongly disagreed or disagreed that there is poor support from the school administration (75%) and the inspectors (54.5%). This means that the administration and inspectorate support them during the teaching and learning processes. They also strongly disagreed or disagreed (88.7%) that there was poor support from the Science department. This implies that the Science department supports teachers with, for example, teaching resources.

The policy pronouncements on recruitment and retention are encapsulated in the inputs in Howie's (2006) model. There was agreement among the respondents that policy documents do not contain pronouncements stipulating how they should be recruited (85.2%) and retained (89.3%). In line with this, Woolhouse and Cochraine (2010:608) advocate for the intensification of policy drives meant to recruit Physics and Chemistry specialists. It is incumbent upon the government to enact policies that would spell out how Physics teachers should be recruited, starting at school level, and how they should be retained once they opt for the teaching profession. This should be the government's priority, since the majority of the officers in the Department of Education have raised their concern on the shortage, and there is nothing tangible that has been done, especially for Physics teachers.

(iii) Subject content:

The subject content is part of the processes in Howie's (2003) and Scheerens' (1990) models, and school climate in Heneveld and Craig (1996) model. The Physics content involves the manipulation of numerical data, thus the need for a strong Mathematics background for learners who intend pursuing Physics courses at tertiary level, and this is supported by the majority of the respondents (89.2%) (as indicated in Table 4.11, subject content). The majority of the respondents noted that the Physics content contains more abstract concepts than the other sciences (60.2%), but at the same time, it is not difficult to teach (68.4%). They strongly disagreed or agreed that the Physics content uses males only in its examples (63.7%), that the learners lack knowledge of the Physics content (56.5%) and that the college syllabus is sub-standard (63.8%). The respondents stated that learners possess adequate Physics content, but this is not in agreement with the observation of UNISWA lecturers as they teach students who studied the SGCSE syllabus offered in senior secondary schools.

Drawing from his experience working with professionals and teachers, on one extreme, the researcher has noted that these professionals argue that the learners possess sufficient knowledge of the subject content, but on the other extreme, the tertiary institutions contend that students lack knowledge of the subject content. The authenticity of this argument needs to be investigated further as purported by both sides. The researcher would argue, from his experience of the examinations and the syllabus that the current Science syllabus does not adequately prepare the learners to handle tertiary courses. Thus, the need to review the contents of the syllabus.

(iv) Motivation:

Motivation, according to the Scheerens (1990) model, is an achievement stimulant which can take on different forms, and is an essential attribute to spur learners to put in more effort in the acquisition of Physics content. The Cornell University (2011:1) noted that the learners are likely to be dissuaded to pursue a career in Physics due to poor initial experiences. The majority of the respondents strongly agreed or agreed (85.1%) (as shown in Table 4.11, motivation) that there are but a few Physics role-models who could motivate the learners, together with exposure to demoralising poor initial Physics experiences (57.5%). The respondents strongly disagreed or disagreed that Physics is boring to teach (93.4%), and that the teachers do not inspire the learners to learn Physics (74.2%). Thus, the teachers are motivated and enjoy teaching Physics, which is manifested in the active participation of the learners in the subject. It is unclear what aspect in the teaching and learning processes motivates them, since in the same section on teacher challenges they argue that they are demotivated.

(v) Attitudes:

Issues on attitude have been classified as ‘outputs’ by Howie (2006) in the school effectiveness model. Some students do not pursue Physics programmes at tertiary level because of the attitude they have towards the subject, which may be rooted in their initial experiences with the subject or the teachers. The majority of the respondents strongly agreed or agreed (79.7%) (as reflected in Table 4.11, attitudes) that Physics is portrayed as belonging to a man's world. This could be one of the reasons that contribute to the few numbers of female Physics teachers. The opinions of the respondents who strongly agreed or agreed with the view that some learners have a negative attitude towards Physics (82%) and that teaching lacks prestige (63.7%), can be regarded as part of the factors contributing to the shortage of Physics teachers.

The IOP (2010:1) blamed the administrators and learners for the shortage of Physics teachers with regard to not showing some respect to them and this study refuted this claim. The majority of the respondents strongly disagreed or disagreed that there is lack of respect for teachers among the administrators (73.8%) and that there existed a lack of respect for teachers among the learners (64.9%). Thus, the Physics teachers are accorded the appropriate respect by both the learners and the administration. Murphy and Whitelegg (2006:290) argue that learners must be motivated to cultivate the right attitude towards Physics so that they could realise its significance later in life.

(vi) Professional development:

In order for learners to develop into professionals, there exists a need for varied courses at tertiary level to attract learners who complete grade 12. Moreover, there is a need for flexibility in the entry requirements at tertiary level, unlike what we have in our local institutions where it is compulsory to obtain a credit in English. In the case of this study, the majority of the respondents (as indicated in Table 4.11, professional development) strongly agreed or agreed that there are only a few Physics courses at tertiary level to attract more learners (67.3%), and that there exists a higher dropout rate in the transition from high school to college (68.1%). They also strongly agreed or agreed that there are very few training institutions for Physics teachers (85.1%), and that the entry requirements for Physics education at tertiary level are rigid (73.8%). There is a need to review the entry requirements in tertiary institutions to accommodate a wider spectrum of learners. This could be done by reviewing the policies that sanction English as a compulsory subject. At the same time, tertiary institutions should provide courses that could attract even the learners who are considered not scientifically inclined.

(vii) Opportunities:

It is should be a normal progression that after graduating, the students should be absorbed by the world of work and enjoy their profession, but this should raise a concern among policymakers if they do not stay in a particular profession for long. This is the case with a number of Physics teachers, and is confirmed by this study. The majority of the respondents strongly agreed or agreed (65.5%) (as indicated in Table 4.11, opportunities) that there are more opportunities offered by Physics compared to other subjects, such as in the industries, with their insatiable need for more people with Physics (83.3%) and other Physics-oriented career-paths (88.7%). This has been alluded to by Magagula (2010:15) and Rundquist (2009:1). It is a concern that some respondents, while they strongly agreed or agreed (25%), acknowledged the fact that some schools do not offer Physics, and this calls for policymakers to ascertain the cause of this anomaly. Nonetheless, the majority of the respondents agreed that most schools offer Physics, and that doing courses in Physics opens more opportunities in the world of work compared to other subjects.

(viii) Teacher challenges:

Each profession has its own challenges and some are unique to that profession. The majority of the respondents (as reflected in Table 4.11, teacher challenges) strongly agreed or agreed that there is insufficient learner discipline in the schools (51.2%), which could interfere with the learning of Physics. This could come in the form of learners absconding from Physics classes. Cartlidge (2001:2) pointed to the workload and working conditions as a possible reason for the shortage of Physics teachers. The majority of the respondents strongly agreed or agreed that Physics teachers are demotivated by their workload (73.8%), as noted by Barmby (2006:247). One of the reasons could be that some of the teachers are not replaced after retirement (68.3%) or being transferred to other professions, thus shifting the teaching load to those remaining, as observed by Magagula (2010:15) and the BBC

News (2008:1). There is a need for TSC to expedite processes for replacement of Physics teachers after leaving the profession, since the load is eventually carried by those who are still in the profession, thus demotivating them to continue teaching.

This section aimed at obtaining the opinions of the Physics teachers in order to gain insight into the factors contributing to their shortage in senior secondary schools. Therefore, in summation, the respondents strongly agreed or agreed that the shortage of Physics teachers is due to the lack of incentives, the lack of continuous support, the lack of subject content knowledge, the lack of motivation, negative attitudes, the lack of professional development, and the lack of opportunities and challenges faced by the Physics teachers in most senior secondary schools in Swaziland. This confirms that there are reasons for the shortage of Physics teachers in the local context, and some could be unique to Swaziland.

In the next section (Section C), the strategies were analysed to retain Physics teachers in senior secondary schools.

4.4.3 SECTION C: STRATEGIES USED TO RETAIN PHYSICS TEACHERS

This part of the questionnaire focuses on strategies that should be used to **retain** Physics teachers in senior secondary schools. The aim of this section was to address the second question, as reflected in chapter one. The following Likert-scale was employed:

1. SD = Strongly disagree
2. D = Disagree
3. A = Agree
4. SA = Strongly agree

Table 4.12: Strategies used to retain Physics teachers (n = 168)

No.	The following are the strategies that should be used to **retain** Physics teachers at school:	Mean	Std. Dev	SD 1	D 2	A 3	SA 4
1	Provide them with hardship allowances.	3.46	.629	1.8	1.8	39.9	**56.5**
	Boutelle (2010:1) argues that Physics teachers should be provided with attractive benefit packages. The majority of the respondents strongly agreed or agreed (96.4%) that the government should provide Physics teachers with hardship allowances to retain them in the teaching profession. The allowance could also vary in respect of the location of the school, with those in rural schools receiving a larger percentage, since teachers are not keen to teach at rural schools.						
2	Increase their salaries.	3.51	.724	3.0	11.9	**55.4**	29.8
	Salaries are hinged on the economic antecedent, as part of the 'inputs' in Howie's (2006) and Scheerens' (1990) models. The argument that prevails holds that teaching is not a better-paying profession. According to Beese and Liang (2010:270), Gold (2006:1), and Boutelle (2010:1), the Physics teachers' salary should be attractive. Thus, the Physics teachers' salary should be topped up as a strategy to retain them at the schools, according to the opinion of the majority of the respondents who strongly agreed or agreed (85.2%) with this view. MoET has been pondering over introducing a retention allowance for Science teachers, but without avail (Magagula, 2010:15). This demonstrates how insensitive the government is towards the shortage of Physics teachers, especially when less viable projects are sequentially initiated.						
3	Provide them with subsidised housing.	3.12	.785	3.6	20.2	**49.4**	26.8
	Housing, as encompassed in Howie's (2006) and Scheerens' (1990) models, is classified as 'infrastructure' or 'physical' in the 'inputs'. One of the benefits that the majority of Physics teachers suggest should be provided to them is subsidised housing (76.2%). The teachers, in general, who occupy						

	government houses, enjoy subsidised housing, but this is not true for the other teachers, especially for those who do not have government-subsidised housing. These are the teachers who reside with their families, not within the school compound, and who have to rent houses. The high costs of housing and transport costs cause a financial drain, thus the Physics teachers either search for alternative employment, or initiate projects to boost their salaries. These projects have a negative effect on the learners, since the teachers tend to concentrate on them, and this affects the teaching and learning processes.						
4	They should be promoted soon.	2.99	.576	.6	2.4	37.5	**59.5**
	All teachers deserve to be promoted, and one wonders what it is in this group that makes it special for their promotion to be quickened. Indeed, Physics teachers are a special group as they have been leaving the teaching profession, thus the need to find ways to retain them. A soon promotion for Physics teachers was advocated for by the majority of the respondents (97%) who suggested that, in order to retain Physics teachers, it should not take long to promote them.						
5	Prioritise their eligibility for further training.	3.56	.613	1.2	3.0	**49.4**	46.4
	Continuing professional development is essential for teachers to keep them abreast with contemporary issues in their field. This is vital for Physics teachers to embrace the changes in technology. The majority of the respondents strongly agreed or agreed that they should be given priority than the other Sciences, for further training in their field (95.8%), in order to retain them.						
6	They have to frequently attend workshops.	3.41	.605	.6	4.2	47.0	**48.2**
	Workshops, classified as 'classroom level antecedents' by Scheerens (1990), also form part of continuing professional development, which is an integral part of keeping teachers informed of developments in their subject, and improve their quality. Santiago (2002:1) contends that the quality of the teachers is an essential determinant in the learners' learning. The majority of the respondents (95.2%) alluded to this, arguing that the frequency of their						

	taking part in workshops should be increased. The University of Swaziland provides in-service training for Science teachers, but this only occurs once a year. It targets new teachers in the profession, or if there is a report from the Examinations Council that needs to be disseminated and discussed. Science panel members have argued that the university fails to adequately support Science, having established a department to in-service teachers. There is a need to raise such issues with the government, since it supports the university with funding to run its projects.						
7	They have to be engaged in Physics research projects.	3.43	.600	.6	4.2	**50.6**	44.6
	Research projects are essential to support a particular theory or to clarify concepts that cannot be easily apprehended by the learners. The projects also contribute to the body of knowledge for the subject. Thus, the majority of the respondents strongly agreed or agreed (95.2%) that Physics teachers should be engaged in research projects to increase their knowledge of the subject by means of a more practical orientation. These projects could be presented at Science exhibitions where they would be displayed for the learners to view and could inspire them to pursue Science-oriented careers, especially teaching.						
8	They must be part of Science research organisations.	3.39	.599	.6	6.0	**58.3**	35.1
	Rosengrant (2010:281) advocated that pre-service teachers should engage in research to enhance their content knowledge. When teachers engage in Science research activities, they feel they are part of the community of practice for the subject (Woolhouse & Cochrane, 2010:607). They can share their projects in these organisations with invaluable feedback from colleagues. In line with this, the majority of the respondents strongly agreed or agreed (93.4%) that Physics teachers must belong to Science research organisations as a strategy to keep them in the schools. Schools are also a forum where they can share their findings and inspire the learners to engage in research projects.						
9	Payment for teachers' membership	3.28	.546	.6	1.2	34.5	**63.7**

	in Science associations by the schools.						
	It is really discouraging for teachers to pay for themselves in order to become members of organisations that benefit their schools. As a member of a number of these organisations, it pains one to see the teachers forking out their own money to subscribe to these organisations or to attend workshops, even though the school also benefits from the information that the teacher acquires. This has greatly affected the operations of subject associations and panels. It is in view of this that the majority of the respondents strongly agreed or agreed (98.2%) that the membership fees of Physics teachers to belong to Science associations should be paid by the schools as a strategy to keep them in the schools.						
10	Encourage and financially assist them to enrol for further training on a part-time basis	3.61	.815	7.1	12.5	**55.4**	25.0
	Further training constitutes continuing professional development for Physics teachers. However, the teaching profession does not offer development and improvement opportunities (Güzel, 2011:1050). Central to their professional development is motivation and financial support that the government should provide to Physics teachers. The majority of the teachers who further their training in various institutions pay for themselves. Some of these teachers do programmes that are relevant to their fields, with no incentive from the government. Thus, the government, according to the opinion of the majority of the respondents who strongly agreed or agreed (80.4%), promised to encourage and financially assist Physics teachers to enrol, on a part-time basis, for further training to keep them in the schools (Government of Swaziland, 2011:41). In this way, the teachers will continue to teach while upgrading their qualifications.						
11	Train non-specialists in Physics by means of evening or weekend classes.	2.98	.830	7.1	9.5	**52.4**	31.0
	Rundquist (2009:1) suggests that teachers with other majors in Science						

	should be recruited and trained during evening classes. Due to the shortage of Physics teachers and very few teacher training institutions, it is essential to find other alternatives. The results indicated that there are teachers who teach Physics having done other subjects like Biology, Chemistry and Agriculture. These teachers could undergo in-service training during the evenings or weekends, as advocated for by the majority of the respondents (83.4%) in this study. The training centres should be established nearer to their work for easier access, and with no expense on the part of the teacher.						
12	Introduce direct entry into Science education at tertiary level.	3.07	.519	0	1.2	**55.4**	43.5
	The initiative by UNISWA of admitting students with no education background at diploma level to the B.Ed. Science programme has not addressed the shortage of Physics teachers, since over the years few students have enrolled and graduated from this programme. The few numbers are probably due to the fact that they are aware that there are no benefits in the teaching profession. The researcher has noted that education students are frustrated by the content since they have to do all the courses done in the Science courses as well as the education courses. Therefore, this becomes a burden to them. Apparently, the best option could be the introduction of Science courses in the Department of Education which has been advocated for in vain by educationists at the university. Another option could be the reduction of the study period for diploma holders who intend to upgrade to the B.Ed. programme (Government of Swaziland, 2011:41). The majority of the respondents strongly agreed or agreed (98.9%) that direct entry must be introduced into Science education at tertiary level to keep them in the schools, but the researcher argued, with the option of transferring the courses to the Education Department.						
13	Introduce teacher outreach programmes in order for them to share experiences and challenges.	3.42	.520	0	1.2	40.5	**58.3**
	Heneveld and Craig (1996) classify these teacher development programmes as ‘supportive inputs’. Having been trained during weekend and evening						

	classes, the teachers can visit other teachers in different regions where they can share their experiences in the subject. The best point of entry are subject clusters which are already in existence in the various regions, but are not fully utilised due to financial challenges for the teachers. In fact, the government should capitalise on the clusters when aiming to provide assistance to the teachers. In line with this observation, the majority of the respondents strongly agreed or agreed (98.8%) that there is a need for the government to introduce teacher outreach programmes for Science teachers to share experiences and challenges with other colleagues, the Inspectorate and INSET officers to keep them in the schools. This would enable the Science teachers to collectively find solutions to their challenges as practitioners.						
14	Collaboration between the university and the schools on Science-teacher promoting projects or initiatives.	3.57	.557	.6	1.2	48.8	**49.4**
	As mentioned before (section 2.2.2.5), namely, that the university provides in-service training to the teachers, however, the training is inadequate. Thus, there is a need for close cooperation between the schools and the university on teacher development initiatives. It is evident in the researcher's interaction with the UNISWA and the schools that the local university works in isolation and hardly visits the schools to obtain feedback on the impact of its programmes. Therefore, there is a need for UNISWA to establish a working relationship with schools as the majority of the respondents strongly agreed or agreed (98.2%) that collaboration between the university and the schools on Science-teacher promoting projects or initiatives should be established to keep Physics teachers in the schools.						
15	Introduce salary increases for professional development.	3.47	.659	.6	13.7	**56.5**	29.2
	The researcher has alluded to the fact that the teachers have to pay for themselves when furthering their training and attending workshops, even though it is the school that benefits from these endeavours. It is, thus, essential that the government shoulders the costs of these activities if it aims						

	to retain Physics teachers in schools. Moreover, the government should establish clear policies on teacher development initiatives. Normally it is the Ministry of Education and Training that selects teachers for further training, using a criterion that the researcher feels is unfair to Physics teachers. Those eligible for training are selected, using an inconsistent formula based on years of experience, but not essential subjects through increasing the number of years if more teachers applied for further training. Teachers who insist on going for training forfeit some benefits enjoyed by those who are at tertiary level. It is for this reason that the majority of the respondents strongly agreed or agreed (85.7%) that Physics teachers' professional development must be paid-for to keep them in the schools.						
16	Tertiary institutions must monitor the graduates in the field.	3.60	.590	.6	3.6	**51.8**	44.0
	The researcher has mentioned that the university does not engage itself in studies to ascertain the impact of its programmes, and how the graduates fare in the teaching profession. Monitoring of graduates in the teaching profession would enable UNISWA to develop relevant and effective programmes. Moreover, the programmes should be relevant to the needs of the society. The majority of the respondents strongly agreed or greed (95.8%) that tertiary institutions must monitor the graduates in the teaching profession, in particular Physics teachers, to retain them in the schools.						

In summary, the respondents strongly agreed that Physics teachers must be provided with hardship allowances, it should not take long to promote Physics teachers, they must frequently attend workshops, their membership fees of associations must be paid for by the schools, teacher outreach programmes must be introduced to share experiences and challenges, and the universities and schools must work together on Science-teacher promoting projects or initiatives in order to retain the Physics teachers in senior secondary schools in Swaziland.

The Physics teachers also agreed that Physics teachers' salaries should be revised, they should be provided with subsidised housing, their eligibility for further training must be prioritised, they must be engaged in Physics research projects, they must be part of Science research organisations, they must be encouraged and financially assisted to enrol, on a part-time basis, for further training, non-specialists in Physics should be trained through evening or weekend classes, their professional development must be paid-for by government, and tertiary institutions must monitor graduates in the schools for the retention of the Physics teachers at the schools. The above factors are essential for the retention of the Physics teachers, as observed by the majority of the respondents in this study.

In the next section (Section D), strategies were analysed to increase the number of Physics teachers in senior secondary schools.

4.4.4 SECTION D: STRATEGIES USED TO INCREASE THE NUMBER OF PHYSICS TEACHERS

This part of the questionnaire focuses on strategies that could be used to increase the number of Physics teachers. This section was meant to address the second research question as reflected in chapter 1. The following Likert scale was employed:

1. SD = Strong disagree
2. D = Disagree
3. A = Agree
4. SA = Strongly agree

Table 4.13: Strategies used to increase the number of Physics teachers (n = 168)

No.	The following are the strategies that could be used to **increase** the number of Physics teachers:	**Mean**	**Std. Dev.**	**SD 1**	**D 2**	**A 3**	**SA 4**
1	Encourage girls to enrol in Physics	3.21	.510	0	.5	43.5	**56.0**

	courses						
	The researcher noted that more girls than boys do Physics at senior secondary level, but at tertiary level there are only a few (or none at all, in some years) girls doing Physics. According to Politis *et al.* (2007:42), there is reluctance among girls to enrol for Physics. It is due to this observation that there is a need for strategies at tertiary level to motivate them so that more girls could enrol for the Physics courses. Thus, the majority of the respondents in this study strongly agreed or agreed (99.5%) that girls should be encouraged to enrol in Physics courses with the aim of increasing the number of Physics teachers.						
2	Provide incentives for the learners who aspire to be Physics teachers	3.55	.737	1.8	14.9	**48.8**	34.5
	Incentives, such as reinforcement, constitute 'process' in Scheerens' (1990) model and 'school climate' in the Heneveld and Craig (1996) model. Recruitment for Physics teachers should start at the school level by providing incentives to learners who aspire to be Physics teachers, as alluded to by the majority of the respondents in this study who strongly agreed or agreed (83.3%) with this view. This could, for example, come in the form of projects with the provision of funding for those who excel in Physics. The Swaziland Education and Training Policy (2011:41) indicated that the government is planning to engage in research to evaluate the incentive schemes for Science teachers in other countries. Studying other countries' schemes will not solve the current challenge in Swaziland if the government does not know its own challenges. Thus, this study will provide some invaluable information to the government.						
3	Review the teaching strategies at high school and tertiary institutions.	3.16	.579	0	4.8	**51.2**	44.0
	Teaching strategies are a component of 'processes' in Howie's (2006) model. Teaching in most schools is examination-driven. The teachers rush through the content to cover most of what is in the syllabus without considering how much the learners assimilate. This is against the principles of meaningful learning. Such examination-driven teaching is, in most cases, promoted by the fact that a school is recognised by the number of A's, B's, or simply by the number of credits it produces in the school-leaving examination. In order to finish the syllabus on time, the teachers						

	opt for the lecture-method which is common in tertiary institutions. This deprives the learners from the opportunity to design and reflect on their own learning. Therefore, there is a need for the revision of teacher education and instructor curricula to align with competency-based education (Government of Swaziland, 2011:43). Thus, the majority of the respondents strongly agreed or agreed (95.2%) with the idea that teaching strategies at high school and tertiary institutions be reviewed to avoid examination-driven teaching.						
4	Involve learners in Physics-oriented educational trips.	3.39	.802	7.2	39.2	**41.0**	12.7
	The more the learners participate in Physics-oriented activities, the more likely they would enjoy or appreciate the subject. The majority of the respondents strongly agreed or agreed (53.7%) to the involvement of learners in Physics-oriented educational trips, in order to increase the number of Physics teachers. On these trips it is anticipated that they will appreciate what Physicists have accomplished. Once there are more Physics specialists, then the industry will have enough Physicists and some will then be accommodated in the teaching profession, since it has been observed that their first preference is high-paying professions offered by the industry.						
5	Review the entry requirements for learners who intend to major in Physics at tertiary institutions.	2.59	.704	1.8	17.9	**56.0**	24.4
	The entry requirements in tertiary institutions are very rigid. In the case of the local university, someone who has not passed with a credit in English is denied entry to the institution. As a result, learners who are good at Physics are frustrated by this situation. The researcher would like to argue that a pass in English, which is the medium of instruction, would suffice for learners who intend studying Physics courses. The university could possibly offer English lessons in the programme in which they feel the students should have a credit, provided they have passed Physics. Since nothing is currently in place to cater for this, therefore the majority of the respondents strongly agreed or agreed (80.4%) that tertiary institutions need to review the entry requirements for learners who intend to major in Physics.						
6	Increase the number of colleges that offer Physics.	3.03	.658	.6	23.2	**58.3**	17.9

	In the case of Swaziland, there are only two institutions that offer Physics courses, but there is only one for the senior secondary level, with limited admissions. This really paints a gloomy picture for the subject. This is the reason why the majority of the respondents strongly agreed or agreed (76.2%) that colleges that offer Physics, with a focus on Science education, should be increased to increase the number of Physics teachers. The government could also upgrade the programmes offered by the local college that currently offers diploma programmes to degree programmes.						
7	Expect from Physics lecturers to teach high school Physics.	2.99	.551	.6	3.6	**64.7**	31.1
	In their spare time Physics lecturers could assist in the teaching of Physics at schools. The researcher believes that it could be more inspiring to the learners to be taught by doctors and professors, and thus they may wish to be like them in the future. The education system is too regimented, namely that it does not permit the sharing of ideas among professionals. Moreover, most of these professionals believe that their profession is better than other professions. If tertiary institutions could heed to the opinion of the majority of respondents (requesting Physics lecturers to teach high school Physics), who strongly agreed or agreed (95.8%) in this study, then the number of Physicists would increase in schools.						
8	Incorporate Physics education in all the years of training at tertiary level in the Bachelor of Science programme.	3.26	.579	0	5.4	**54.8**	39.9
	The incorporation of science education in the four years of teacher training was proposed by Volkmann (2011:1), but in local institutions this is not the case, especially in the B.Sc. programme. The opportunity to do education courses at certificate level is only offered to graduates at tertiary level who have decided to join the teaching profession. This was not the case during the '80's. The education courses were integrated in all the years of training in the B.Sc. programme, hence graduates were offered a concurrent diploma in education. The researcher would like to advocate for the re-introduction of these courses, since the graduates would not re-apply to the institution for another year. Also, there is no need for extra classrooms to accommodate them, since currently the number of those who enrol for the post-graduate certificate is limited by these resources. It is due to this observation that the						

	majority of the respondents strongly agreed or agreed (94.7%) to the incorporation of Physics education in all the years of training at tertiary level in the Bachelor of Science programme, in order to increase the number of Physics teachers at the schools.						
9	Encourage chemists and biologists to study Physics.	3.35	.572	.6	3.0	**56.5**	39.9
	The study has shown that there are teachers who are Chemistry and Biology specialists who teach Physics, which undermines the subject. These specialists are assigned by school administrators to teach the subject due to the persistent shortage of Physics teachers. The administrators base their argument on the fact that some of them have at least done Physics in the first year in the B.Sc. programme. Others base their argument on the fact that they are teachers, have done Physics in grade 12, and thus can handle most of the subjects, irrespective of their qualification. This is a fallacy, since a teacher must have sufficient knowledge of the subject content to be confident to share the concepts imbedded in the subject. Thus, it is essential that Chemistry and Biology teachers are trained in the subject content, as the majority of the respondents strongly agreed or agreed (96.4%) that chemists and biologists be encouraged to study Physics to handle the subject's concepts.						
10	Increase the number of periods accorded to Physics at high school.	3.36	.606	.6	4.2	46.4	**48.8**
	Rosengrant (2010:281) argues that, due to insufficient time, the curriculum at tertiary level cannot accommodate other activities. Similarly, at senior secondary level, there is no extra time on the timetable to be allocated to more Physics lessons, since each subject has a specified number of periods within the eight hours allocated for teaching (Marope, 2010:38). Some subjects (e.g. English) are unnecessarily allocated a lot of periods, because a learner cannot proceed without passing them. Thus, it would be impossible to allocate more periods to Physics. However, the researcher would like to suggest some solutions to this challenge, that a learner should not be constrained to proceed to the next level if she/he fails English, as well as reduction in the number of periods allocated for subjects like English. This would give the learners more time to learn Physics concepts and engage in Physics experiments. It is in this regard that the majority of the respondents strongly agreed or						

	agreed (95.2%) to the increase of the number of periods accorded to Physics at high school.						
11	Provide training during holidays, with incentives or credits.	3.43	.437	0	.6	22.0	**77.4**
	As mentioned before, within continuing professional development, training is essential to keep the individual abreast with contemporary issues in the subject. This training should be coupled with incentives or credits to spur on the Physics teachers to remain in the profession. The government of Swaziland plans to create incentives for experienced Science teachers holding diplomas in education (Government of Swaziland, 2011:41). Incentives could also be meant to attract more learners who intend to be Physics teachers. Moreover, these incentives should be provided to the teaching profession with the emphasis on Physics courses. Alluding to this statement, the respondents strongly agreed or agreed (99.4%) to the provision of training on holidays, with incentives or credits to keep Physics teachers at the schools, as well as to attract more graduates to join the profession.						
12	Provide incentive packages for undergraduates to consider teaching Physics.	3.77	.501	0	1.2	32.1	**66.7**
	The majority of learners start to be aware of what they want later in life at senior secondary level. The senior secondary level is the stage where learners can be encouraged to choose Physics teaching so that when they enrol for tertiary education they already know what they will benefit from this profession. At the tertiary level, those who opt for Physics teaching could be provided with incentives as observed in the opinion of the majority of respondents who strongly agreed or agreed (98.8%) that undergraduates should be provided with incentive packages to consider Physics teaching. Subsequently, these incentives would attract more learners to Physics teaching, thus increasing the number of Physics teachers.						
13	Establish a Physics education research faculty.	3.65	.579	.6	2.4	45.8	**51.2**
	The researcher has, as a member of research organisations, observed that there is dearth of research for lecturers on pertinent educational issues in local tertiary institutions. Those who engage in research have to incur the costs and that is quite						

	demotivating, especially when the institution would benefit from the findings. Nonetheless, the majority of the respondents (97%) suggested that education research faculties should be established at tertiary institutions to investigate into issues pertaining to Physics and Physics teaching. The begging question is: namely "If there is reluctance among the lecturers, then who will establish and manage these research faculties, especially when there are no benefits and lack of support from government?"						
14	Companies should make funds available for prospective Physics teachers.	3.48	.434	0	0	**75.0**	25.0
	In a couple of years back, there were instances where a number of companies would sponsor students in specific Science courses, and the names of successful candidates were published in the media. But, currently one hardly hears of sponsorship benefits for students who have enrolled at tertiary institutions. Nowadays most of the sponsors support non-academically inclined activities like sports, in which the sponsors benefit by gaining public recognition and support through adverts. There is a need for companies to sponsor students since they benefit when investing in education. Provision of funds by companies was supported by all the respondents who strongly agreed or agreed (100%) that companies should make funds available for prospective Physics teachers to increase their numbers in the schools.						
15	Provide scholarships and awards to encourage learners to pursue Physics education.	3.25	.579	0	1.4	**57.8**	39.9
	Scholarships are awarded by the government to learners who aim to further their education at tertiary level, but this is done on a merit-basis within a stiff competitive environment. Unfortunately, the inadequacy of scholarships side-lines capable students who have an interest in pursuing science-oriented careers. Moreover, these scholarships are inadequate to cater for the majority students who aim to enrol at tertiary level. It was once proposed that financial institutions should also support tertiary education, but it would come at a cost for students due to interests that would charged for the loans by the financial institutions. However, there is still a need for the government to find other means of supporting tertiary education in terms of financial support for the students. Other organisations could possibly, as the majority of						

	respondents strongly agreed or agreed (97.7%), provide scholarships and awards to encourage learners to pursue Physics education at tertiary level in order to increase the numbers of Physics teachers. This has been advocated by Woolhouse and Cochraine (2010:608), and Gold (2006:1).						
16	The government should provide more grants for further studies.	3.22	.678	0	3.0	**52.1**	44.9
	One of government's prerogatives is to support education, since it develops the nation. Currently, the government relies on donor funds to support those who want to further their studies. Notably, funds are reserved for other projects of which some hardly generate any revenue for the country. The researcher once argued in an article in one of the media houses (Times of Swaziland) that the government should revisit its priorities and focus on Health and Agriculture, and Education should get a bigger share of the budget. This could be achieved through providing more grants for those who intend to further their studies, especially in the field of Science, in accordance with the majority of the respondents who strongly agreed or agreed (97%) to the view in this study, and with the support from the Swaziland Education and Training Sector Policy (2011:42). Central to these grants should be prospective Physics teachers.						
17	Distance learning should be supported and promoted.	3.34	.672	0	1.2	**50.0**	48.8
	Tertiary institutions cannot absorb all the learners from all the schools in Swaziland, because they are few tertiary institutions. There has not been much development in the infrastructure for education in this country. Therefore, Physics teachers have to be motivated to engage in distance learning, as is also acceded to by Boutelle (2010:1). As mentioned before, the government has shifted its focus from education to other projects in the guise of millennium development projects, thus depriving education its vital place and role in the society (Simelane, 2012:27). Thus, there is a need for the government to fund educational projects. Currently, those who cannot be admitted by these institutions are enrolled in distance education programmes. It is in this way that the majority of the respondents strongly agreed or agreed (98.8%) that distance learning should be supported and promoted to increase the numbers of Physics teachers in the schools.						

18	Check the affective domain of the Physics learners.	3.65	.562	0	0	22.0	**78.0**
	Research indicates that positive learner attitudes are essential in the teaching and learning environment. A learner with a negative attitude towards a subject and a particular teacher tends to perform badly in the subject associated with the teacher. The reason is possibly that there are few specialists in the subject in the teaching profession, and it can be due to the learners' attitude towards the subject. Thus, in line with all the respondents who strongly agreed or agreed (100%) in respect of learner attitude, there is a need to check the affective domain of Physics learners in order to develop an interest in Physics. This is aimed at motivating the learners to enrol in Physics courses at tertiary level, finally benefitting the teaching profession. The learners' motivation and attitude towards Physics is reflected within 'outputs' in Howie's (2003) model, and classified as 'school climate' by Heneveld and Craig (1996) in their model. Changing both the learners' and students' attitude towards Physics could increase the number of Physicists. As argued before, an excess of Physicists in the industry is a benefit for the teaching profession, as the surplus could probably opt for the teaching profession, of course, with some in-service training to equip them with teaching skills.						

In summary, the respondents strongly agreed to the increase of periods accorded to Physics at high school, the provision of training during holidays together with incentives or credits, provision of incentive packages for undergraduates to consider Physics teaching, the establishment of a Physics education research faculty, and the checking of the affective domain for Physics learners in order for them to develop an interest in Physics to increase the number of Physics teachers.

The respondents also agreed to the encouragement of girls to enrol in Physics courses, the provision of incentives for learners who aspire to be Physics teachers, a review of the teaching strategies at high school and tertiary institutions, the involvement of learners in Physics-oriented educational trips, a review of the entry requirements for learners who intend to major in Physics at tertiary level, an increase in the number of colleges that offer Physics, a request for Physics lecturers to teach high school Physics, the incorporation of Physics education in all the years of training at tertiary level in the Bachelor of Science programme, the encouragement of chemists and biologists to study Physics, the funding of prospective Physics teacher by companies, the provision of scholarships and awards to encourage learners to pursue Physics education, the provision of more grants by the government for further studies, and the support and promotion of distance learning in order to increase the number of Physics teachers in senior secondary schools in Swaziland. The findings in this study on how to increase the numbers of Physics teachers are in agreement with the reasons reflected in the literature review.

In the next section, a discussion is given of the inferential statistics that were computed on the strategies that were analysed to increase the number of Physics teachers in senior secondary schools.

4.4.5 INFERENTIAL STATISTICAL ANALYSIS OF DATA

This section presents a couple of tables, namely on the mean scores and standard deviations of the responses of the Physics teachers in the three sections (sections B, C and D) of the questionnaire (Table 4.14), a paired sample test for the sections (Table 4.15), Pearson's correlations on the three dimensions (Table 4.16), an exploratory factor analysis of the strategies to retain Physics teachers (Table 4.17), and an exploratory factor analysis of the strategies to increase the number of Physics teachers (Table 4.18).

The section that follows presents the mean scores and standard deviations of male and female Physics teachers who responded to the questionnaire.

4.4.5.1 Measuring how statistically significant is the difference between the mean scores and standard deviations of male and female Physics teachers

The mean scores and statistical significance between the opinions of the male and female Physics teachers were computed. In chapter one, three hypotheses were advanced and in this chapter they were tested in order to successfully carry out the objectives of this study. The data relating to the first three hypotheses were not discussed in isolation since they all focused on the opinions of Physics teachers. These hypotheses were as follows:

HYPOTHESIS 1

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the shortage of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the shortage of Physics teachers in Swaziland.

HYPOTHESIS 2

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the retention of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the retention of Physics teachers in Swaziland.

HYPOTHESIS 3

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the increase in the number of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the increase in the number of Physics teachers in Swaziland.

Table 4.14 presents a comparison of the mean scores of both the male and the female respondents. Thus, it contains the sum of the scores from sections B, C and D, the number of male and female respondents, and the mean scores of male and the female respondents, as well as the standard deviation for each gender. The contents of Table 4.15 have been developed from Table 4.14 by providing the mean differences which contribute to the formulation of the significance value (2-tailed).

Table 4.14: Mean scores and standard deviations for Physics teachers (n = 168)

Questionnaire sections	Gender	N	Mean	Std. Deviation
Sum of scores for Section B: Factors that influence the shortage of Physics teachers	Male	132	99.818	8.982
	Female	36	100.861	9.280
Sum of scores for Section C: Strategies used to retain Physics teachers	Male	132	53.530	4.945
	Female	36	53.056	4.208
Sum of scores for Section D: Strategies to increase the number of Physics teachers	Male	132	59.515	4.668
	Female	36	58.778	4.176

The information in Table 4.14 reflects the mean scores and standard deviations of both the male and female respondents in the three sections (sections B, C, and D) of the questionnaire. The statistics show that for the section on strategies to retain Physics teachers (section C), the male respondents (mean = 53.530; SD = 4.944) scored slightly higher than the female respondents (mean = 53.056; SD = 4.208). Also, the statistics for the section on strategies to increase the number of Physics teachers (section D), the male respondents (mean = 59.515; SD = 4.668) scored slightly higher than female respondents (mean = 58.778; SD = 4.176).

However, the statistics for the reasons for the shortage of Physics teachers (section B) indicate that the female respondents (mean = 100.861; SD = 9.280) scored slightly higher than the males (mean = 99.818; SD = 8.982). In summary, since the differences are insignificant, this means that the conceptions of the male and female respondents on the reasons for the shortage of Physics teachers, and the strategies to retain and increase the number of Physics teachers are nearly the same.

The section that follows elaborates on Table 4.15.

In order to compare the sample, a paired independent sample t-test was computed on the three dimensions regarding the shortage, retention and increase in the number of Physics teachers in senior secondary schools in Swaziland (Table 4.15). Table 4.15 comprises the sum of the scores for the three sections (sections B, C and D) of the questionnaire. This table also consists of values for standard error (variance of sample means) for generating the mean difference, (the mean difference generated from Table 4.14), the t-test for comparing two means that were generated by the mean difference and standard error, the degrees of freedom, Levene's test and 95% confidence interval. The t-test, mean difference and standard error dovetail to the significance (2-tailed) value which is the *p* value. The *p* value "…refers to the probability that the result is due to chance and something is deemed statistically significant if the *p* value is less than 0.05" (Wagner, 2013:93). Equal variances are meant to indicate if the variances between the two means are equal or different.

The assumption among common statistical procedures is that equality in variances exists in the populations from which samples are drawn. The variances are assessed by Levene's test. Levene's test can also be used to test for the equality of or the differences in variances in two samples of the same population. In this study, Levene's test was used to ascertain if the variances in the responses to the questionnaire by the two genders in the sample of Physics teachers were equal or different.

The variability in the conditions is more or less the same for a value of significance greater than 0.05. This means the variability in the conditions is not significantly different. The values of significance in Table 4.15 are greater than 0.05 (namely, 0.740, 0.382, and 0.464), and thus there is no variance in what the males and females stated as the reasons for the shortage, and the ways of retaining and increasing the number of Physics teachers. In other words, what the males regard as the reasons for the shortage, and the ways to increase and retain Physics teachers are the same as what the females suggested.

McMillan & Schumacher (2010:296) argue that the confidence interval is conceived of as a range of numbers, within boundaries (lower and upper boundaries) called *confidence limits*, containing the actual value of the population probability. It is common that confidence intervals can be reported at the 95 or 99 percent confidence interval. This means that the probability of the population value being between the confidence limits is 95%. It also means that the researcher is 95% certain that the confidence interval contains the true mean of the population, as reflected in Table 4.15. The 95% confidence interval reflects a significance level of 0.05.

Table 4.15: Paired sample test on the strategies to address shortage, retention and increase in the number of Physics teachers (n = 168)

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Diffe-rence	Std. Error Diffe-	Lower	Upper

								rence		
Sum of scores for B	Equal variances assumed	.110	.740	-.613	166	.541	-1.043	1.701	-4.401	2.315
	Equal variances not assumed			-.602	54.221	.550	-1.043	1.733	-4.517	2.431
Sum of scores for C	Equal variances assumed	.768	.382	.526	166	.599	.475	.902	-1.307	2.256
	Equal variances not assumed			.577	63.895	.566	.475	.822	-1.169	2.119
Sum of scores for D	Equal variances assumed	.538	.464	.858	166	.392	.737	.859	-.959	2.433
	Equal variances not assumed			.915	61.036	.364	.737	.806	-.874	2.349

Sig. $p \leq 0.05$

The results in Table 4.15 (for equal variances not assumed for section B) indicate that the mean difference = -1.043, and the standard error difference = 1.733. The results for section C indicate a mean difference of 0.475 and a standard error of 0.822. The results for section D indicate a mean difference of 0.737 and a standard error of 0.806. In conclusion, based on the results in Table 4.15 regarding the paired sample t-test, which reflect the overall scores of the Physics teachers in relation to their opinions in Sections B, C and D, the males' perceptions are not statistically significant better than those of the female Physics teachers.

In this study, the above conclusion can be conceived of as the opinions put forth by the males as the reasons for the shortage, and the ways to increase and retain Physics teachers, which are the same as what the females suggested, since the significance values (2-tailed) are greater than 0.05. As a result of this, the researcher can conclude that there is no statistically significant difference between the means for both the males and the females on the reasons for the shortage, and the ways to increase the number of Physics teachers and retain them. Thus, the H_1 hypotheses (for the three hypotheses) are rejected, because there is no statistically significant difference in the opinions of both genders of Physics teachers.

In the next section the researcher discusses the computed Pearson's Product Moment correlation coefficient on the statements for the three sections (section A, B and C) of the questionnaire.

4.4.5.2 Computed Pearson's Product Moment correlation coefficient of the three dimensions of the factors impacting on the shortage, retention and increase in the number of Physics teachers.

In Table 4.16 the Pearson's Product Moment correlation coefficient ($r > 0.001$ level) on three dimensions of the factors impacting on the shortage, retention and increase in the number of Physics teachers in schools were computed. The Pearson's Product Moment correlation, a statistically significant correlation measurement, was employed to determine whether there are statistically significant correlations between the reasons for the shortage of Physics teachers, the strategies to retain, and the strategies to increase the numbers of Physics teachers. It was simply employed to ascertain if there was a significant relationship among three sections (sections B, C and D) of the questionnaire. As reflected below, Table 4.16 comprises the sum of the scores for three sections (sections B, C and D) of the questionnaire, the values for the Pearson's correlation coefficient, the significance value (2-tailed), and the number of respondents.

Table 4.16: Pearson's Correlations on the three dimensions (n = 168)

Correlations				
		Sum of scores for B	Sum of scores for C	Sum of scores for D
Sum of scores for B	Pearson Correlation	1	.119	.088
	Sig. (2-tailed)		.125	.258
	N	168	168	168
Sum of scores for C	Pearson Correlation	.119	1	.522
	Sig. (2-tailed)	.125		.000
	N	168	168	168
Sum of scores for D	Pearson Correlation	.088	.522	1
	Sig. (2-tailed)	.258	.000	
	N	168	168	168

p = .000

Using the Pearson's Product Moment correlation coefficient, a statistically significant correlation was found on the strategies to retain (r = 0.522, *p* = 0.000), and the strategies to increase the numbers of Physics teachers (r = 0.088; *p* = 0.258). Furthermore, the strategies to increase the number of Physics teachers (r = 0.522, *p* = 0.000) correlated with the strategies to retain the Physics teachers (r = 0.088; *p* = 0.258). Thus, the dimension, strategies to retain Physics teachers is statistically significant as correlated with the strategies to increase the number of Physics teachers (r = 0.522, *p* = 0.000). Therefore, these results indicate that, for one to increase the number of Physics teachers, there is also a need to put strategies in place on how to retain them in the teaching profession.

In the section that follows the researcher discusses and presents the factor analysis on the teachers' opinions on the strategies to retain and increase the number of Physics teachers.

4.4.5.3 Factor analysis on the strategies to retain and increase the number Physics teachers

Factor analysis is a statistical process for identifying a few factors that can be used to represent relationships among sets of interconnected variables. The statements for the retention strategies for Physics teachers in table 4.17 were grouped into two variables, namely remuneration and in-service training. The purpose of this was to employ Exploratory Factor Analysis (EFA). EFA, as a method within the factor analysis, was employed to identify the fundamental relationships between the measured variables. EFA was used to find meaningful patterns in the data from the questionnaires on strategies to increase and retain Physics teachers.

EFA was applied to sixteen question statements on Section C and eighteen on D in the questionnaire regarding the strategies employed to increase and to retain Physics teachers at the school. The Kaiser-Meyer-Olkin (KMO) coefficients of sampling adequacy indicate that factor analysis is appropriate for the items in the questionnaire. A KMO-value which is greater than 0.5, indicates that the variable is significant at that level. The KMO-values relating to all the strategies employed to increase and to retain Physics teachers at the school, included in the factor analysis, are presented in Table 4.18 (KMO value scale was used: 0.90 to 1.00 = marvellous or 0.80 to 0.89 = meritorious or 0.70 to 0.79 = middling or 0.60 to 0.69 = mediocre or 0.50 to 0.59 = miserable and 0.000 to 0.49 = do not factor).

After the analysis of the responses to the questionnaires in section C, it was found that a certain group of statements could be clustered together within two variables (remuneration and in-service training). Each statement in section C was then collated with these two variables to identify the strength of the relationship as shown in Table 4.17. The factor loadings in Table 4.17 indicate a strong association between the variables and statements, most reflecting p values that are greater than 0.7 ($p > 0.7$). Table 4.17 contains the statements from section C and the two variables (remuneration and in-service training), as well as their factor loadings.

Table 4.17: Exploratory Factor Analysis on strategies to retain Physics teachers (n = 168)

	Statements	Remuneration	In-service Training
1	Provide them with hardship allowances	.970	.670
2	Top up their salaries	.881	.701
3	Provide them with subsidised housing	.887	.697
4	They should be promoted quickly	.702	.918
5	Prioritise their eligibility for further training	.803	.861
6	They must frequently attend workshops	.892	.952
7	They must be engaged in Physics research projects	.801	.931
8	They must be part of science research organisations	.700	.925
9	Payment for teachers' membership in science associations by schools	.610	.906
10	Encourage and financially assist them to enrol for further training on a part-time basis	.884	.904
11	Train non-specialists in Physics by means of evening or weekend classes	.872	.922
12	Introduce direct entry into science education at tertiary level	.704	.884
13	Introduce teacher outreach programmes to share experiences and challenges	.835	.905
14	Collaboration between university and schools on science-teacher promoting projects or initiatives	.870	.970
15	Introduce salary increases for professional development	.623	.911

16	Tertiary institutions must monitor graduates in the field	.782	.918

**KMO = p < 0.7*

The data in Table 4.17 show that the overall measuring of sampling adequacy Kaiser-Meyer-Olkin (KMO) was 0.846 and Bartlett's Test Sphericity was significant, χ^2 (N=165 = 3126.77, df =325, p< 0.881) indicating that the sample and correlation matrix were appropriate and meritorious.

Furthermore, each item in the questionnaire was factorised on two principal component factors to retain the number of Physics teachers, i.e. remuneration ranging from, namely Provide them with hardship allowance (0.970) to Tertiary institutions must monitor graduates in the field (0.782) (eleven items score above 0.7), and in-service training ranging from, namely Collaboration between university and schools on science teacher promoting projects, or initiatives to prioritise their eligibility for further training (0.861) (thirteen items score above 0.7) as computed in Table 4.17. Thus, the two factors or variables can be used to represent most of the items in section C. In other words, most of the statements on retention strategies are hinged on remuneration and in-service training for Physics teachers.

Factor analysis was also used to identify meaningful patterns in the data from the questionnaires on strategies to increase the numbers of Physics teachers (section D). After an analysis of the responses to the questionnaires, it was found that a specific group of statements can be clustered together, viz. Promoting and advocacy for the subject in schools, Partnership with higher learning institutions, and Incentives and scholarships to advance the subject. The factor loadings in Table 4.18 indicate a strong association between the variables and factors, most reflecting p values that are greater than 0.7 (p > 0.7). Table 4.18 comprises the statements from section D, and the three variables (Promoting and advocacy for the subject in schools, Partnership with higher learning institutions and Incentives and scholarships to advance the subject), as well as their factor loadings.

Table 4.18: Exploratory Factor Analysis on strategies to increase the number of Physics teachers (n = 168)

No.	Statements	Promoting and Advocacy for the subject in schools	Partnership with higher learning institutions	Incentives and scholarships to advance the subject
1	Encourage girls to enrol in Physics courses	.972	.870	.970
2	Provide incentives for learners who aspire to be Physics teachers	.881	.678	.881
3	Review teaching strategies at high school and tertiary	.887	.697	.887
4	Involve learners in Physics-oriented educational trips	.792	.708	.702
5	Review the entry requirements for learners who intend to major in Physics at tertiary institutions	.803	.861	.703
6	Increase the number of colleges that offer Physics	.702	.952	.692
7	Request Physics lecturers to teach high school Physics	.780	.925	.670
8	Incorporate Physics education in all the years of training at tertiary level in the Bachelor of Science programme	.770	.906	.780
9	Encourage Chemists and Biologists to study Physics	.884	.904	.884
10	Increase the number of	.872	.712	.772

	periods accorded to Physics at high school			
11	Provide training during holidays with incentives or credits	.704	.884	.704
12	Provide incentive packages for undergraduates to consider teaching Physics	.835	.905	.835
13	Establish Physics education research faculty	.670	.970	.870
14	Companies should fund prospective Physics teachers	.623	.911	.783
15	Provide scholarships and awards to encourage learners to pursue Physics education	.807	.517	.907
16	The government should provide more grants for further studies	.970	.670	.973
17	Distance learning should be supported and promoted	.681	.701	.881
18	Check the affective domain of Physics learners	.887	.697	.687

**KMO = p < 0.7*

Most of the items correlated with the variables to some level of correlation. Those that did not correlate with the variables could not be regarded as being part of the same factor. The data in Table 4.18 show that the overall measuring of the sampling adequacy Kaiser-Meyer-Olkin (KMO) was 0.801 and Bartlett's Test of Sphericity was significant, χ^2 (N = 165 = 3342.77, df = 311, p < 0.829), indicating that the sample and correlation matrix were appropriate and meritorious.

Furthermore, each item in the questionnaire was factorised on three principal component factors to increase the number of Physics teachers, namely Promoting and advocacy for the subject in schools, ranging from, namely Encourage girls to enrol in Physics courses (0.972), to Incorporate Physics education in all the years of training at tertiary in the Bachelor of science programme (0.770) (thirteen items score above 0.7). Partnership with higher learning institutions ranging from, namely Increase colleges that offer Physics (0.952), to Increase periods accorded to Physics at high school (0.715) (eleven items), and Incentives and scholarships to advance the subject ranging from, namely The government should provide more grants for further studies (0.973), to Increase periods accorded to Physics at high school (0.772) (thirteen items score above 0.7) as computed in Table 4.18. Thus, most of the factors could be adequately represented by the three variables. This means that the statements can be explained by the promoting and advocacy for the subject in schools, the partnership with higher learning institutions, and incentives and scholarships to advance the subject, as essential elements for the increase of the numbers of Physics teachers at school.

4.5 SUMMARY

The thrust of this chapter was to ascertain, through eliciting opinions by means of a questionnaire, from Physics teachers, the reasons for the Physics teacher shortage, how they could be retained, and their numbers increased in senior secondary schools in Swaziland. The findings revealed that the majority of Physics teachers are Swazi males. Also, the majority of Physics teachers are qualified teachers in general, with a reasonable teaching experience, and experience teaching the subject. The majority hold a Bachelor’s degree as an academic qualification, as well as a post-graduate certificate in education. Most of the teachers are qualified to teach Physics, but the number of those without a relevant qualification to teach the subject is quite high.

In response to the reasons for their shortage, the teachers cited a lack of incentives, support from policy level, and motivation. Other reasons are the negative attitude of the learners towards the subject, the lack of professional development and Physics-promoting opportunities, and teacher challenges to Physics teaching at school level.

Central to strategies to retain the teachers were incentives, professional development, a review of entry requirements at tertiary level, and the monitoring of graduates in the teaching profession to ascertain their challenges. Some of the strategies they suggested could be used to increase the number of Physics teachers are, namely encourage more girls to enrol in Physics courses, the provision of incentives to learners who aspire to be Physics teachers, involving the learners in Physics-oriented activities, the incorporation of Physics education in all the years of training at tertiary level in the BSc programme, encouraging biologists and chemists to study Physics through in-service training, the provision of support from the government and other organisations for aspiring Physicists, and the checking of the affective domain of learners for the subject.

The opinions of both the male and female respondents on strategies to retain and increase the number of Physics teachers when compared, after subjecting them to some statistical analysis, were to a larger extent, found to be similar. Most of the opinions of the teachers pointed to remuneration and in-service training as strategies for their retention in schools. They also regarded the promoting and advocacy for the subject in schools, partnership with higher learning institutions, and incentives and scholarships to advance the subject, as strategies to increase their numbers at school.

In the next chapter the researcher presents a summary and the conclusions drawn from the analysed and interpreted data. Furthermore, the limitations and recommendations from this study are highlighted.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

In the previous chapter the data were presented, analysed and interpreted, based on the questionnaire that was completed by Physics teachers in senior secondary schools. The factors in the questionnaire were subjected to statistical analysis through the calculation of, for example, means, standard deviation and t-test. The thrust of the analysis was to ascertain the extent to which the respondents agreed or disagreed with factors associated with the shortage of Physics teachers, how they can be retained and their number increased. Moreover, the analysis demonstrated the extent to which both male and female respondents perceive these factors, i.e., if these perceptions are the same or different for both genders.

In this chapter the findings and interpretations are summarised in order to draw conclusions and to provide recommendations that could be used as guidelines for those engaged in teacher development programmes. First of all a summary is given of the literature review, followed by a summary of the empirical findings.

5.2 SUMMARY OF THE EMPIRICAL FINDINGS

Descriptive statistics was used to analyse the data. Different statistical techniques (section 1.7.8) were used in the analysis of the data. A total of 168 (91.3%) questionnaires out of 184 were received from the sample of Physics teachers. The t-test was computed to compare the means for the strategies to retain and increase the number of Physics teachers. The mean standard deviation, Pearson's Product Moment Correlation Coefficient, was applied to factors in sections B, C and D.

5.2.1 Biographical data

The majority of the teachers who responded to the questionnaire were male teachers (79%), and 21% were female. This indicates that Physics is a male-dominated subject, as observed by Politis *et al.* (2007:42). The majority of the respondents were Swazi (85%), and the rest (15%) were non-Swazi, which addresses government's wish for localisation of teaching posts. Most of the respondents (80.4%) possessed a Bachelor's degree as the highest academic qualification, and are thus qualified to teach at senior secondary level. Due to the shortage of specialist Physics teachers at senior secondary level, diploma-holders are occasionally (13%) assigned to teach at this level, although they are not qualified for it. The majority of the respondents (33.3%), compared to the other professional qualifications, possessed a post-graduate Certificate in Education, and this means they are qualified teachers, in general. The respondents with relevant qualifications (44.6%) majored in Mathematics and Physics, and are qualified to teach at senior secondary level.

Only 25.5% of the respondents had their teaching experience in general lying between 0-5 years and they are a majority in this category. They cannot be regarded as experienced in teaching Physics. In general, the data indicated that the majority of the teachers (74.5%) have an overall experience of 10 years and more, and have the required teaching experience. This does not mean that the accumulated experience is in respect of teaching Physics. Respondents who had taught Physics within the range of 0-5 years constituted 41.6% in the category of experience teaching Physics at senior secondary school. The respondents with 10 years or more experience (58.4%) have sufficient experience in Physics teaching. The majority of the respondents (36.3%) studied Physics up to the 4th year at tertiary level and have sufficient Physics content knowledge. The number of those who did Physics up to Year 1 (33.9%) is quite high and a concern, since they do not have sufficient content knowledge to teach at this level. Most of the respondents (67.1%) who studied towards a secondary Science education degree at tertiary institutions are relevant for the senior secondary level. This means Physics is taught mostly by qualified teachers.

5.2.2 Factors that influence the shortage of Physics teachers

The factors that influence the shortage of Physics teachers that were identified by the respondents were:

- lack of incentives (96.4%) and unattractive salaries (89.9%);
- lack of recruitment policy/strategy (85.2%), retention policy/strategy (89.3%) and teaching resources (57.6%);
- Physics requires a strong mathematical background (89.2%) and Physics has more abstract concepts (60.2%);
- few Physics role-models (85.1%) and demoralising initial Physics experiences (57.5%);
- Physics is portrayed as a subject that belongs to males (79.7%), the subject also lacks prestige (63.7%) and learners have negative attitude towards Physics (82%);
- few courses at tertiary to attract more learners (67.3%), the drop-out rate in transition from high school to college is high (68.1%), few training institutions for Physics teachers (85.1%) and rigid entry requirements for Physics education at tertiary level (73.8%);
- Physics has more opportunities than other subjects (65.5%); industries need more people with Physics content knowledge (83.3%); inequality in access to opportunities in Physics education (51.2%) and availability of other lucrative career paths than teaching that attract Physics teachers (88.7%);
- inadequate learner discipline at school (51.2%), retirement of Physics teachers without being replaced (68.3%) and the workload is too much for Physics teachers (73.8%).

It can be concluded that the shortage of Physics teachers in all the senior secondary schools in Swaziland is due to lack of incentives and support within the school, the subject content has more abstract concepts and requires a strong mathematical background. There is also lack of motivation due to demoralising initial Physics experiences as well as lack of Physics role models. The respondents noted that learners have a negative attitude towards Physics and there were few opportunities for those who intend to join the profession. A major in Physics opens more job opportunities in industries and the challenges that Physics teachers face in the teaching professional make them to join other professions.

5.2.3 Strategies used to retain Physics teachers

The strategies that should be used to retain Physics teachers are *inter alia*, the provision of hardship allowances (96.4%), an increase in their salaries (85.2%), they should be provided with subsidised housing (76.2%), their promotion should not be delayed (97%), their eligibility for further training should be prioritised (95.8%), they have to attend workshops frequently (95.2%), their membership fees for Science teachers' associations must be paid for by the schools (63.7%), teacher outreach programmes must be introduced in order to share their experiences and challenges (98.8%), and universities and schools must collaborate in respect of Science-teacher promoting projects or initiatives (98.2%), their salary should be adjusted to promote professional development (85.7%), their eligibility for further training must be prioritised, they must be engaged in Physics research projects (93.4%), they must be encouraged and financially assisted to enrol, on a part-time basis, for further training (80.4%), non-specialists in Physics should be trained during evening or weekend classes (83.4%), paid-for professional development in associations (98.2%) must be introduced, and tertiary institutions must monitor graduates in the teaching profession (95.8%) or provide support for the retention of Physics teachers in schools.

5.2.4 Strategies that could be used to increase the number of Physics teachers

The strategies that should be used to increase the number of Physics teachers were the following, namely increase the number of periods accorded to Physics at high school (95.2%), provide training during the holidays with incentives or credits (99.4%0, as well as incentive packages for undergraduates to consider teaching Physics (98.8%), establish a Physics education research faculty (97%), check the affective domain of Physics learners (100%), encourage girls to enrol in Physics courses (99.5%), provide incentives for learners who aspire to be Physics teachers

(83.3%), review the teaching strategies at high school and tertiary level (95.2%), involve the learners in Physics-oriented educational trips (53.7%), review the entry requirements for learners who intend to major in Physics at tertiary level (80.4%), increase the number of colleges that offer Physics as a subject (76.2%), expect from Physics lecturers to teach high school Physics (95.8%), incorporate Physics education in all the years of training at tertiary level in the Bachelor of Science programme (94.7%), encourage chemists and biologists to study Physics (96.4%), encourage funding by companies for prospective Physics teachers (100%), provide scholarships and awards to encourage learners to pursue Physics education (97.7%), provide more grants for further studies (97%), and support and promote distance learning (98.8%).

5.3 RESEARCH CONCLUSIONS

This section summarises the research findings in conjunction with each research question for the study, as stipulated in chapter 1. The findings that scored high (ranging from 'agree' to 'strongly agree') in the Likert-scale are indicated, since they embody the views of the majority of the respondents.

The first question, as reflected in Chapter 1 (section 1.3), was phrased thus: "What are educationists' opinions on the reasons for the shortage of specialist Physics teachers in senior secondary schools in Swaziland?" This question was aimed at ascertaining the factors that contribute to the shortage of Physics teachers in senior secondary schools in Swaziland. The factors that mainly contribute to the shortage, as unravelled in the study, were:

The lack of incentives, and moreover, the remuneration is not attractive; government does not have a recruitment and retention policy or strategy for Physics teachers, as well as teaching resources; Physics requires a strong mathematics background and has more abstract concepts than the other sciences; there are few Physics role-models; the initial Physics experiences are demoralising; Physics is portrayed as a 'man's world'; the learners have a negative attitude towards Physics; teaching lacks prestige; a qualification in Physics opens more opportunities, e.g., in industries; there is a lack of opportunities for professional development; the teachers are faced with a number of challenges, e.g. insufficient learner discipline, and are overloaded, as they are not replaced after retirement.

The second research question (Chapter 1, section 1.3) was indicated as, "What are the educationists' views on how the number of specialist Physics teachers in schools can be retained, and also increased?" This question was aimed at extricating the strategies that should be used to retain and increase the number of Physics teachers. The strategies for retaining Physics teachers emanating from the study were:

Provide the Physics teachers with hardship allowances and subsidised housing; increase their salaries, and introduce professional development that is paid for by government; it should not take long to promote them; prioritise their eligibility for further training; they must take part in workshops and belong to Science research organisations, and their membership fees should be paid by the schools; they must be engaged in Physics research projects; they must be financially assisted to enrol, on a part-time basis, for further training; non-Physics specialists must be trained during evening and weekend classes; introduce direct entry into Science education at tertiary level; introduce teacher-outreach programmes for them to share their experiences and challenges with others; there should be collaboration between the university and the schools on Science-teacher promoting projects or initiatives; and tertiary institutions must monitor graduates in the teaching profession.

The other aspect of the second research question (Chapter 1, section 1.3) dealt with ascertaining strategies that could be used to increase the number of Physics teachers. The opinions that were elicited by the study were as follows:

Encourage girls to enrol for Physics courses; provide incentives for learners who aspire to be Physics teachers; review teaching strategies at high school and tertiary level; involve learners in Physics-oriented educational trips; review the entry requirements for learners who intend to major in Physics at tertiary level; increase the number of colleges that offer Physics as a subject; request Physics lecturers to teach high school Physics; incorporate Physics education in all the years of training at tertiary level in the Bachelor of Science programme; encourage chemists and biologists to study Physics; increase the number of periods accorded to Physics at senior secondary level; provide training during holidays, with incentives or credits; provide incentive packages for undergraduates to consider teaching Physics; establish a Physics education research faculty; companies should be encouraged to finance prospective Physics teachers; provide scholarships and awards to encourage learners to pursue Physics education; the government should provide more scholarships or grants for further studies; distance learning should be supported and promoted; and the affective domain of learners for the subject should be checked.

Moreover, the study also addressed the following hypotheses and their alternative hypotheses, as reflected in Chapter 1 (section 1.3):

HYPOTHESIS 1

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the shortage of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the shortage of Physics teachers in Swaziland.

HYPOTHESIS 2

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the retention of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the retention of Physics teachers in Swaziland.

HYPOTHESIS 3

H_o : There is no statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the increase in the number of Physics teachers in Swaziland.

H_1 : There is a statistically significant difference between the opinions of male versus female Physics teachers on the reasons for the increase in the number of Physics teachers in Swaziland.

In accordance with these hypotheses, the quantitative analysis showed no significant difference between the opinions on gender basis. The mean and standard deviation for strategies to retain Physics teachers for male respondents (mean = 53.530; SD = 4.994) is slightly higher than the females' (mean = 53.056; SD = 4.208). In the same vein the mean and standard deviation for strategies to increase the number of Physics teachers for males (mean = 59.515; SD = 4.668) is slightly higher than the females' (mean = 58.778; SD = 4.176). On the contrary, for reasons influencing the shortage of Physics teachers female respondents (mean = 100.861; SD = 9.280) scored slightly higher than males (mean = 99.818; SD = 8.982). This means that the reasons presented by the males as reasons for the shortage, and the ways to increase the number of Physics teachers and retain them were the same as those suggested by the female respondents.

The congruence of opinions for both genders for reasons for Physics teachers' shortage (mean difference = -1.043, standard error = 1.733), strategies to retain (mean difference = 0.475, standard error = 0.822) and increase their numbers (mean difference = 0.737, standard error = 0.806) is attested to by the paired sample test. The Pearson's Product Moment correlation coefficient indicated that there was a correlation between strategies to increase the number of Physics teachers (r =

0.522; p = 0.000) and strategies to retain them (r = 0.088; p = 0.258). This means that once the number of Physics teachers is increased, strategies should be put in place that could be used to retain them. When the opinions on retention strategies were subjected to factor analysis, respondents were in agreement that remuneration (hardship allowance = 0.970) and in-service training (further training = 0.861) could retain Physics teachers in the profession. The opinions for strategies to increase the number of Physics teachers were also subjected to factor analysis. The respondents' opinions were, among others, that girls should be encouraged to enrol in Physics courses (0.972), the government should provide more grants for further studies (0.973) and increase the number of colleges that offer Physics (0.952).

The strategies for retaining and increasing the number of Physics teachers must be sequenced into a hierarchy, since these strategies cannot be implemented simultaneously by the government, since they would require a great deal of funds. One of the solutions of addressing the challenges affecting Physics teacher shortage is the development and implementation of interventions that can serve to encourage more learners to follow a career in Physics education.

Thus, the recommendations that follow should help in addressing the shortage of Physics teachers.

5.4 RECOMMENDATIONS

The recommendations from the study focus on the strategies that could be employed to retain and increase the number of Physics teachers. The recommendations follow from the opinions of the Physics teachers on the research questions. The research findings revealed that the shortage of Physics teachers is mainly due to a lack of incentives and motivation, and the inadequate professional development of the teachers. The findings form the basis on which the recommendations were formulated. The recommendations are two-fold, since they focus on both the teacher and learner, and government should support them at policy and institutional levels. More attention was given to the factors that scored high in the Likert scale analysis.

The recommendations that focus on the teachers with regard to the research findings are as follows:

1. Provide the teachers with attractive salaries and allowances.
   The Government of Swaziland (GoS) pays teachers both travel and car allowances. Car allowance is money paid to those who use their own transport to work. GoS should provide the teachers with attractive salaries and allowances because, currently, the teachers are not adequately remunerated and there are no allowances to sustain those who reside in remote areas. The travel allowances paid by GoS to teachers are insufficient, since the teachers are only able to claim from GoS after six months and the amount they receive is equivalent to one month's public transport costs. It is an additional challenge for those who travel by private transport in the advent of the unending escalation of petrol prices. There is also a need for the GoS to increase car allowances due to the rise in petrol prices and these allowances should be easily accessible, since the documentation for claiming such is tedious.

2. Provide the teachers with subsidised housing.
   Some of the teachers reside in expensive houses due to their need for employment and proximity to their families, and the shortage of government-owned accommodation. Thus, the GoS should provide the teachers with subsidised housing or increase their housing allowance, since the current amount is hardly enough to enable the teachers to rent a decent one-roomed flat. This does not imply that GoS does not provide allowances, but the argument is that the allowances are not enough for some of the teachers' needs, such that the teachers end up using the larger portion of their salaries to augment the allowances. The teachers benefit relatively nothing by being employed by the GoS.

3. In order for the teachers to be abreast with issues pertaining to their discipline, there is a need for the GoS and other institutions to provide them with professional development by means of:

(i) Workshops:

Workshops are a component of teacher outreach programmes. The Inspectorate, INSET and NCC organise workshops for teachers on a termly basis, as stipulated in the policy documents. The researcher has observed that most teachers bear the costs themselves to attend the workshops even though it is for the benefit of the school. Therefore, the workshops venues should be accessible and the funds should be provided by the GoS and school administrators. At the moment most of the teachers spend more time travelling to workshop venues, and also pay for themselves. This is demotivating to the teachers, and thus affects their attendance and participation in such events, especially when curricular innovations need to be disseminated to them.

(ii) Further training:

This is essential for continuous professional development. Teachers who intend furthering their studies encounter some major obstacles and one of these is sponsorship from the GoS even after promising and encouraging the teachers to enrol for further training. The researcher would like to suggest that the GoS should inject more funds for professional development. Professional development is essential for attaining Swaziland's Vision 2022. The aspiration of this Vision is that Swaziland should attain first-world status by 2022. This vision could just be a mirage if the GoS does not invest in its human resources, and in self-sufficiency in terms of food production, health and education.

(iii) Weekend and evening classes:

These classes can be initiated by UNISWA to provide professional development to the teachers. Many teachers have enrolled at different institutions and some are not recognised by government and this shows the teachers' insatiable appetite for education. UNISWA has programmes for teachers on a part-time basis, but the programmes are insufficient and irrelevant to the teachers' needs, especially those who intend to venture into other fields. Some of the fields assist the teachers to impart concepts in subjects, like ICT. Thus, there is a need for UNISWA to introduce relevant programmes that will utilise this time (weekends and evenings) for teachers who show interest to upgrade their content knowledge.

(iv) Paying the teachers' subscription fees to research organisations and engaging them in research projects:

The research organisations are meant to develop the teachers professionally and should be supported by the GoS, NGOs and other organisations. Some NGOs provide minimal support for teachers who intend taking part in research. Some of the research is presented at international conferences. The support that is provided by GoS is sometimes non-existent to the teachers who intend engaging in research, as well as participating in conferences. The researcher would like to suggest that the GoS budgets for such activities.

(v) Encourage chemists and biologists to study Physics on a part-time basis.

By means of the study it was revealed that there are Chemistry and Biology teachers teaching Physics. Thus, the researcher would like to recommend that the teachers who specialised in Biology and Chemistry be provided with Physics content during vacation or weekends to augment their content knowledge for this discipline, while the GoS finds other means to address the shortage. These teachers (Biology and Chemistry specialists) already posses the teaching skills, therefore, they need more Physics content knowledge, since some of these specialists may have learnt it in their first year at tertiary level. Training of non-Physics specialists should be initiated by the GoS and UNISWA as major stakeholders in professional development programmes.

4. Monitor graduates in the field or teaching profession.

UNISWA should engage in a study as it did during the inception of the IDE programme, to monitor graduates in the teaching profession and to ascertain their educational needs, with the purpose of initiating relevant teacher development programmes. The study will inform UNISWA in respect of the relevance and impact of the teacher development programmes and thus devise ways to improve them where necessary. There is also a need for UNISWA to collaborate with the schools on other educational activities that are essential for teachers' professional development.

5. Review the teaching strategies or methods used at school and tertiary level.

   By means of the study it was indicated that some of the teaching strategies or methods employed at the school and tertiary institutions were not assisting the learners and students to understand Physics content. School administrators and the inspectorate, as school supervisors, should monitor how teachers impart the concepts and assist them when they encounter some challenges. School administrators should also organise school-based workshops on weekends and invite reputable lecturers and experienced teachers to share experiences on how to teach some of the Physics content. At the tertiary level it is common among lecturers who have no education background to be not well informed on how the learning process takes place. Thus, the administrators at UNISWA could make it a requirement that lecturers take a course in education before or once they join tertiary institution, as some institutions have made it a requirement.

6. Incorporate education in all the years of training in the BSc programme.

   The respondents felt that education courses should be introduced again in the BSc programme, since these courses were phased out a long time ago, even though they were equipping the students with teaching skills that were useful once they completed the programme. Moreover, the students did not have to apply, after completion, for the PGCE, which currently, has limited admissions. It is still unclear why the concurrent education courses were discontinued. The researcher can speculate that it was anticipated that the Education Department at UNISWA would admit more teachers who intended to major in science education. Unfortunately, it was not the case. Thus, there is a need for UNISWA to re-introduce concurrent education courses in the BSc programme to address the shortage of Physics teachers.

As mentioned above, some of the recommendations should focus on the learner, as indicated by the findings of the study. The recommendations are as follows:

7. Encourage girls to enrol for Physics courses:

   The study revealed that the majority of the Physics teachers are males. There is a need to encourage more girls to study Physics as this might increase the number of Physics teachers. School administrators and teachers should hold school-based Science exhibitions and other Science oriented activities, with some awards or incentives, where more girls are encouraged to participate. It is anticipated that these exhibitions would probably motivate girls to study Physics and increase the number of those who study Physics at school level. In fact, solutions to address the Physics teacher shortage should start at the school level. In the demise of AFCLIST at UNISWA, there was no other local initiative in place to encourage girls to study Science. Thus, there is a need for UNISWA and the GoS, in conjunction with companies or NGOs, to develop programmes that would encourage more girls to study Science and showcase their skills or products at the Trade exhibition centre and at other Science exhibition events. Apparently, such activities would probably increase the number of girls who study Physics at tertiary level.

8. Increase the number of institutions that offer Physics courses.

   There is only one institution that offers Physics courses for the senior secondary school level with strict entry requirements and limited admissions. UNISWA should review the entry requirements for the Science programme, since some capable students are not admitted at the institution. UNISWA should also increase the number of Physics programmes. Also, review the demand of Physics courses offered in the

B.Ed. programme. An increase in the number of Physics courses would call for an increase in the number of lecturers which should be budgeted for by the GoS. UNISWA could also tap on the expertise of Swazis and non-Swazis, on a part time basis, to teach the extra programmes and to attract more students who intend to study Science. The above recommendations demand an increase in the number of institutions and this should be planned for by the GoS as she has done with some developmental projects, termed ‘millennium projects’, in Swaziland. It is anticipated that an increase in the number of institutions that offer Physics courses, would attract and accommodate more students.

9. Provide incentives (rewards) for the learners who aspire to be Physics teachers.

As mentioned before, support for learners who aspire to major in Physics should start at school level and be facilitated by the teachers, and this should be accompanied with incentives (rewards) provided by the various sectors of the society. The GoS should request companies, parastatals and NGOs to assist in supporting learners who aspire to be Physics teachers. The aim would be to have more Physics specialists to benefit the teaching profession and the remaining specialists would benefit the industry and other institutions.

10. The teachers should involve the learners in Physics-oriented educational trips.

Educational trips are part of the school’s programme for each year and should be properly budgeted for. These trips should not be meant to while away time that has not been planned for, but should be focused and informative. Some learners do not have an opportunity to engage in education trips this, thus the need for school administrators to sensitise parents on the significance of educational excursions for their financial support. Some schools engage in fund-raising activities to reduce the costs so that more learners can partake in the excursions. This requires that teachers develop comprehensive programmes and proposals for trips with the emphasis on what the learners would accrue from the educational excursion. An exposure to the world of science and scientific innovations in these trips could motivate the learners to enrol in Physics courses with the aim of increasing the number of Physicists.

11. Provide scholarships and awards to encourage learners to pursue Physics education courses.

    The learners are never assured of GoS sponsorship at tertiary once they have completed their senior secondary education. The provision of sponsorship is sometimes by merit as well as area of priority that is prescribed by the GoS. Each year the number sponsored by the GoS varies depending on the money budgeted for tertiary education. The GoS should prioritise Physics-oriented courses. Similarly, companies, parastatals and NGOs could also provide assistance to students who intend majoring in Physics. The support from the companies, parastatals and NGOs would probably increase the number of Physics specialists.

12. Develop the learners' affective domain.

    Amidst the plethora of incentives or rewards that spur an individual to pursue a discipline is the appreciation or affection for it. In the absence of the affection the individual just accrues or reaps the benefits without effectively contributing to the development of the subject. The development of this domain is meant for the teachers and learners at the school level and students at tertiary level. The affective domain of the learners for Physics should be developed by the teachers and administrators. These officers should encourage the learners to learn Physics in order to make a positive contribution to the discipline as they engage in research projects. An occasional visit to schools by lecturers to make presentations on the significance of Physics should be encouraged and supported by the school administrators and Heads of Departments. Company managers should also visit schools to present to learners and teachers on the significance and relevance of Physics in industry. Probably, in pursuit of education, the majority of the learners would be drawn towards this discipline and develop an appreciation for its significance.

5.5 FINAL REMARKS

The need for qualified specialist Physics teachers is one of the aspirations of policymakers for improving the quality of Science education and the content acquired by learners in sub-Saharan Africa and the world over. This means policymakers are cognizant of the role played by qualified Physics teachers, and the fact that the learners cannot perform better in Physics in the absence of a qualified Physics teacher. Thus, in order for the learners to perform better in Physics they have to be be taught by teachers who have a deep understanding of content knowledge and how to impart it to them. It is unfortunate that, in both developing and some developed countries, there are not sufficient qualified Physics teachers and that some of them are also without the essential content knowledge to teach to the learners. Therefore, in order to empower the teachers with content knowledge there is need for appropriate professional development strategies that will equip all the teachers with the necessary knowledge and skills that will enhance the learners' performance in Physics. These professional development strategies should be initiated and supported by government through consultation with the teachers. In fact, the strategies should be geared towards increasing the number of Physics teachers in the schools, as well as retaining them.

It was the impetus of this study to ascertain the factors associated with the shortage of Physics teachers, and has succeeded in eliciting the factors from the practitioners (Physics teachers) in order to provide information to local (Swaziland) education stakeholders. The findings of this study will also benefit the larger community of science educators and policymakers in sub-Saharan Africa, since we all share most of these challenges in our education systems. Thus, policymakers in other settings should explore other Physics teacher challenges from the Physics teachers themselves. This would help the policymakers to understand the reasons for Physics teacher shortage and generate relevant solutions by drawing on the findings of this study.

The researcher hopes this study will contribute meaningfully to the body of knowledge in respect of the challenges faced by Physics teachers and how to address them. The researcher also believes that solutions should be sought with the input from Physics teachers as they have first-hand information on their challenges. The researcher has experienced and witnessed some of these challenges as a Physics teacher, as Head of a Science Department, as Curriculum Educator, and when visiting schools to monitor trial-testing of instructional materials. The marking of learners' final examinations in Physics has provided him with invaluable feedback on learner performance in the subject, which resonates with the findings of this study. Having engaged in this study and as revealed by the findings, the researcher hopes to share the invaluable information with MoET officials, especially the Senior Inspector for the Sciences, taking advantage of his position as a member of the Curriculum Coordinating Committee (CCC), Senior Curriculum Designer and examiner of Physics.

This study has unravelled the reasons for the nagging issues on Physics teachers for most governments, especially the local government. Thus, government should review the budget that is allocated to the Department of Education. Moreover, the share allocated to incentives and professional development for teachers should be increased, as well as at tertiary level for learners who intend pursuing a career in Physics. It is hoped that the findings of this study will stimulate further research into the pedagogic content knowledge (PCK) of Physics teachers and the specific reasons for the poor performance in the subject. According to the statistics for Science graduates at the local tertiary institution, the majority of science students choose other subjects at tertiary level rather than Physics. Thus, the need exists for local research to ascertain the actual reasons for these preferences, as they may have repercussions on Physics teacher training.

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Annexure A

In reply please
Quote
Ref: No:………

KINGDOM OF SWAZILAND

MINISTRY OF EDUCATION AND TRAINING

TELEPHONE : 404-3761/2 P. O. BOX 229
FAX: 404-2955 MBABANE

INFORMATION LETTER FOR THE REGIONAL EDUCATION OFFICER

FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS RESEARCH PROJECT

Dear Sir/Madam

My name is Torch Z. Dlamini. At present I am studying towards a Master of Education (MEd) in Curriculum Studies at the University of South Africa. My study focuses on Educators' perceptions on factors associated with shortage of Physics teachers and how to retain them.

I am requesting for permission to work with senior secondary school Physics teachers in your region. The teachers will be asked to state some demographic information and their views on factors associated with shortage of Physics teachers, how to retain them and how their number could be increased.

I intend to protect the teachers' confidentiality and schools anonymity. In fact, all information obtained from the questionnaire will be treated confidentially.

If you are happy for the institutions to participate, please indicate that you have read and understood this information letter by signing the accompanying consent form and returning it to me. Should you require any further information kindly contact me.

Mr Torch Z. Dlamini

T.Z.Dlamini

torchdlamini@yahoo.com
(+268) 76075632

Annexure B

In reply please

Quote

Ref: No:………

KINGDOM OF SWAZILAND
MINISTRY OF EDUCATION AND TRAINING

TELEPHONE : 404-3761/2
FAX: 404-2955

P. O. BOX 229
MBABANE

6 June 2013

Dear Sir/ Madam

CONSENT FORM FOR THE REGIONAL EDUCATION OFFICER (REO)

FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS RESEARCH PROJECT

Researcher: Mr Torch Z. Dlamini

Supervisor: Mr TI Mogashoa

I ……Regina……Shongwe…………………………… agree that the schools can participate in the project named above. The details of the research purpose have been explained to me. An information letter has been given to me to keep.

I give consent to the following: (Tick to indicate your selection)

Participation of schools and teachers:

Yes No

The possible future use of the findings to inform government:

Yes No

----------------	01/07/13----------
REO signature	Date
----------------	01-07-13----------
Witness	Date
T.Z. Dlamini----------	01-07-13----------
Researcher	Date

Annexure C

INFORMATION LETTER FOR THE PRINCIPAL

FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS RESEARCH PROJECT

Dear Principal

My name is Torch Z. Dlamini. At present I am studying towards a Master of Education (MEd) in Curriculum Studies at the University of South Africa. My study focuses on teachers' opinions on factors associated with shortage of Physics teachers and how to retain them.

I am requesting for permission to work with one of your staff members in this study. If you agree that he/she participates, she/he would be asked to state some demographic information and his/her views in a questionnaire on factors associated with shortage of Physics teachers, how to retain them and how their number could be increased.

I intend to protect the anonymity and the confidentiality of the teacher, yours and your school. Your name, teacher's name, school name and contact details will be kept in a separate file from any data that are supplied. This will only be linked to the data by me.

Please be advised that the participation of your school in this research project is paramount and voluntary. Should you wish the school to withdraw at any stage, or withdraw any unprocessed data you have supplied, you are free to do so. Your decision for the school to participate or not, or to withdraw, will be completely independent of your dealings with the University of South Africa.

If you are happy for your school to participate, please indicate that you have read and understood this information letter by signing the accompanying consent form and returning it to me. Should you require any further information do not hesitate to contact me.

Mr Torch Z. Dlamini

T.Z.Dlamini

torchdlamini@yahoo.com
(+268) 76075632

Annexure D

CONSENT FORM FOR THE PRINCIPAL

FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS RESEARCH PROJECT

Researcher: Mr Torch Z. Dlamini
Supervisor: Dr TI Mogashoa

I ……………………………………………………………………………. agree that the school can participate in the project named above. The details of the research purpose have been explained to me. An information letter has been given to me to keep.

I give consent to the following: (Tick to indicate your selection)

Participation of school and teacher:

Yes No

The possible future use of the findings to inform government:

Yes No

-- --
Principal's signature Date

-- --
Witness Date

-- --
Researcher Date

Annexure E

INFORMATION LETTER FOR THE TEACHER

FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS RESEARCH PROJECT

Dear Teacher

My name is Torch Z. Dlamini. At present I am studying towards a Master of Education (MEd) in Curriculum Studies. My study focuses on teachers' opinions on factors associated with shortage of Physics teachers, how to retain them and how their number could be increased.

Your Principal has given me permission to send you this letter to invite you to participate in this research project. Once you have read the letter you can decide whether you want to participate or not. Should you agree to participate, I will ask you to fill in the questionnaire.

I will protect your identity and your responses will be kept confidential. Your name and contact details will be kept in a separate file from any data that you supply.

Please be informed that your participation in this research project is voluntary. Should you wish to withdraw at any stage, or withdraw any unprocessed data you have supplied, you are free to do so.

If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it to me.

Should you require any further information do not hesitate to contact me.

Mr Torch Z. Dlamini

T.Z.Dlamini

torchdlamini@yahoo.com
(+268 76075632)

Annexure F

CONSENT FORM FOR THE TEACHER

FACTORS ASSOCIATED WITH SHORTAGE OF PHYSICS TEACHERS RESEARCH PROJECT

Researcher: Mr Torch Z. Dlamini
Supervisor: Dr TI Mogashoa

I.. agree to participate in the project named above. The details of the research purpose have been explained to me. An information letter has been given to me to keep.

I give consent to the following: (Tick to indicate your selection)

Provision of a section in questionnaire on demographic information:

Yes No

The possible future use of the findings to inform government:

Yes No

-- ------------------------------------
Signature of teacher Date

-- ------------------------------------
Signature of witness Date

-- ------------------------------------
Signature of researcher Date

Annexure G

UNISA college of education

Research Ethics Clearance Certificate

This is to certify that the application for ethical clearance submitted by

TZ Dlamini [45187983]

for a M Ed study entitled

Factors associated with shortage of Physics teachers in senior secondary schools in Swaziland

has met the ethical requirements as specified by the University of South Africa College of Education Research Ethics Committee. This certificate is valid for two years from the date of issue.

Prof CS le Roux
CEDU REC (Chairperson)
lrouxcs@unisa.ac.za
Reference number: 2013 JUNE/45187983/CSLR

7 June 2013

Annexure H

VALIDATION FORM

For

Teacher questionnaire

Researcher	Validator
Name: Mr Torch Z. Dlamini **Institution:** University of South Africa	**Name:** ______Thulisile Nkambule_ **Title** ____Mrs_ **Institution/ organisation:** _________UNISA_________ **Occupation:** **Research Assistant**

The following questions are based on a questionnaire to be administered to a group of Physics teachers, in rural and urban schools. The purpose of the questionnaire is to seek their opinions on the factors associated with shortage of Physics teachers, how they can be retained and how they can be increased.

You are kindly requested to provide feedback on the validity of the questionnaire by answering the questions below. You can provide your feedback by inserting a cross (X) in appropriate spaces. Your feedback to the questions will be highly valued for the success of this research.

Question	YES	NO
1. Are the items in the questionnaire representative of the research objectives?	X	
2. Are the items in the questionnaire at the level of understanding of the Physics teachers?	X	
3. Will the questionnaire be able to gather information on the research questions?	X	
4. Is the questionnaire valid?	X	

Please provide comments, if necessary, on the strengths and weaknesses of the questionnaire.

The questionnaire is valid and has a potential of enabling the researcher to identify the challenges faced by the education system in Swaziland. The strength of the questionnaire is that it also offers the researcher possible solutions to the problems that might be identified from the participants point of view. However, the issue raised in item number seven need some consideration. The reason being that it request participants to identify their nationalities, therefore, I think the researcher should state whether he is asking for experience of teaching Physics in Swaziland or elsewhere.

Signature: Nkambule **Date:** 6/03/2012

Official Stamp:

Annexure I

<u>QUESTIONNAIRE FOR PHYSICS TEACHERS</u>

This questionnaire seeks information on opinions of Physics teachers on the factors influencing their **shortage** in schools, how they can be **retained** and how their number can be **increased**.

Please complete all the items, unless advised differently.

Section A:	Demographic information

*Answer each question by **circling** the appropriate number in the **shaded box** or by writing your opinion in the space provided.*

1 Sex

Male	1
Female	2

2 Nationality

Swazi	1
Non-Swazi (specify):	2

3 Highest academic qualification

Certificate	1
Diploma	2
Bachelor's degree	3
Honours degree	4
Masters degree	5
Other (specify):	6

4 Highest professional qualification

Certificate in education	1
Post grad. certificate in education	2
Diploma in education	3
Post grad. diploma in education	4
Bachelor of education	5
Bachelor of Science (Agric) education	6
Honours degree in education	7

None	8
Other (specify):	9

5 Choose your majors

Mathematics/ Chemistry	1
Mathematics/ Physics	2
Chemistry/ Physics	3
Biology/ Chemistry	4
Other (specify):	5

6 Teaching experience (in years)

0 - 5	1
6 - 10	2
11 - 15	3
16 - 20	4
Above 20 (specify):	5

7 Experience teaching Physics (in years)

0 - 5	1
6 - 10	2
11 - 15	3
16 - 20	4
Above 20 (specify):	6

8 Last year of your studying Physics at tertiary institution

Year 1	1
Year 2	2
Year 3	3
Year 4	4

9 State whether you did primary or secondary science education at degree level

Primary science education	1
Secondary science education	2
Other (specify):	3

10 Type of your current school

Government	1
Private government-aided	2

Mission	3
Community	4

11 Location of your current school

Urban	1
Semi-urban	2
Rural	3

12 Location of school where you completed Form V

Urban	1
Semi-urban	2
Rural	3

For sections **B**, **C** and **D**, please indicate the extent to which you **agree** or **disagree** with each statement listed below by **circling** the number that reflects your opinion according to the following scale:

SD = Strongly Disagree (1)	D = Disagree (2)	A = Agree (3)	SA = Strongly Agree (4)

Section B:	The shortage of Physics teachers is due to the following factors:

No.	Statements	SD 1	D 2	A 3	SA 4
Incentives					
1	The salary is not attractive	**1**	**2**	**3**	**4**
2	There are no incentives	**1**	**2**	**3**	**4**
Support					
1	There is poor support from school administration	**1**	**2**	**3**	**4**
2	There is poor support from science department	**1**	**2**	**3**	**4**
3	There is no recruitment policy/strategy for physics teachers	**1**	**2**	**3**	**4**
4	There is no retention policy/strategy for physics teachers	**1**	**2**	**3**	**4**
5	Lack of Physics teaching resources	**1**	**2**	**3**	**4**
6	Lack of support from inspectors	**1**	**2**	**3**	**4**
Subject content					
1	Physics requires a strong mathematics background	**1**	**2**	**3**	**4**
2	Physics content is not easy to teach	**1**	**2**	**3**	**4**

3	Physics has more abstract concepts	**1**	**2**	**3**	**4**
4	Physics content uses males in its examples	**1**	**2**	**3**	**4**
5	Tertiary learners lack Physics content knowledge	**1**	**2**	**3**	**4**
6	Physics syllabus at college is sub-standard	**1**	**2**	**3**	**4**
Motivation					
1	There are few Physics role models	**1**	**2**	**3**	**4**
2	Physics is boring to teach	**1**	**2**	**3**	**4**
3	Physics teachers do not inspire learners	**1**	**2**	**3**	**4**
4	Demoralising poor initial Physics experiences	**1**	**2**	**3**	**4**
Attitudes					
1	Physics is portrayed as a man's world	**1**	**2**	**3**	**4**
2	Teaching lacks prestige	**1**	**2**	**3**	**4**
3	Lack of respect for teachers among students	**1**	**2**	**3**	**4**
4	Lack of respect for teachers among administrators	**1**	**2**	**3**	**4**
5	Learners have a negative attitude towards Physics	**1**	**2**	**3**	**4**
Professional development					
1	Few Physics courses at tertiary to attract more learners	**1**	**2**	**3**	**4**
2	Dropout rate in transition from high school to college	**1**	**2**	**3**	**4**
3	Very few training institutions for Physics teachers	**1**	**2**	**3**	**4**
4	Rigidity of entry requirements for Physics education at tertiary	**1**	**2**	**3**	**4**
Opportunities					
1	Physics has more opportunities than other subjects	**1**	**2**	**3**	**4**
2	Industries need more people with Physics	**1**	**2**	**3**	**4**
3	Physics is not offered by all schools	**1**	**2**	**3**	**4**
4	Inequality in access to opportunities in Physics education	**1**	**2**	**3**	**4**
5	Lucrative career paths than teaching that attract Physics teachers	**1**	**2**	**3**	**4**
Teacher challenges					
1	Insufficient learner discipline in school	**1**	**2**	**3**	**4**
2	Lack of learner discipline in school	**1**	**2**	**3**	**4**
3	Physical assault on teachers by learners	**1**	**2**	**3**	**4**
4	False accusations directed to Physics teachers by learners	**1**	**2**	**3**	**4**
5	Retirement of Physics teachers without replacements	**1**	**2**	**3**	**4**
6	The work load is too much	**1**	**2**	**3**	**4**

Section C:	The following are the strategies that should be used to **retain** Physics teachers:

No.	Statements	SD 1	D 2	A 3	SA 4
1	Provide them with hardship allowance	**1**	**2**	**3**	**4**
2	Top up their salary	**1**	**2**	**3**	**4**
3	Provide them with subsidised housing	**1**	**2**	**3**	**4**
4	It should not take long to promote them	**1**	**2**	**3**	**4**
5	Prioritise their eligibility for further training	**1**	**2**	**3**	**4**
6	They must partake in workshops frequently	**1**	**2**	**3**	**4**
7	They must be engaged in Physics research projects	**1**	**2**	**3**	**4**
8	They must partake in science research organisations	**1**	**2**	**3**	**4**
9	Payment for teachers' membership in science associations by schools	**1**	**2**	**3**	**4**
10	Encourage and financially assist them to enrol on a part time basis for further training	**1**	**2**	**3**	**4**
11	Train non-specialists in Physics through evening or weekend classes	**1**	**2**	**3**	**4**
12	Introduce direct entry into science education at tertiary	**1**	**2**	**3**	**4**
13	Introduce teacher outreach programmes to share experiences and challenges	**1**	**2**	**3**	**4**
14	Collaboration between university and schools on science teacher promoting projects or initiatives	**1**	**2**	**3**	**4**
15	Introduce paid for professional development	**1**	**2**	**3**	**4**
16	Tertiary institutions must monitor graduates in the field	**1**	**2**	**3**	**4**

Section D:	The following are the strategies that should be used to **increase** the number of Physics teachers:

No.	Statements	SD 1	D 2	A 3	SA 4
1	Encourage girls to enrol in Physics courses	**1**	**2**	**3**	**4**
2	Provide incentives for learners who aspire to be Physics teachers	**1**	**2**	**3**	**4**
3	Review teaching strategies at high school and tertiary	**1**	**2**	**3**	**4**
4	Involve learners in Physics oriented educational trips	**1**	**2**	**3**	**4**
5	Review the entry requirements for learners who intend to major in Physics at tertiary	**1**	**2**	**3**	**4**
6	Increase colleges that offer Physics	**1**	**2**	**3**	**4**
7	Request Physics lecturers to teach high school Physics	**1**	**2**	**3**	**4**
8	Incorporate Physics education in all the years of training at tertiary in the Bachelor of Science programme	**1**	**2**	**3**	**4**

9	Encourage Chemists and Biologists to study Physics	**1**	**2**	**3**	**4**
10	Increase periods accorded to Physics at high school	**1**	**2**	**3**	**4**
11	Provide training on holidays with incentives or credits	**1**	**2**	**3**	**4**
12	Provide incentive packages for undergraduates to consider Physics teaching	**1**	**2**	**3**	**4**
13	Establish Physics education research faculty	**1**	**2**	**3**	**4**
14	Companies should fund prospective Physics teachers	**1**	**2**	**3**	**4**
15	Provide scholarships and awards to encourage learners to pursue Physics education	**1**	**2**	**3**	**4**
16	Government should provide more grants for further studies	**1**	**2**	**3**	**4**
17	Distance learning should be supported and promoted	**1**	**2**	**3**	**4**
18	Check affective domain for Physics learners	**1**	**2**	**3**	**4**

This is the end of the questionnaire

Thank you very much!

Annexure J

Analysis of results for Science degree programmes for UNISWA graduates from 2000 - 2010

A: UNISWA BSc graduates from 2000 to 2005/6

Subjects	Year	2000/2001		2001/2002		2002/2003		2003/2004		2004/2005		2005/2006	
	Gender	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Bio/Chem		5	15	6	14	4	8	5	5	4	8	8	17
	total	**20**		**20**		**12**		**10**		**12**		**25**	
Bio/Geo		1	3	0	0	0	0	1	0	0	0	0	0
	total	**4**		**0**		**0**		**1**		**0**		**0**	
Chem/Math		5	9	4	4	5	1	6	3	7	1	7	6
	total	**14**		**8**		**6**		**9**		**8**		**13**	
Chem/Phys		0	0	0	0	0	0	0	0	0	0	0	0
	total	**0**		**0**		**0**		**0**		**0**		**0**	
Phys/Math		6	2	3	2	2	3	3	2	8	3	4	0
	total	**8**		**5**		**5**		**5**		**11**		**4**	
Phys/Comp		0	0	0	0	0	0	0	0	3	0	3	0
	total	**0**		**0**		**0**		**0**		**3**		**3**	
Geo/Comp		0	0	0	0	0	0	0	0	0	0	0	0
	total	**0**		**0**		**0**		**0**		**0**		**0**	
Math/Comp		3	0	8	3	11	5	6	2	9	1	6	6
	total	**3**		**11**		**16**		**8**		**10**		**12**	
Geo/Math		0	0	1	1	0	0	0	0	0	0	2	1
	total	**0**		**2**		**0**		**0**		**0**		**3**	

A (cont): Graduates from 2006 to 2010

Subjects	Year	2006/2007		2007/2008		2008/2009		2009/2010	
	Gender	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Bio/Chem		5	14	13	8	10	10	4	12
	total	**19**		**21**		**20**		**16**	
Bio/Geo		0	3	0	1	0	0	0	0
	total	**3**		**1**		**0**		**0**	
Chem/Math		5	1	5	4	6	4	10	3
	total	**6**		**9**		**10**		**13**	
Chem/Phys		0	0	0	0	0	0	2	0
	total	**0**		**0**		**0**		**2**	
Phys/Math		4	0	5	1	2	2	6	1
	total	**4**		**6**		**4**		**7**	
Phys/Comp		1	0	1	0	7	0	3	0
	total	**1**		**1**		**7**		**3**	
Geo/Comp		0	0	1	0	1	1	2	0
	total	**0**		**1**		**2**		**2**	
Math/Comp		12	6	13	3	3	4	4	3
	total	**18**		**16**		**7**		**7**	
Geo/Math		0	3	0	0	0	0	2	1
	total	**3**		**0**		**0**		**3**	

B: Percentages of graduates by gender from 2000 to 2005/6 for Physics combinations; G – gender and T – total.

Subjects		2000/2001		2001/2002		2002/2003		2003/2004		2004/2005		2005/2006	
	G	M	F	M	F	M	F	M	F	M	F	M	F
Chem/Phys	**T**	**0**		**0**		**0**		**0**		**0**		**0**	
%		0	0	0	0	0	0	0	0	0	0	0	0
Phys/Math	**T**	**8**		**5**		**5**		**5**		**11**		**4**	
%		75	25	60	40	60	40	60	40	73	27	100	0
Phys/Comp	**T**	**0**		**0**		**0**		**0**		**3**		**3**	
%		0	0	0	0	0	0	0	0	100	0	100	0

B (cont): Percentages of graduates by gender from 2006 to 2010 for Physics combinations

Subjects		2006/2007		2007/2008		2008/2009		2009/2010	
	G	M	F	M	F	M	F	M	F
Chem/Phys	**T**	**0**		**0**		**0**		**2**	
%		0	0	0	0	0	0	100	0
Phys/Math	**T**	**4**		**6**		**4**		**7**	
%		100	0	83	17	50	50	86	14
Phys/Comp	**T**	**1**		**1**		**7**		**3**	
%		100	0	100	0	100	0	100	0

C: Analysis of Bachelor of Education (Science secondary) graduates from 1998 to 2010.

Year	1998-2004	2005	2006	2007	2008	2009	2010
Science	0	2	2	0	2	3	4