

**THE INFLUENCE OF AN AUDIO-TUTORIAL
SELF-STUDY PROGRAMME ON THE
KNOWLEDGE AND INSIGHT OF SCIENCE
EDUCATORS**

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THE INFLUENCE OF AN AUDIO–TUTORIAL SELF–STUDY PROGRAMME ON THE KNOWLEDGE AND INSIGHT OF SCIENCE EDUCATORS

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DECLARATION

I declare that the study: “Influence of an audio-tutorial self-study programme on the knowledge and insight of science educators”, is my own work. It is being submitted for the MAGISTER EDUCATIONIS degree to the Potchefstroomse Universiteit vir Christelike Hoër Onderwys, Potchefstroom. It has not been submitted previously, for any degree or examination in any university.

Mlungisi Nyamane

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DEDICATION

I dedicate this mini-dissertation to my late wife, Dikeledi Shiela Nyamane (Sejake) whom I dearly loved. May GOD sanctify her soul.

ABSTRACT

The majority of learners perform badly at the end of the formal schooling in South Africa. This point is verified by the poor results after almost every Grade 12 Final examination. The statistics of candidates who wrote the Senior Certificate examination at the end of 1996 reflect a 53,9% pass rate and that of 1997, 47,4% (Department of Education, 1999: 12). It was also mentioned that the depicted scenario prompted a national outcry from several sectors of the South African community.

This study shows that the grade 12 examination results did not reflect a significant change during the years that followed 1997. The study further pinpoints Science as a learning area that learners fail alarmingly. It also goes on to isolate electricity as an area that is difficult for both the learners and the educators to understand, thereby contributing enormously towards the very high failure rate mentioned earlier.

The researcher also found that literature revealed that not much in-service education and training has been done to redress the malpractices that may be the contributory factors towards the high failure rate in question.

The researcher introduced the audio-tutorial self-study programme to assess its influence on the knowledge and insight of Science educators. Conclusions are made and the recommendations are drawn based on the findings of the study.

Key words

Audio-tutorial; Electricity; In-service education and training; Learning; Science; Self-study; Teaching.

SUMMARY

The study focuses on the influence of an audio-tutorial self-study programme on the knowledge and insight of science educators. Chapter One deals with the problem statement, the aim of the research, the hypothesis and the method of research.

A literature review is done in Chapter Two to verify the problem that was identified in Chapter One. Hence Chapter Two deals with the problems that are encountered in the teaching and learning of electricity. Chapter Three is also a review of literature that is based on the in-service programmes for the science educators.

The empirical study is done in Chapter Four. Data was collected with the aid of various questionnaires. The audio-tutorial self-study programme was introduced to enable the researcher to check its influence on the knowledge and insight of Science educators.

The findings are discussed in Chapter Five. Conclusions and recommendations are also made in the same chapter.

OPSOMMING

Die fokus van die studie was op die invloed van 'n oudio-toriale selfstudie-program met betrekking tot die kennis en insig van wetenskap-onderwysers. Hoofstuk Een handel oor die probleemstelling, die doel van die navorsing, die hipotese en die metode van navorsing.

'n Literatuurstudie WORD in Hoofstuk Twee gerapporteer om die probleem te verifieer wat in Hoofstuk Een geïdentifiseer is. Dus handel Hoofstuk Twee met die probleem wat teëgekom is in die onderrig en leer van elektrisiteit. Hoofstuk Drie bied 'n literatuur oorsig van die literatuur oor die in-diens- opleidingsprogramme vir wetenskap-onderwysers.

Die empiriese studie word in Hoofstuk Vier gerapporteer. Inligting is versamel deur middel van verskeie vraestelle en vraelyste. Die oudio-toriale selfstudie-program is bekend gestel, sodat die navorser kon kontroleer wat die invloed daarvan is op die kennis en insig van wetenskap-onderwysers.

Die bevindinge is in Hoofstuk Vyf bespreek. Gevolgtrekkings en aanbevelings is ook in dieselfde hoofstuk gedoen.

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CHAPTER ONE

1. ORIENTATIVE INTRODUCTION

1.1 Problem statement

The national outcry was that the standard of teaching, learning and service was very low at the public schools of the Republic of South Africa. The poor matric results, year after year, best described the situation at those schools. Taunyane (1998:17) cited the poor matric results as constituting “a national disaster”.

A study of the matric results over a few years showed that there was a continuous decline in the South African education system as a whole. The statistical graphs drawn by Perkins (1998: 4) reflected the pass rate of matriculants as follows: 1994 (58%), 1995 (53,4%), 1996 (54,7%) and 1997 (47,4%). The overall decline between 1996 and 1997 was a disappointing 7,6%. This decline was really a cause for concern.

It was reported that the examination results showed a slight decline in the performance of the Senior Certificate candidates of 1999. The report (Department of Education, 1999) mentioned that there was an improvement in the pass rate from 47,4% to 49,3% in 1998, and 1999 has recorded a slight decrease in the pass rate from 49,3% to 48,9%.

The drop in the learners' performance, as reflected at matric level, was the culmination of a lack of teaching, which was in turn brought about by many factors. A few of these factors include the educators' poor qualifications, their lack of commitment, their lack of knowledge and insight of the subject content, and the lack of in-service training of educators. The educators' performance in the classroom was also regarded as a contributing factor in the production of bad results. Bridgraj (1998: 6) quoted Ntombela as saying that there was a situation where some educators who had only a primary school teachers' qualifications were teaching at matric level.

The poor academic performance in South African schools became much clearer when the teaching of individual subjects was analyzed. Various sources had it that Physical Science was one of the subjects that were mostly failed by learners. The Free State Department of Education (1998: 154-167; 1999; 2000: 5-6; 2001: 156-172) issued the following statistics for Physical Science for schools in Kgotsong Township:

Table 1: Average percentage pass rate for Physical Science per school in Kgotsong.

School (Centre no.)	1997	1998	1999	2000	Grade
Mamellang- Thuto (3060617)	31,34 32,84	32,29 24,74	- 22,00	55,00 48,35	HG SG
Mophate (3060619)	23,43 19,74	22,10 21,67	27,43 26,09	24,11 30,43	HG SG
Oziel Selele (3060624)	24,86 26,41	28,61 34,33	41,10 39,25	41,75 38,13	HG SG
Diphetoho (3060632)	37,44 36,49	39,95 -	30,75 34,04	- 46,82	HG SG
Dr ML Maile (3060635)	- -	26,08 23,07	22,63 25,91	27,57 28,30	HG SG
District	38,90	38,23	39,45	47,84	HG
Average %	31,03	31,67	33,66	37,73	SG
Provincial	36,98	36,87	37,19	44,12	HG
Average %	31,36	31,88	31,08	36,31	SG

Dooms (1998:7) referred to Rutherford, the director of the College of Science at Wits University as saying: "The majority of Physical Science teachers do not have good science qualifications and they are struggling with the content knowledge." Although there were many factors linked to the production of bad results, it was also common knowledge that poor results were directly linked to poor teaching at school level. Angstey (1998: 4) pointed out that "a marker of science standard grade papers said only 10 to 20 percent of what he had marked showed any understanding". Generally, poor understanding of scientific concepts by learners can be attributed to poor teaching by educators. According to Gray (1995: 47) "... even where schools are fortunate enough to have adequate facilities, these are generally under-utilized, often because teachers lack the confidence and the necessary organizational and teaching skills for practically based science lessons".

Electricity is a major division of Physical Science and it permeates the Physical Science syllabus. It is studied in Grades 8, 9 10 and 12. It seemed, due to poor results, that learners perceive electricity as a difficult part of the subject. Smit and Finegold (as quoted by Smit & Nel, 1997:202) maintained that their findings gave rise to the hypothesis that Physical Science educators also had inadequate knowledge of models in Physics and this might have been one of the fundamental reasons why secondary school learners experienced problems with the understanding of electricity.

“There is a short-sight on the upgrading of serving educators”, suggested Mkhize and Gounden (1990: 2). They further picked up the fact that the problem was situated in the in-service training of educators as shown by the De Lange Report (HSRC: 1981). The absence of in-service training of educators induced poor teaching, hence the examination results were very bad. There were many ways in which this problem was being addressed. For example, the development of audio and audio-visual teaching aids, microcomputer programmes and other aids for self-instruction. All these projects, and many more, aimed at improving the educators’ knowledge and insight of Physical Science, in particular, the electricity part of it. Another method of addressing this problem is through the use of the audio-tutorial self-study programme (ATSP).

This study would focus on one specific method, namely, an audio-tutorial selfstudy programme (ATSP) developed by the Unit for Physical Science teaching at the Potchefstroom University for Christian Higher Education.

1.2 The problem questions

- 1.2.1 What are science educators’ knowledge of and insight into electricity?
- 1.2.2 What is the impact of a specially developed audio-tutorial selfstudy programme on the knowledge and insight of science educators at secondary schools?

1.3 The aim of the research

The aim of the research was to determine the:

- science educators’ knowledge of and insight into electricity.
- impact of an audio-tutorial self-study programme on the science educators’ knowledge and insight of electricity.

1.4 The hypothesis

The audio-tutorial self-study programme can improve the knowledge of and insight into electricity of science educators at secondary schools.

This hypothesis was tested in the study of the influence of an audio-tutorial self-study programme on the knowledge and insight of science educators at secondary schools of the Kgotsong township in the Welkom district, Free State.

1.5 Method of research

1.5.1 Literature study

A thorough review of literature on the teaching and learning of electricity at secondary school level was conducted. The researcher used the Internet, books, journals, bulletins, periodicals, dissertations and theses that dealt with aspects of the problem.

A literature review is described in chapters two and three.

1.5.2 The empirical research

The Physical Science educators were drawn from the five secondary schools of Kgotsong. An educator per grade (grade 8-12) represented each school; i.e. the total number of participants was 25.

Data were collected with the aid of questionnaires prepared in cooperation with Professor Vreken and associates, based at the Potchefstroom University for Christian Higher Education to determine the science educators' knowledge of and insight into electricity and the impact of an audio-tutorial self-study programme on the science educators' knowledge thereof.

The educators were exposed to pre- and post-tests, with the audio-tutorial self-study programme applied in-between. Their responses were marked and the scores were used for statistical purposes.

Data obtained from questionnaires was processed using the SAS-programme in consultation with the Statistical Consultation Services of the Potchefstroom University for Christian Higher Education.

1.6 Chapter classification

The chapters in this mini-dissertation are classified as follows:

Chapter 1: Problem statement, aims and method of research.

Chapter 2: The teaching and learning of electricity.

Chapter 3: In-service programmes for science educators.

Chapter 4: Empirical study.

Chapter 5: Conclusions and recommendations.

CHAPTER TWO

2. THE TEACHING AND LEARNING OF ELECTRICITY

2.1 INTRODUCTION

This chapter focuses on the teaching and learning of electricity at secondary schools. As stated in chapter 1 electricity ranks high among the sections of physics that learners and educators find difficult. Shipstone *et al.* (1988:303) and McDermott (1991:304) also raised this notion.

It is a known fact that loafing by both educators and learners, stagnation of science educators, lack of exposure and initiative are impediments in the teaching and learning of electricity (ANON., 1998:36.)

The discussion that follows will specifically deal with the problems that are encountered by both educators and learners with the process of teaching and learning of electricity.

2.2 RESEARCH DONE ON THE TEACHING AND LEARNING OF ELECTRICITY

The last 20 years has seen an increase in research on the learning of electricity. More progress in this field was made subsequent to the first meeting on the teaching of electricity convened by Duit, Jung and Von Rhoneck (1985) in Ludwigburg, Germany in 1984 (Calliot, 1993).

Recent research on the teaching of electricity shows that big gaps exist between its different parts, namely, electrostatics, electrodynamics and electromagnetism (Calliot, 1993). New propositions to make the teaching of electricity a coherent unit are made by educationists, especially with the introduction of Outcomes-Based Education (OBE) in South Africa, as contained in the policy document that describes educational reform (Department of Education, 1997:1). Smit and Nel (as quoted by Wesi, 1997: 123) found that South African educators generally had problems with the understanding of electric current.

Students' conceptions of electric current have been extensively studied, ranging from the simple notions treated in primary school Science up to the more sophisticated notions only addressed in introductory Physics courses at university level. The collection edited by Duit *et al.* (1985) provides an overview of the research conducted up to 1985. Such research has revealed the conceptions that students hold and the difficulties they have in understanding the concept of electric current, even when applied to simple situations (Borges & Gilbert, 1999: 95).

Wesi (1997:123) also maintained that the research results showed persistent deficiencies after instruction, in both the structure of the learners' knowledge of physics and in their problem-solving skills. McDermott (1991: 308) indicated that learners failed to make correct qualitative predictions about electric circuitry because of a lack of conceptual models for it.

The discussion that follows will unearth the complexities surrounding the teaching and learning of electricity in secondary schools.

2.3 PROBLEMS IN THE TEACHING OF ELECTRICITY

2.3.1 Introduction

The problems that secondary school educators experience with the teaching of electricity will be highlighted in this section.

Webb (as quoted in Wesi *et al.*, 1999:13) cited the problems associated with teachers' own knowledge structures and understanding as a focal point if teaching and learning problems were to be addressed. The educators' qualifications and the purpose of teaching Science will also be unmasked. Their language-related experiences and the way they conduct practical work, as well as the relevance of textbooks will also be discussed in the following paragraphs.

2.3.2 Educators' understanding of electricity

Whereas some learners fairly pass Physics, a lot of them do not understand the concepts of electricity. One of the main causes of this problem is that teachers' understanding of electricity is lacking (Gray, 1995:48).

It appears that it is a worldwide problem that many science educators' knowledge of electricity is wanting. Hence one science educator in New Zealand conceded: "I just know nothing about basic concepts of electricity."(Osborne & Freyberg, 1985:20). This serves as a measure of the lack of understanding and possibly a lack of knowledge of electricity by educators who teach the subject.

Science educators have stagnated due to a lack of exposure to current trends in the teaching of electricity. Webb (as quoted by Wesi *et al.*, 1999) went further to say students and even teachers experience conceptual difficulties with the section on direct current (d.c.) circuits.

Smit and Finegold (as quoted by Smit & Nel, 1997) found that prospective Physical Science educators in their final year at South African universities had inadequate knowledge for the teaching of the nature and functions of models in Physics. This may be one of the reasons why secondary school learners also experience problems with the understanding of electricity, as we make use of many models in the teaching of electricity.

Wesi *et al.* (1999:13) demonstrated how educators could not explain how potential difference (emf) gives rise to current. It showed that the educators lacked the understanding of the concepts of electricity. Smit and Nel (1997:205) verified that from written justifications and interviews it was clear that a group of educators did not clearly understand the terms anion, anode, cation, cathode and oxidation.

From this discussion it is clear that the educators' lack of understanding of the concepts of electricity is a contributory factor to the high failure rate in South African secondary schools.

2.3.3 Educators' qualifications

It appears that many Physical Science educators did not specialize in the subject. The lack of suitably qualified educators who can handle the subject matter in a proficient manner has been cited as one of the reasons for the recurrent high failure rate in Physical Science in South African schools (Wesi *et al.*, 1999:170). Cortie and Cortie (1997:348) also maintain that the big problem in the majority of schools in South Africa is a severe shortage of properly qualified educators.

The provincial review report (Department of Public Service and Administration, 1997: 59) mapped five provinces of the Republic of South Africa experiencing a shortage of qualified educators in general, and a shortage of Science and Mathematics educators specifically.

The report further noted that in another province voluntary severance packages (VSPs) were being offered to Science and Mathematics educators, among others, despite the fact that the Department generally had a shortage of these educators. The very few properly qualified science educators were allowed to leave the education system in that province, thereby exacerbating the problem of the shortage of the said educators. This translated in worsening the pass rate in Science.

2.3.4 Lack of trained science educators

Science educators attend to their classes without having prepared for the lessons they were supposed to deliver. "It is clear that teachers who participated in this study were not prepared for their task as science teachers and in particular for teaching electricity..." said Wesi *et al.* (1999:175). There is a general shortage of properly trained science educators.

2.3.5 Language-related experiences in the teaching of electricity

Smit and Nel (1997:205) conducted interviews, which revealed language-related problems educators have with the teaching of electricity. In almost all the previously black South African secondary schools Science is taught in either English or Afrikaans. Neither of these languages is the mother tongue of the learners found in these institutions. Howie and Hughes (1998:19) also found that South African learners with English or Afrikaans as a home language performed better than those learners with other home languages.

As learners are struggling with the language that is not their mother tongue, educators also find it difficult to describe or explain concepts in electricity to them, using these languages. Smit and Nel (1997:205) also found that the necessary terms for the learners' mother tongue in electricity are either absent or mismatch the scientific concepts.

2.3.6 *Relevance of textbooks*

There are many different textbooks that are prescribed for Physics in South African secondary schools. These prescribed textbooks do not address the concept of electricity properly. Smit and Nel (1997:205) also clarified this notion. They found that "the three series of Physical Science textbooks currently in use in South African schools display serious shortcomings in the treatment of the two models for electric current". They also said that the shortcomings emanating from those textbooks could be directly related to the Physical Science syllabuses. Since most of Physical Science educators use the textbook as the main source of information on the subject, the implications for the teaching of electricity would be obvious.

McBride and Chiappetta (1992:21) also lamented: "Students are surrounded by electrical devices that they use every day. Unfortunately, science textbooks rarely include electrical safety guidelines. Consequently, students may not learn to apply their science knowledge in this area." It is clear that the prescribed textbooks are totally divorced from the learners' daily experiences with electrical appliances and other devices.

2.3.7 *Practical work*

Cilliers and Reynhardt (1998:178) mentioned that Physics, as a Natural Science, is essentially investigative by nature, which makes experimentation an essential part of gathering information.

Educators though, do not bother to prepare experiments so that learners can engage with electricity concepts in a practical manner. O'Neill (1994:58) queries how the practical work being done can possibly be of benefit when the teachers don't know any good reason for doing it.

In addition to the problems that the educators are experiencing with the teaching of electricity a new approach came along with the introduction of Outcomes-Based Education in South Africa.

2.3.8 *OBE and the teaching of science*

It is unquestionable to state that many science educators find it difficult to adapt to new methods of teaching that came with the introduction of Outcomes-Based Education (OBE) in South Africa. Le Grange and Reddy (2000:21) cited educators' views on OBE and Curriculum 2000 as varied. Here are some of their views:

- "I don't know enough to form solid opinions"
- "I am still in the dark"
- "I need more information"
- "It is a mystery and I am looking for someone to solve it"
- "All I know is that learners must acquire certain pre-planned skills"
- "It sounds good on paper but how do you manage this with 58 learners in your class?"
- "It should be implemented gradually"
- "Not everything in the old system was negative"
- "It is a sophisticated system that will take a while before it will be effectively and successfully used in schools", and
- "It is long overdue"

The science educators' views mentioned above are indications that the majority does not know anything about the newly introduced way of teaching, through Outcomes-Based Education. Their statements also reflect an element of fright and flight in some, and confusion in others.

It is general knowledge that the old system of education had some good attributes that should not be abandoned altogether. Examples include making daily lesson preparations, conducting class visits, monitoring and controlling of work done by science educators. Still, many science educators feared that the new education system was doomed to fail, whereas others believed that it should be introduced gradually.

Teaching is always reciprocated by learning, hence the problems that are experienced in the teaching of science also induce the same in the learning thereof.

2.4 PROBLEMS IN THE LEARNING OF ELECTRICITY

2.4.1 Introduction

All the learners in the South African public schools take Physical Science as part of general science in Grades 8 and 9. Others register it as a choice subject in Grades 10, 11 and 12. Some also enrol electronics as a subject in technical schools. All these learners, including those in the primary schools, engage in concepts of electric circuitry during the said phases of their education. Von Rhoneck *et al.* (1998:551) defined learning as an active, constructive and a goal-oriented process that is aimed at the acquisition of knowledge and abilities.

Neimeyer (1993:4) also asserted that learning is founded on the premise of meaning making, which is called constructivism. It is this drive towards meaning and understanding that necessitates learning. Educational changes in South Africa since the introduction of democracy are characterized by focusing on the outcomes at the end of formal learning. This new system, OBE (SABC Education, 2001), carries the tenets of constructivism in that the learner is allowed to make meaning that does not necessarily correspond to the world but rather to his/her understanding, which is in turn guided by the expected outcomes of the learning programme. Wittrock (1974) added that knowledge construction is a generative learning process.

It is against this background that the learning of the concepts of electricity become of paramount importance in this section. The discussion that follows will focus mainly on some of the impediments to the learning of electricity.

2.4.2 Language-related experiences

The majority of learners in South African schools use English as a medium of instruction. And it is not their first language. In electrical circuitry, learners in secondary schools, especially in lower grades, are not yet fluent in their medium of instruction. They struggle to make meaning of what they learn, for they first have to deal with interpreting the language of instruction to theirs (mother's tongue). Kelly *et al.* (1998:852) also maintained that for conceptual change to take place, learners were to adopt the language of the group they were part of.

Howie and Hughes (1998:19) concerted, through their achievement tests, that there was evidence of language problems among the learners in the international study that was conducted, including the South African learners. They found that the vast majority of South African learners wrote the Third International Mathematics and Science Study (TIMSS) test in a language that was not their mother tongue.

2.4.3 Reasoning

Learners' responses to questions about electricity reveal their lack of power of reasoning. Cilliers and Reynhardt (1998:176) pointed out that physics students come from diverse educational backgrounds and represent a wide range of intellectual skills. A significant portion of students though, are not able to use formal reasoning patterns.

Reasoning also reveals their understanding of the subject matter. Kelly *et al.* (1998:853) assessed the learners' performance in electrical circuitry to examine their reasoning when solving science problems. Kelly *et al.* (1998:867) found that learners reached conclusions consistent with the acceptable knowledge of science, but did so with apparently faulty warrants. They "also noticed several instances of students using warrants which were consistent with a scientific notion of electricity in support of incorrect claims."

Although some learners perform well in electricity, Furio and Guisasola (1997:520) emphasized that the high level of failure may have been due to a functional reduction in the students' way of reasoning. They went further to quote Furio and Calatayud (1996) and Viennot (1992) as saying the concepts of electric force and electric field intensity are epistemologically bound, but students reasoned on the basis of the operative definition that establishes the proportionality between force and intensity ($E = F/q$) and transformed it into an equivalence.

Osborne and Freyberg (1987: 20) quoted one Physics educator saying: "Electric circuits ... they get right through to the sixth form and they don't understand the difference between a series and a parallel circuit ... or why you put a voltmeter in parallel and an ammeter in series."

It is evident that the learners' reasoning is wanting in electric circuitry.

2.4.4 Cognitive factors

2.4.4.1 Anxiety

Learners who succeed in Physics do so because of the expectations that are put before them by their parents and educators from their childhood through adolescence. It is this anxiety that leads to successful learning in school (Von Rhoneck *et al.*, 1998: 563). The opposite also maintains because anxiety is an emotional factor. The statistics in Chapter One shows that South African learners are probably less anxious to achieve in science. Hauptfleisch (1980: 10) confirmed this assertion by citing examples that showed that the picture was even worse than thought by many in the country. That is, a lot of learners who took science as one of their subjects performed badly.

2.4.4.2 Interest

Learners develop interest through the conduction of experiments in electricity. Their desire to explore and inquire about the concepts of electricity becomes aroused. Von Rhoneck *et al.* (1998) posited that interest had a big effect in active and passive learners. Lack of interest in electricity is very high among the majority of the learners in South Africa. This is a problem area for the education department of South Africa. Hughes (1998:23) noted that the impact of science on the people's everyday lives have generally not been part of the awareness of most South Africans.

2.4.4.3. Environmental influence

The environment, both at school and home, plays a predominant role in the performance of learners in electricity. The availability and use of circuit boards and relevant textbooks in the said localities is a crucial performance factor in electrical circuitry. Howie and Hughes (1998:20) reported that the Third International Mathematics and Science Study (TIMSS) unearthed the fact that South African science learners who were doing Grade 12 performed poorly in the science test because: almost all their parents had primary education only; 92% of them (learners) did not have computers at home; 81% of them (learners) rarely or never used a computer; their homes had a limited amount of books. These are just some examples that show that the environment has a great influence on the performance of learners in science.

The learners' interaction with family members, peers and educators is also important in determining their performance in electrical circuitry. Von Rhoneck *et al.* (1998) also noticed that learners who view their educators and colleagues more critically, performed well in Physics.

The foregoing discussion notes that there are problems in the teaching and learning of science, particularly electricity. It is appropriate to figure out how science lessons can be developed through the employment of the new model of Outcomes-Based Education in South Africa.

2.5 THE PLACE OF ELECTRICITY IN CURRICULUM 21

2.5.1 Introduction

The education system of every country has a specific model. Steyn and Wilkinson (1998: 203) also stressed that every education model has a theoretical basis. OBE is the new model for South Africa, and the entire model is expected to be operational by the year 2005, hence it is often called Curriculum 2005.

The Independent Review Committee appointed by the Minister of Education, Professor Kader Asmal, proposed that while the principles of OBE should be maintained, Curriculum 2005 (C2005) should be phased out (Potenza, 2000a). The same committee further proposed that a revised and streamlined, outcomes-based Curriculum 21 (C21), should replace Curriculum 2005 (C2005).

It was mentioned that the education ministry of the Republic of South Africa, through its minister, accepted most of the recommendations of the Review Committee which stated that C2005 should be replaced by C21 (Potenza, 2000b).

The underlying paragraphs are an attempt to locate where the teaching and learning of electricity is situated in C21.

2.5.2 Theoretical background

- Behaviourism

Steyn and Wilkinson (1998:204) highlighted the fact that it should be easy to observe that the OBE model with visible, measurable and specifically formulated outcomes is based, among other things, on behaviouristic assumptions. This is a very strong point since OBE focuses on what the learner should be able to do at the end of the process.

- Social reconstructivism

Social reconstructivism aims at social transformation. Steyn and Wilkinson (1998:20) maintain that on the agenda of social reconstructivists are issues such as empowerment, transformation and the emancipation of the suppressed and denationalized communities. In education the idea of learning as a constructive process is widely accepted; learners do not passively receive information but instead actively construct knowledge as they strive to make sense of their own world (Cobb in De Corte & Weinert, 1996:338).

- Critical theory

Key focus areas of this philosophy are the change and emancipation of societies and individuals from being regulated and indoctrinated towards being critical and questioning (Steyn & Wilkinson, 1998:204).

The discussion document on OBE in South Africa stresses the critical attitudes and skills to be acquired by learners. Learning programmes should promote the learners' ability to think critically. One of the national critical outcomes, as formulated by South African Qualifications Authority (SAQA), is the following: "Collect, analyse, organise and critically evaluate information" (Department of Education, 1997: 10).

A further theoretical basis of OBE as planned for South Africa is to be found, among other things, in the critical theory and, as such, it is acknowledged in official documents (Department of Education, 1996: 3). The products of OBE will therefore be expected to be critical thinkers who will question and interrogate situations where necessary.

- Pragmatism

"Pragmatism is a philosophy that encourages us to seek out the process and do the things that work best to help us achieve desirable ends" (Ozmon & Craver, 1995:121). Furthermore it is "... a philosophy that stresses the relation of theory to praxis and takes the continuity of experience and nature as revealed through the outcome of directed action as a starting point of reflection" (Audi, 1995:638).

In the OBE designed for South Africa the concept of outcomes is explained as that which the learner must be able to do at the end of the learning experience. This indicates that the OBE model for South Africa has pragmatic underpinnings (Steyn & Wilkinson, 1998: 205).

Ralph Tyler divided the philosophies into two macro-paradigms, namely, the means-end and the critical pedagogical (Arjun, 1998:23). The dominant one is the means-end and the emerging one is the critical pedagogical. According to Arjun (1998:24) there is no substantial difference between an outcomes-based curriculum and the means-end paradigm.

“A paradigm shift occurs when, as a result of research and ongoing debate, the major ruling paradigm is annihilated and scientists begin to accept another philosophical scheme of thought or frame of reference. An analysis of the proposed new curricula for South Africa reveals that the impending shift does not have this kind of depth and magnitude, hence it cannot be regarded as a paradigm shift in Kuhn’s scheme”, proclaimed Arjun (1998:25).

On the overall, Curriculum 2005 is a mixture of the said philosophies, yielding a unique and balanced paradigm. It remains an open question whether there is a paradigm shift in science education, more so with special reference to Outcomes-Based Education of South Africa.

2.5.3 Science and OBE

There has been a shift in the manner with which learners’ work is assessed in all the subjects, lately called learning areas. But Arjun (1998:25) does not think that there is any paradigm shift brought about by OBE, for Tyler’s means-end paradigm is also outcomes-based.

Curriculum 2005 is being implemented in the South African educational system reflecting an integrated approach to assessment (Kotze, 1999:31). In preparation for OBE in secondary schools Continuous Assessment (CASS) will be introduced in Grades 10, 11 and 12 from 2001 (Department of Education, 2000). It was indicated that the first year of formal implementation of C21 would likely be 2004 as C2005 would be gradually phased out (Potenza, 2000b).

The learners will be assessed on a continuous basis. Their continuous evaluation marks will be worth 25% and another 25% will be for orals and practicals, where possible (Department of Education, 2000). The remaining 50% will be for the final examination mark.

In OBE science is part of the learning area called Natural Sciences (NS), which is offered from Grade 1 to Grade 9. And in Grades 10 to 12 it remains a separate subject, called Physical Science.

OBE falls directly in line with principles of constructivism in that it suggests, like Lambert *et al.* (1995:171) outlined, that:

- Learning is an active rather than a passive process.
- Learning is by nature social and is most likely to occur when learners share ideas, inquire, and problem – solve together.
- Learners, to go beyond rote learning, must have opportunities to make sense of new knowledge and create meaning, for themselves based on individual and shared experiences.
- Reflection and metacognition contribute to the construction of knowledge and the process of sense-making.
- Prior experience, values, and beliefs mediate new learning.

Cortie and Cortie (1997:346) went further to say the OBE curriculum emphasizes self-discovery and experimental work. The learners would discover as they learn through experimentation and practical work, whereas educators would be providing a suitable environment for the said processes to come to fruition.

There are basically nine specific outcomes that a learner should understand in the learning area of Natural Sciences, and they should be understood the OBE way. Cortie and Cortie (1997:347) outlined them as: being able to investigate; interpret; understand and apply scientific knowledge; management of natural resources; responsible decision-making; relationship between science and culture; an understanding of the changing contested nature of science; knowledge of ethical issues, bias and inequalities; and the effect of science on socio-economic development.

2.6 CONCLUSIONS

The concepts discussed in this chapter focussed mainly on the problems encountered by both educators and learners in the teaching and learning of electricity.

The learners' reasoning, language-related experiences and cognitive factors have a bearing on their general performance in electricity. It can be stated that educators' problems in electricity include the following: their understanding of electricity, qualifications, lack of preparation for their teaching of electricity, language-related experiences, relevance of textbooks and the practical work. Reflection upon OBE has also been made, although it is a new approach in the South African education system.

The next chapter will explore the in-service training of educators.

CHAPTER THREE

3. IN-SERVICE PROGRAMMES FOR SCIENCE EDUCATORS.

3.1 INTRODUCTION.

Educators ought to be at their best throughout their teaching career. This necessitates the existence of an entity that will address their needs so that they can perform maximally. Oldroyd and Hall (1991:2) maintain that In-Service Education and Training (INSET) is planned training activities practiced both within and outside school primarily to develop the professional staff in school.

Seakamela (1993:5) says in-service education and training refers to all courses and/or activities in which a serving educator may participate for his/her professional and personal growth in order to improve his/her career prospects.

The educators in South Africa are working in an environment that has changed drastically, particularly with the introduction of the new democratic political system since 1994. This environment is actually ever-changing, placing increasing demands on educators. Bell and Gilbert (1996:141) found this to be the case in the United Kingdom and New Zealand. They further indicated that 'the voices of the educationalists have been most influential in determining the direction and scope of educational change. They have arguably had more influence historically on policy formation than the ideologies of politicians, the ambitions of particular parents, or the interests of potential employers. But this is changing: the voices of politicians, claiming also to speak on behalf of parents and of employers, are being more clearly heard, at the expense of those educationalists'.

Furthermore, "many teachers are reluctant to teach Science or if they do, they teach in a manner that does not promote scientific curiosity", said Lawrenz (1987:251). The problem is particularly acute for the physical sciences (Layman, 1982; Porter, 1981; Wilkinson *et al.*, 1987)). By implication, in-service education in Physical Science, and electricity in particular, is neglected, or, if it exists, does not make any difference. Millar (1988:41) said the educators' view indicate that electricity (including electromagnetism and electronics) and mechanics are clear priorities for in-service education.

It is very important to map out the significance of in-service education and training for educators. Chin (2000) maintains that the role of educators shifted from that of being the primary knowledge providers to a supportive one. She further emphasized that educators still needed to be good at their jobs. This suggests that educators of today need greater access to quality training and upgrading than has been available in the past. The said training will also enable them to keep pace with the current technological developments. South Africa is one of the SADC (Southern African Development Community) countries that agreed to collaborate on a five-year distance education project to train upper primary and junior secondary educators (Chin, 2000). Chin (2000) wrote that STAMP 2000+, i.e. the Science, Technology and Mathematics (STM) Programme provides in-service skills training for STM educators in participating countries.

To attain this, the aims of in-service education and training are outlined in the next discussion.

3.2 THE AIMS OF IN-SERVICE EDUCATION AND TRAINING FOR SCIENCE EDUCATORS.

Sikhavhakhavha (1999:36,139) retorted that the aim of in-service education and training is to increase competence and performance of educators in the classroom. He also mentioned that in-service education and training aims at making the educators effective in the classroom by supplementing knowledge acquired during pre-service training.

Gurney (1990:94) pointed out that many educators went to in-service courses and returned to the classroom to implement their new skills and insight if they were appropriate to the reality of their syllabus, their children and their school, without knowing how they developed or improved. This implies that the educators' academic and professional competence is improved through the programmes of in-service education and training.

In-service education programmes could aim at equipping educators with specific skills to respond to a particular need or the programme could aim at enriching the educators' general professional culture, Seakamela (1993:13) pointed out.

Hussen and Postlethwaite (1985) indicated that a British government committee suggested that the aims for in-service education and training were to enable educators:

- (a) to develop their professional competence, confidence and relevant knowledge;
- (b) to evaluate their own work and attitudes in conjunction with their professional colleagues in other parts of the education service;

- (c) to develop criteria which would help them to assess their own roles in relation to a changing society for which schools must equip their pupils; and
- (d) to advance their careers.

They added that the Organization for Economic Co-operation and Development's (OECD) Trade Union Advisory Committee laid even more stress on educators' contributions to society in general, suggesting that in-service education and training should:

- (a) maintain the knowledge and skills of educators;
- (b) give them the opportunity to enlarge and improve their knowledge and educational capacities in all fields of their work;
- (c) make them ready and able to understand and face in time new situations coming up in society and to prepare their students for the new economic, social and cultural challenges;
- (d) enable them to gain additional qualifications and to develop their special talents and dispositions; and
- (e) raise the cultural and professional standard of the teaching force as a whole and strengthen its innovative vigour and creativity.

It is the responsibility of every government to provide in-service education and training to its teaching corps. Hussien and Postlethwaite (1985) also maintain that national governments have been giving increasing attention to in-service education and training for some of the following reasons:

- (a) they believe that educational practice needs to be more closely linked to the national needs and/or the needs of the local community;
- (b) approaches to educational change which neglect the in-service education and training dimensions are usually unsuccessful;
- (c) educators, like other adults, need continuing education to keep abreast of changes in modern society;
- (d) there is growing concern in some countries about the quality of teaching and career development of those who have had less basic education and training than current trends to teaching;
- (e) demographic trends have reduced the demand for new educators in some countries, cutting off one important source of new ideas, diminishing career prospects, and focusing attention on those educators who are already in service;
- (f) the general feeling that education has failed to fulfil the hopes of the expansionist era between 1964 and 1974 has created a public pressure for improved school performance (This pressure for improved school performance is also exerted to schools in the new South African dispensation today.)

If these are the aims of and reasons for in-service education and training for science educators, and other educators in general, then there should be programmes in place to ensure their attainment.

3.3 PROGRAMMES FOR IN-SERVICE EDUCATION AND TRAINING FOR SCIENCE EDUCATORS.

The programmes for in-service education and training of science educators are usually found within schools or in the educators' centres.

Hussen and Postlethwaite (1985) described the educators' centres as distinguishable from other forms of support for educators in that within one institution they:

- (a) provide diagnosis and provision of in-service professional development activities which are essentially local in their nature;
- (b) have a primary focus upon improving classroom practice;
- (c) develop professional esteem through involvement;
- (d) provide professional development programmes, both at the centre and in the schools, which begin from the educators' own starting point, and encourage educators to participate in the design of the programme.

The educators' centres should be closely linked to the provincial and/or national curriculum centres so that the educators could be directly involved in the development of the teaching/learning materials.

The in-service programmes are also school-based activities that aim at developing the educators' experience and performance. The personnel should practice the in-service activities within the school set-up (Seakamela, 1993:20).

3.3.1 School-based in-service programmes.

Sikhavhakhavha (1999:38) outlined the activities that could be included as part of the in-service programmes at school level as: teacher appraisal, reflective practice, observation, monitoring of written work and staff meetings. Science educators could be empowered through those in-service programmes.

3.3.1.1 Appraisal of educators

Appraisal is a way of assessing the educator's performance, thereby improving on the weaknesses and maintaining the strengths. Bell (1991:5) is of the opinion that the individual educator wants a process that caters for his/her personal improvement and which acknowledges the difficulties and complexities of the job.

Piek (1989:66) maintains that during appraisal attention should be paid to the educator's control over the teaching situation, the motivation of the learners in the course of the teaching/learning activities, the use of teaching methods, and the personal appearance of the educator.

Oldroyd and Hall (1991:73) see appraisal as taking place against the background of what both the individual educator and his/her appraiser know about the school needs. Sikhavhakhavha (1999:19) says appraisal of educators differs from school to school in the Northern Province. Preferably there should be only one form of appraisal in a particular education system.

An appraisal system should cover the aspects mentioned above. It should be a planned, properly coordinated and controlled organ, with measurable effects. The intentionality of the appraisal system should primarily yield a competent teaching force.

3.3.1.2 Reflective practice

Osterman and Kottkamp (1993:19) see reflective practice as a means by which practitioners can develop a great level of self-awareness about the nature and impact of their performance and awareness that create opportunities for professional growth and development.

Educators should perceive reflective practice as a developmental process, and not as a punitive measure. Hence Osterman and Kottkamp (1993:45) mentioned that individuals need to believe that the discussion of problems will not be interpreted as incompetence or weakness.

Osterman and Kottkamp (1993:45) also maintain that for reflective practice to flourish in a particular school, the participants should be confident that the information they disclose will not be used against them.

3.3.1.3 Observation

According to Wajnryb (1992:1), being in the classroom as an observer opens up a range of experience to the observing educator of what happens in the classroom situation. Some pre- and post-observation meetings will be necessary to make the whole process of observation a success.

3.3.1.4 Monitoring of written work

Monitoring written work should determine whether the marking programme of the educator is organized effectively and whether written work is distributed in such a way that the educator is not overloaded with marking work, according to Piek (1989:66). Marking should be done constantly, in a planned manner.

3.3.1.5 Control of examination content

Sikhavhakhavha (1999:41) maintains that the control of examination content can also serve the aim of assisting the individual educators to improve their competence to set an examination paper of balanced quality as well as to assist educators in evaluating the quality and organization of their own teaching.

3.3.1.6 Staff meetings

According to Mutsila (1996), staff meetings are divided into general and emergency ones. The general meetings of staff are usually planned in advance, whereby they may vary in form and content. They will differ from ordinary staff meetings to information sessions and workshops, depending on what is on offer at the moment.

3.3.2 College and university-based in-service programmes

College and university-based in-service programmes also aim at improving the science educators' professional competence. "According to teachers who enrolled in these institutions, Lyceum improves the secondary school teachers' professional competence in collaboration with Rand Afrikaans University, and Success with Pretoria and Stellenbosch Universities", said Sikhavhakha (1999:43).

3.3.3 Departmental in-service education and training programmes

Departmental in-service education and training programmes are usually carried out with the purpose of improving the competence and performance of educators in general, and that of science educators in particular. Sometimes these are done to effect changes to the curriculum of the country, especially when there is a switch between governments. The outcomes-based model of education is replacing the old one in the Republic of South Africa at the moment, hence the learning facilitators are conducting courses, and establishing learning area committees in schools and within districts.

In-service programmes for Science are carried out by learning area facilitators (LAFs) and school management developers (SMDs), previously referred to as subject advisers and inspectors respectively. Razwiendani (1997) sees the visits by LAFs and SMDs to the classroom as corresponding with those by principals, their deputies and the departmental heads of particular schools.

Sikhavhakhavha (1999:45) grouped the in-service programmes by the Department of Education as follows: class visits; subject committee meetings; and regional or decentralized courses.

SMDs and LAFs conduct class visits and panel inspections. Subject committee/learning area meetings of different subjects/learning areas are held in each and every circuit by LAFs. Netshiombvani (1996) sees these meetings as aiming at enabling educators to discuss the subject matter and problems they are faced with in the classroom.

Regional/decentralized courses are offered at district and provincial levels. These are mainly intended to update educators on the current developments and major changes that take place within the subject/learning area curriculums.

Most importantly, in-service programmes should provide more opportunities for educators to explore their attitudes, values, and beliefs through small-group counseling, sensitivity training, and individual guidance, highlighted Deighton (1971:81).

The said programmes for the in-service education and training of educators should be relevant to their needs and should also be in accordance to their job description. Millar (1988:49) maintains that educators in general tended to take the view that some formal in-service Physics education would be welcome and, indeed, necessary if they were to teach the new Science syllabus effectively. This suggests that educators should be expecting something empowering from in-service programmes.

3.4 WHAT DO EDUCATORS WANT FROM IN-SERVICE EDUCATION AND TRAINING?

Keast (as quoted by Murphy, 1985:9) formulated four basic categories that attempt to embrace the educators' needs. These are:

- (a) school-based in-service education and training which aims at helping the educators improve the quality of work in their own schools;
- (b) job-related in-service education and training which aims at assisting educators to be more effective in their own posts and to derive more job satisfaction;
- (c) career-oriented in-service education and training, which aims at preparing educators for promotion; and
- (d) qualification-oriented in service education and training, which aims at providing educators with further qualifications.

Years ago Bell and Peightel (1976:11) stressed the fact that educators are continually involved in new alternative learning programmes that require them to utilize different behavior and classroom organization. They maintain that educators have the right to expect continuing in-service programmes that will help them to be successful in new and often threatening situations. This still holds today.

It has been found that a lot of educators find it very difficult to initiate discussions in their classes. Other skills like the diagnosis of the learners' individual learning problems are lacking in many educators. Bell and Peightel (1976:15) said: "Teachers need and want in-service opportunities to help them improve teaching skills."

In Physics, safety is also an issue when various apparatuses are used. Millar (1988:39) mentioned one educator reporting “worry about safety aspects of electricity”; another asked about the Van de Graaff generator saying: “Is it really safe to use on children?” Proper training and experience of the educators would be the correct response to the fear of injury during the conduction of experiments that involve learners. Millar (1988:47) concludes the issue of safety of apparatuses by saying a Physics in-service education programme may address it directly and explicitly.

It seems that the providers of in-service education and training should be highly skilled, experienced and knowledgeable individuals and/or institutions so as to ascertain that the educators’ expectations are fully met.

3.5 PROVIDERS OF IN-SERVICE EDUCATION AND TRAINING

The school in-service education and training programmes should not only make use of opportunities for educators to attend outside courses, but also consider whether various in-service providers in the neighbourhood can offer what the school requires. The in-service providers discussed below were identified by Dean (1991).

3.5.1 Higher education staff

Lecturers can provide courses leading to a certificate, diploma and/or degree. They may also be available as consultants over particular aspects of the school’s work, for example, evaluation, action research, classroom observation, exchange arrangements and involvement of learners.

3.5.2 Learning area facilitators and school management developers

LAFs and SMDs may be used as in-service providers on many aspects. They may give advice on teaching practice, organization and management, forms of in-service provision for school-based work. They may also contribute towards the formulation of an in-service programme for the school.

3.5.3 *Advisory educators*

The advisory educators can provide advice on classroom practice; advice on material, equipment and classroom organization; work with learners in the classroom; lecture on classroom practice. These are educators within the same school, sometimes from other schools.

3.5.4 *Educators from other schools*

Educators from other schools may provide specific training in particular areas of work. They may also lecture on particular classroom work.

3.5.5 *Local industry*

Local industry may provide in-service courses that are relevant to their institutions. They may also provide work experience for educators. They may provide information about their institutions' staff development programmes.

The provision of in-service training courses and/or workshops at school will be beneficial to the involved school, the Department of Education, both the local and national industry and the immediate and larger communities of South Africa. It appears though, that there are a lot of disruptions whenever in-service education and training is provided at secondary schools.

3.6 DISRUPTIONS CAUSED BY IN-SERVICE EDUCATION AND TRAINING IN SECONDARY SCHOOLS

In-service education and training for educators have been provided during school time and outside of it, asserted Burgess *et al.* (1993:113). They also mentioned that non-learner days (up to 5 per year), week-end courses, conferences in holidays and twilight sessions on weekdays all have the advantages of reaching educators out of learner-contact time. However, non-learner days are too few to accommodate the volume of in-service education and training that may be planned.

Burgess *et al.* (1993:113) also indicated that access to conferences is restricted because of the implications of cost and travel, while twilight sessions can lack appeal for educators with domestic commitments that prevent extensions of the working day. Inevitably then, in-service education and training has in part to be delivered during the day. Other factors leading to this outcome are associated with the work of those who provide training (LAFs, speakers, advisory educators, teachers' center staff and others) which could not conceivably be done exclusively in educators' non-contact time. In addition, if educators attend in-service education and training courses/workshops during the school day, then they will to a greater or lesser extent be required to be absent from the classes they would otherwise have taught. Schools will as a result experience some disruptions of the day-to-day routines.

The disruptions caused by in-service education and training programmes necessitate the debate over the materials developed for the said programmes.

3.7 THE USE OF THE LEARNING MATERIALS FOR IN-SERVICE EDUCATION AND TRAINING FOR SCIENCE EDUCATORS

Neville *et al.* (1982:14) maintain that the cost of transporting the educators or their release from duty was a concern for the committee that recommended the use of in-service education and training materials.

Another view focused on the costing of the materials-based and "conventional" in-service education and training, and the results showed that under the right circumstances the materials-based in-service education and training would be "cheaper".

The learning materials at the centers that are accessible to many schools would not be available to the majority of educators. Neville *et al.* (1982:14) mentioned the fact that the few educators who might gain access to the materials would not operate on the same level with their un-empowered colleagues who are also not interested in in-service education and training. They stated that the long-term effect of those materials is little or there is no change in methods or performance of a school staff as a whole.

It is sometimes risky to use some learning materials for in-service education and training in Science. Millar (1988:47) emphatically said the issue of safety of apparatus might need to be addressed directly and explicitly in a program of physics in-service education and training.

Neville *et al.* (1982:14) highlighted the fact that the current interest in school-focused approaches to in-service education and training probably stem from disillusionment, and material-based in-service education seems to provide a logical alternative: logical in that it overcomes many of the difficulties which are thought to contribute to the effectiveness of “taught course” in-service education and training.

It is a fact that materials-based in-service education and training is expensive. Neville *et al.* (1982) summed it up by saying materials-based in-service education and training is either uneconomical, impracticable or unsuited to the objectives of training in many ways.

3.8 APPRAISAL AND IN-SERVICE EDUCATION AND TRAINING FOR SCIENCE EDUCATORS

Noting that in-service education programmes cause disruptions at secondary schools, and further realizing that the materials-based in-service education and training is expensive, the appraisal of educators is another option that should be tried.

Hewton (1988:63) says ‘appraisal should be a continuous and systematic process intended to help individual teachers with their professional development and career planning and also to ensure that the in-service training and development of teachers matches the complementary needs of the individuals and their schools.’

Science educators who received regular in-service training showed positive and upward trends when appraised, as compared to those who were neglected. Bell and Gilbert (1996:157) observed that in a proportion of cases the outcomes of appraisal are linked to the provision of in-service education and training opportunities.

Earlier Seakamela (1993:12) posited that in-service education and training has been regarded as an integral part of the whole process of teacher education in many countries. He further noted that it has been accepted as an essential element in the sphere of educator preparation, development and maintenance. It is imperative to mention that in-service education and training should not be divorced from appraisal, it is actually part thereof.

It has recently been difficult to measure the educators' performance both in the classroom and in their general practice. Wragg *et al.* (1996:1) also said evaluating what educators do in the school generally, and in their classrooms in particular, is specially problematic. They maintain that the appraisal of educators cannot be dispensed within a few minutes because there is often disagreement about what constitutes effective teaching, and the gains sought are usually long term, rather than short term.

In-service education and training should be done in schools, and not somewhere in the so-called education centers, for the appraisal of science educators to be effective. Hence it has been confirmed that in-service work is more school-based (Bell and Gilbert, 1996:158). They further said that educators reported that there is not enough time for in-service work and the current level of in-service work is not enough to implement the rapid and extensive changes being sought.

Whereas funding for in-service education and training is done by the employer, appraisal is mainly driven from within, with most of the appraisers being school-based. The fact that in-service work should be mainly school-based indicates its close relationship with appraisal. Hence educators viewed appraisal as: (1) the assessment of the performance of the educator; (2) the development of the individual; (3) appraisal for improvement and celebration; and (4) the development of the whole school (Wragg *et al.*, 1996).

Many educators see appraisal as a means for development, both at a personal level and for their schools. Their views on appraisal are actually an entrenchment of the aims of in-service education and training as stated by Hussen and Postlethwaite (1985) earlier. This serves as a further assertion that appraisal and in-service education and training are supposed to be treated as complementary entities rather than different concepts.

3.9 THE NEED FOR IN-SERVICE EDUCATION AND TRAINING TO INTRODUCE OUTCOMES-BASED EDUCATION IN SOUTH AFRICA

The literature available shows that not much in-service training has been done with regard to science in the past. The introduction of the outcomes-based education system in South Africa since 1998 has seen the implementation of in-service work in many secondary schools as a myth to the majority of educators. The outcomes-based system of education brings along the element of continuous evaluation/assessment of the learners' work with it. According to Reddy and le Grange (1996:18), this is beneficial for all the stakeholders. But they indicate that the whole process should be well-planned, in-service education should take place and the necessary infrastructure should be able to support the innovation that should be in place before this form of assessment can be implemented. The same goes for science and the learning area of Natural Sciences (NS).

Bell and Gilbert (1996:158) found that the demands for in-service training to implement the new government policy of New Zealand left little money, time and energy for educators to address their own professional concerns. Very few in-service and training sessions took place to introduce Outcomes- Based Education in South Africa. Reddy and le Grange (1996:20) explicitly stated that all the evidence points to the fact that no national strategy for in-service education and training exists in South Africa. Even in the United States, where expenditure on in-service education and training is probably the highest, Corrigan (as quoted by Hussen & Postlethwaite, 1985:2512) was able to state that “there is almost universal consensus among all persons involved that most in-service efforts are relatively ineffective”.

Ineffective as it may be, in-service education and training for science educators is important and necessary for the implementation of outcomes-based education in South Africa. “Mandated change arises when new policies are introduced, and in-service education and training is needed to guide and support the implementation”, retorted Hussen and Postlethwaite (1994:5967). Pressures are exerted on many educational systems to rethink their curricula to make them more relevant to the needs of both the individuals and the society at large, said Seakamela (1993:16). It is therefore imperative for the South African government to ensure that proper in-service education and training is embarked upon to introduce Outcomes-Based Education. Goddard (1989:12) also asserted that educators have to be ready to meet and satisfy these challenges and demands.

The swift adjustment and re-alignment of the psycho-philosophical approach of educators, as well as their didactic practice, is important for the immediate overhaul of the education system. The expected change can be realized through thorough training of the teaching corps. Seakamela (1993:16) also mentioned that rapid growth and change in the educational system demand large scale efforts to provide retraining and further training for the mass of the serving educators who will continue to set the educational standards for many years to come.

Since educators are agents of change, it therefore follows that in-service education and training can help them to effect the said changes.

3.10 RECOMMENDATIONS FOR THE IN-SERVICE EDUCATION AND TRAINING PROGRAMS FOR SCIENCE EDUCATORS.

The foregoing discussion has an element of disparity between in-service education and training and appraisal. There should be a concerted effort to close the gap that exists between the two. This suggests that in-service education and training should be mainly school-based.

Ashley and Mehl (1987:10) insist that in-service education and training should be seen in context as only one facet of a total, integrated teacher education strategy, in which there should be strong links between initial and in-service education and training. It is important and clear that there should be thorough pre-service education.

Schools, colleges of education and universities should constantly operate as a unit so as to keep being informed about the aspects that affect all the stakeholders in the education system of the country, especially educators, who serve as propellers.

Educators in general tended to take the view that some formal in-service physics education would be welcome and, indeed, necessary if they were to teach the new science syllabuses effectively, according to Millar (1988:49). It follows that science in-service programmes should be developed, and practiced in schools, for Outcomes-Based Education to take wing. Millar (1988:51) also indicated that in-service courses are vehicles for promoting development and instigating conceptual change. He pointed out that in practice that would mean adopting a constructivist or generative model of learning.

3.11 CONCLUSION

This chapter focused on the programmes for in-service education and training in secondary schools. It also isolated the providers of in-service education and training in those schools.

The disruptions brought about by implementing the programmes intended for in-service education and training at secondary schools were outlined. The use of the in-service education and training materials at schools as an alternative to combat the said disruptions were also discussed.

The concept of educator appraisal was merged with that of in-service education and training in an endeavor to reconcile the two.

The discussion on the teaching and learning of electricity, and the one on the in-service programmes for science educators necessitate an empirical study in this regard. The next chapter will specifically do so, focusing primarily on the impact of the audio-tutorial self-study program for electricity.

CHAPTER 4

4 EMPIRICAL STUDY

4.1 INTRODUCTION

Chapter Two dealt with the teaching and learning of electricity, whereas Chapter Three focused on the in-service programmes for science educators. Both chapters discussed the knowledge and insight of science educators, based on a literature review. The concept *electricity* was the area of focus in both chapters.

This chapter deals with the problem questions stated in the first chapter (see 1.2.1 and 1.2.2).

The measuring instruments, namely, the test papers and the questionnaires, will provide the data that will be analyzed. The response from the participants and the statistical techniques used in the analysis will be described, and the data and the statistical information will be provided in tabular form and in graphical representations.

4.2 THE AIM OF THE RESEARCH

The main aim of the research (see par. 1.3) is to determine the:

- science educators' knowledge and insight of electricity.
- impact of an audio-tutorial self-study programme on the science educators' knowledge and insight of electricity.

4.3 RESEARCH OBJECTIVES

To attain the aim specified in paragraph 4.2 the following hypothesis was tested: *The audio – tutorial self-study programme will improve the knowledge and insight of science educators at secondary schools.*

4.4 POPULATION AND SAMPLING

A population of educators was drawn from the five township schools of Kgotsong, Bothaville, in the Welkom district.

A sample of five science educators per school, representing each grade (Gr 8 – 12) was constituted.

4.5 ANTICIPATED RESPONSES AND DATA RECEIVED

4.5.1 Expected numbers

It was expected that the five secondary schools would be represented by five science educators each. The total number of expected educators was 25.

4.5.2 Actual responses

All the five schools were represented by five science educators each, i.e. there were 25 science educators who participated in the study.

4.5.3 Problems encountered

All the educators responded to the first questionnaire and the first part (pre-test) of the second questionnaire. Only one participant, who had to attend to sudden and urgent family matters, did not respond to the second part (post-test) of the second questionnaire, together with the evaluation form.

4.6 DATA RECEIVED

Three types of data were received to enable the researcher to assess the influence of an audio-tutorial self-study programme on the knowledge and insight of science educators. The first type of data was designed to mainly unearth information about the science educators' background (biography), their subject specialization and their experience as well.

The second type of data was collected with the aid of the pre- and post-test questionnaires. The participants were exposed to the pre- and post-tests. The tests were based on the Grades 8, 9, 10 and 12 syllabi. The questions for setting the tests were drawn from the manuals that contained test and examination questions. Prof. J.J.A. Smit of the Potchefstroom University for Christian Higher Education compiled the manuals mentioned earlier. Other test and examination questions were also taken from the supplementary exercises compiled by Professor Smit and associates (Smit, 1986; Smit and Nel, 1986; Smit, Nel, Du Toit and Vreken, 1989).

Both the pre- and post-tests lasted 20 minutes each.

The audio-tutorial self-study programme was introduced in between the said tests. The programme consisted of the tape recorder, with headphones and the audio-cassette that would be played for approximately one hour.

The participants were expected to respond to the pre-test questionnaire for the set time (20 minutes). They were then exposed to the audio-tutorial self-study programme. The participants were expected to read along as the tape was being played, make some notes (if they wanted to) and respond to the questions at given intervals (they would receive instructions from the tape). The participants would also match their responses to the answers that were provided at the end of the manuals. They were further allowed to work through the manuals at their own pace. Lastly, they were expected to respond to the post-test questionnaire (that is the same set of questions as in the pre-test).

Making use of the pre- and post-test questionnaire provided the second set of data. The researcher aimed at extracting information that pertains to the group's understanding, knowledge and insight of electricity.

The data from the second questionnaire was used to measure the practical significance of the results.

Lastly an evaluation form was introduced to determine the extent of the impact of the audio-tutorial self-study programme on the knowledge and insight of science educators (Appendix 8).

4.7 PROCEDURE

The school management teams (SMTs) of the secondary schools in Kgotsong, Bothaville, were requested, by way of letters (Appendix 1 & 2), to participate in the research. The exercise of collecting data was an activity for a single day.

4.7.1 The first questionnaire

The participants were requested to respond to the questions that were contained in the questionnaire, which was more biographical (see Appendix 3). This exercise was done at the beginning of the exercise of data collection.

The purpose of the questionnaire is as explained in 4.6 above.

4.7.2 The second questionnaire

Questions that appeared in this questionnaire were based on the electricity part of the Grades 8, 9, 10 and 12 syllabi. There was a separate questionnaire for each of the said grades.

The science educators were spread randomly over all the grades in question, with each school represented by at least one educator.

4.7.2.1 The pre-test questionnaire

All the participants were exposed to the questionnaire of the grade they represented. Appendices 4, 5, 6, and 7 are copies of the questionnaire for Grades 8, 9, 10 and 12 respectively.

4.7.2.2 The audio-tutorial self-study programme

Participants were given the audio-tutorial self-study programme based on electricity to work on it after completing the questionnaire in paragraph 4.7.2.1.

The programme was designed by Vreken and Smit (1993:103) for audio-tutorial self-study packets by Romisszowski in 1988. The programme consisted of an audio-cassette, a manual and worksheets. Instructions on the use of the programme were incorporated in the manual.

A programme could be studied independent of a tutor at a pace set by the participant him/herself. A tape recorder of the walkman type was the most technological aid required.

4.7.2.3 The post-test questionnaire

The same questionnaire (see Appendices 4, 5, 6, & 7) that were issued out during the pre-test (see par. 4.7.2.1) were administered again, after the participants worked through the audio-tutorial self-study programme on electricity.

4.8 STATISTICAL ANALYSIS

The raw data was obtained with the aid of questionnaires as explained in the previous section.

The data obtained through the first questionnaire was analyzed by the researcher, whereas that from the second one was processed by the Statistical Consultation Service of the Potchefstroom University for Higher Education, using the SAS computer programme (SAS Institute, 2000).

4.8.1 Presentation, analysis and interpretation of results

4.8.1.1 Interpretation of data for the first questionnaire

Participants were expected to respond to 12 questions that were based on their background, specialization subjects/learning areas, and their experience.

4.8.1.1.1 Interpretation of data for question one

Question one (see Appendix 3) required the respondents to indicate for how long they have been teaching science. Their responses were as follows:

Table 4.1: Respondents' teaching experience

No. of years	0	1	2	3	4	5	6	7	8	9	12
Educators	2	2	2	5	4	3	3	1	1	1	1
%	8	8	8	20	16	12	12	4	4	4	4

Few respondents (12%) had teaching experience that exceeded eight years of teaching science, whereas most (64%) taught science for a period ranging between three and seven years. Some respondents (24%) had an experience of less than three years engaged with the teaching of Science.

4.8.1.1.2 Interpretation of data for question two

Question two (see Appendix 3) was about the respondents' professional qualifications. This is how they responded:

Table 4.2: Educators' professional qualifications

Professional Qualifications	SPTD	STD	STD & HED	BA & HED	Total
No. of educators	6	15	2	2	25
%	24	60	8	8	100

The majority (60%) of the respondents were in possession of Secondary Teachers' Diploma (STD). Some (8%) were in possession of two diplomas, namely, a Secondary Teachers' Diploma (STD) and a Higher Education Diploma (HED). Another 24% of the respondents had a Senior Primary Teachers' Diploma (SPTD).

4.8.1.1.3 Interpretation of data for question three

The participants were expected to mention whether Science was their specialization subject/learning area (see Appendix 3). Their responses were:

Table 4.3: Educators' specialization

Educators	Frequency(f)	%
Specializing in science	17	68
Not specializing in science	8	32

There were many respondents (68%) who specialized in science. About one-third of the respondents (32%) did not specialize in the subject.

4.8.1.1.4 Interpretation of data for question four

Question four (refer to Appendix 3) required the respondents to indicate how they improved their knowledge of science. They responded:

32% responded by indicating that they were doing nothing about improving their knowledge of science. Others (36%) said they read textbooks and literature to improve their knowledge of science. A few respondents (20%) mentioned that they attended workshops if there were any. A further 8% would seek help from their colleagues and only 4% registered with an institution of learning to further their studies so as to improve their knowledge of science.

4.8.1.1.5 Interpretation of data for question five

Participants were requested to indicate how often they attended science workshops (see Appendix 3). Their responses were:

Table 4.4: Educators' attendance of science workshops

Educators' attendance	Frequency	%
Regular	3	12
Sometimes	13	52
Never	9	36

The majority of respondents (52%) sometimes attended Science workshops, whereas 36% never attended any workshop. A handful of them (12%) attended science workshops regularly.

4.8.1.1.6 Interpretation of question six

Question six (refer to Appendix 3) required the respondents to mention how they experienced the teaching of electricity in relation to other topics/divisions of Science. The responses were:

Table 4.5: Respondents' experience of teaching electricity

Responses	%
No response/experience	8
Difficult, confusing & calculations difficult too	16
No problem	8
Interesting & lively	32
Easy & practical	36

A small percentage of respondents (8%) neither responded to the question nor had any experience of the teaching of electricity in relation to other topics/divisions of Science. Another 16% of respondents saw the teaching of electricity in relation to other topics/divisions of science as very difficult, confusing and the calculations also difficult. A further 8% of respondents had no problems with the teaching of electricity in relation to other topics/divisions of Science. Many participants (32%) responded by saying that the teaching of electricity in relation to other topics/divisions of science was interesting and lively. The majority of respondents (36%) maintained that the teaching of electricity in relation to other topics/divisions of Science was easy and practical.

4.8.1.1.7 Interpretation of question seven

Question seven (see Appendix 3) searched for information about the learning of electricity in relation to other topics/divisions of Science. The responses were as follows:

Table 4.6: Respondents' experience of learning electricity

Responses	%
I don't know	8
Learners had no experience/basics of electricity	8
Learners experience difficulties/problems	32
Learners find it understandable	20
Learners find it easy & enjoyable	28
Learners find it interesting	4

8% of the respondents indicated that they could not answer the question as they don't know. A further 8% mentioned that the learners had experience of the basics of electricity. The majority (32%) said that learners experience difficulties or problems with the learning of electricity in relation to other topics/divisions of Science. 20% of respondents mentioned that the learning of electricity was understandable in relation to the learning of other topics/divisions of Science. Another 20% of respondents also mentioned that the learning of electricity was easy and enjoyable in relation to other topics/divisions of Science. 4% of the learners find the learning of electricity interesting in relation to other topics/divisions of Science.

4.8.1.1.8 Interpretation of question eight

Question eight (refer to Appendix 3) required respondents to explain to what extent they prepared for electricity lessons. Their responses were:

Table 4.7: Respondents' extent of preparing for electricity lessons

Responses	Frequency	%
No preparation	12	48
Prepared to a greater extent	5	20
Prepared every day	3	12
Prepared concept by concept	1	4
Prepared every time before a lesson is developed	4	16
Total	25	100

The majority of the respondents (48%) mentioned that they had no experience of preparing for electricity lessons because they didn't know how to prepare for the said lessons. Some (20%) said they prepared for electricity lessons to a greater extent. Others (12%) indicated that they prepared every day for electricity lessons, whereas very few (4%) said they do it concept by concept. 16% of the respondents mentioned that they prepared for electricity lessons every time before the presentation of the lesson.

4.8.1.1.9 Interpretation of data for question nine

In question nine (see Appendix 3) the respondents were required to indicate to what extent they used teaching aids when presenting electricity lessons. The responses were as follows:

Table 4.8: Respondents' extent of using teaching aids

Extent of using teaching aids	Frequency	%
Nothing/no response	3	12
Other responses	12	48
Use aids if necessary	3	12
Use aids very seldom	2	8
Use aids often	2	8
Use aids not so much	2	8
Total	25	100

The majority of respondents (48%) provided inappropriate responses to their use of the teaching aids when presenting electricity lessons. Some respondents (12%) did not respond or said they did nothing with regard to the use of teaching aids when presenting electricity lessons. Another set of respondents (24% in total) indicated that they used teaching aids quiet often, very seldom or not so much.

4.8.1.1.10 Interpretation of data for question ten

Respondents were required to mention the type of teaching aids they mainly used in electricity lessons (see Appendix 3). Their responses were:

Table 4.9: Types of teaching aids used by respondents

Type of teaching aid(s)	Frequency	%
Electricity kit	16	64
Magnets	3	12
Non – conductors	1	4
Textbooks	2	8
Transformers	1	4
Visual aids	1	4
Van der Graaf generator	1	4
Total	25	100

Many participants (64%) mainly used the electricity kit provided to schools in developing electricity lessons. Some (12%) used magnets and others (8%) textbooks as their main teaching aids in electricity lessons. A few (4%) either used non–conductors, transformers or visual aids.

4.8.1.1.11 Interpretation of data for question eleven

Question eleven (see Appendix 3) required the participants to indicate whether it was possible to conduct experiments when teaching electricity. They were also expected to provide motivation for their responses. The responses were:

Table 4.10: The respondents' possibility of conducting experiments

Response	Frequency	%
Yes	22	88
No	3	12
Total	25	100

The majority of respondents (88%) showed that it was possible to conduct experiments when teaching electricity. 8% of those whose response was “no” provided no reasons, whereas 4% (one respondent) mentioned that the school laboratory was burnt down. Those who responded by “yes” were further requested to indicate how often they would conduct experiments when teaching electricity. Their responses were the following:

Table 4.11: The frequency with which the respondents would conduct experiments

How often	Frequency	%
Every lesson	6	27
Once a week	6	27
Seldom	10	46

The majority of the respondents (46%) seldom conduct experiments when teaching electricity lessons. Half of the remaining 54% would conduct electricity experiments during every lesson and the other half once a week.

4.8.1.1.12 Interpretation of data for question twelve

Question twelve (see Appendix 3) required respondents to provide any other comment on the teaching of electricity. The responses were:

16% of the respondents did not respond to the question, whereas 8% mentioned that it was irrelevant to teach electricity. 20% indicated that there was a serious shortage of facilities when it comes to the teaching of electricity. A further 20% said the Department of Education should provide the necessary equipment for the teaching of electricity in schools. A few respondents (8%) indicated that it was not possible to teach some electricity concepts. Another 12% indicated that workshops should be held regularly for science educators to be able to improve on their teaching of electricity lessons. Only 16% of the respondents mentioned that the teaching of electricity was easy and practical.

4.8.1.2 Interpretation of data for the second questionnaire

The participants were provided with sets of questions based on the syllabi for grades 8, 9, 10 and 12. The purpose of extracting information by way of a pre- and post-test questionnaire was as explained in paragraph 4.6.

The data collected was processed with the assistance of the Department of the Statistical Services of the Potchefstroom University for Christian Higher Education, whereby the computer programme performed the TEST procedure of SAS System for Windows Release 8.01 (SAS institute, 2000; Steyn, 1999).

The Department of Statistical Services mentioned earlier could not do a t-test for the data collected. They said the entire group that served as a sample was too small. An effect size was calculated to determine the practical significance between the pre – and post-test scores as follows:

$$d = \frac{X1 - X2}{S}, \text{ where}$$

d = effect size
X1 = mean of post-test
X2 = mean of pre-test
S = largest standard deviation between that of pre- and post-tests.

If d = 0,2 then there is a small effect
d = 0,5 then there is a medium effect
d = 0,8 then there is a large effect
If d > 0,8 then the difference between the means is practically significant.

Table 4.12: THE MEANS PROCEDURE

Variable	N	Mean	Standard Deviation	Minimum	Maximum
Pre – test	25	28.240	16.470	3.00	61.00
Post – test	24	45.375	21.311	10.00	78.00
Difference	24	17.083	13.200	-18.00	43.00

$$d = \frac{45,375 - 28,240}{21,311} = 0,804$$

The difference between the pre- and post-test is practically significant. This means that the audio-tutorial self-study programme had a very high impact on the knowledge and insight of the respondents. The introduction of the audio-tutorial self-study programme tremendously improved the knowledge and insight of the science educators that participated in the study.

4.8.1.3 Interpretation of data for the evaluation form

The participants were lastly given a questionnaire (refer to Appendix 8) so that they could evaluate the impact that the audio-tutorial self-study programme and on their knowledge and insight of electricity. Their responses were:

In responding to (a) some indicated that they needed to prepare for the questions before they could answer them. Many of the respondents mentioned that the questions were initially difficult, but after going through the audio–tutorial self-study programme found them to be easy. Others said the questions were standardized. A few indicated that they were very easy. A fraction indicated that they were either good, relevant, promising and/or challenging.

Above 70% mentioned that the audio–tutorial self-study programme could be used for both revision and developing electricity lessons. This was a response to (b):
On (c) many of the respondents settled for using the audio–tutorial self-study programme for one hour, two hours or half an hour.

In response to (d) more than 60% of the respondents indicated that the audio–tutorial self-study programme would be suitable for developing lessons in electricity. Around 30% of them said it would be suitable for revision.

A response to (e) was an overwhelming 64% that saw the audio–tutorial self-study programme as a tool for enhancing the teaching of electricity. They mentioned that it will help educators to acquaint themselves with outcomes-based education (OBE); it enhances teaching; it explains electricity concepts thoroughly; it develops study methods; it is understandable; it improves lesson preparation; it promotes listening skills; it allows some playback to repeat a lesson.

A few responded to (f) by saying the audio–tutorial self-study programme is time-consuming. Some mentioned that it gives no room for conducting practical sessions. Many (40%) saw nothing wrong with the audio-tutorial self-study programme.

According to some, the merits (g) of the audio–tutorial self-study programme are that: it gives clear explanation on concepts of electricity; it promotes self-study; it develops skills like listening, recording and data collection; it is time-saving; it promotes individualization; it is relevant to the syllabus.

More than 68% of the respondents indicated that their schools would be interested in other audio–tutorial self-study programmes developed for the teaching and/or learning of science concepts.

The respondents furnished the following information about the use of an audio–tutorial self-study programme in the teaching of electricity; it improves language proficiency; it improves the learners’ interest in the subject/learning area; it is easy to handle; it is complementary to the teacher and textbooks; it trains the brain; it develops concentration; it is empowering; it is time-consuming because it is used by one person at a time; it needs thorough preparation.

4.9 CONCLUSIONS

The first questionnaire revealed that there were many respondents (science educators) that were teaching science but lacked the necessary teaching experience and professional qualifications. It was also found that some of the respondents taught science but they did not specialize in it. Furthermore, the majority (64%) attended the workshops regularly or at least sometimes.

Contrarily, few participants found the teaching of electricity interesting and lively. They found the teaching of electricity in relation to other topics/divisions of science easy and practical. The participants also highlighted the fact that the average number of learners understood and enjoyed the concepts that are dealing with electricity.

Just about half (56%) of respondents made lesson preparations before they engaged the learners with the concepts of electricity. All of them used teaching aids, but very few used a variety. Those that used the teaching aids preferred the readily available electricity kit to others. It is ironic that the majority of the participating science educators indicated that it was possible for them to conduct experiments when teaching electricity. The foregoing sentence suggests that the necessary facilities/apparatuses were available at the various participants’ schools, but they failed to conduct experiments during lessons in electricity. It came out loud and clear that most of the respondents would seldom conduct experiments when teaching electricity.

Many respondents, when asked to make general comments, showed no interest in the teaching of electricity by shifting the responsibility to the Department of Education, or by mentioning the shortage of science educators as a scapegoat.

The second questionnaire, made of the pre- and post-tests together with the audio-tutorial self-study programme, revealed that the audio-tutorial self-study programme had a very high impact on the knowledge and insight of science educators who participated in the study. The hypothesis formulated in paragraph 1.4 holds. It may be inferred that the same instrument might have a very high impact on the knowledge of science educators in general, the learners and almost all other people who might be exposed to it.

The respondents indicated through the evaluation form that the audio-tutorial self-study programme made it easy for them to understand electricity concepts, hence they had no difficulties in responding to the post-test questionnaire. The majority of the respondents also felt that the audio-tutorial self-study programme could be used for both revision and developing electricity lessons. The instrument could also be used for enhancing the teaching of electricity. It could further be employed in the implementation of outcomes-based education in South Africa.

The respondents mentioned that the audio-tutorial self-study programme gives clear explanation on concepts of electricity, it promotes self-study, it is time-saving, it develops skills, e.g. listening and recording, and it is OBE compliant. They also said the audio-tutorial self-study programme improves language proficiency, it improves the science educators' interest in the learning area, it is complementary to the educators' handbooks, it trains the brain and it develops concentration.

4.10 SUMMARY

This chapter enabled the researcher to obtain a general view with regard to the science educators' knowledge and insight of electricity.

The first (biographical) questionnaire revealed information pertaining to the science educators' background, their specialization subjects/learning areas and their experience with regard to the teaching of Science. The second (academic) questionnaire specifically tested the impact of an audio-tutorial self-study programme on the science educators' knowledge and insight of electricity. The third questionnaire (evaluation form) sought the reaction (impression) of the participants about the audio-tutorial self-study programme.

The next chapter will concentrate on the findings, suggestions and recommendations that are based on the outcomes of this investigation.

CHAPTER FIVE

5. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

One of the aims of this study was to determine the knowledge and insight of science educators regarding electricity. A literature review was done in Chapters Two and Three.

Chapter four focused on the main aim of the study that was to determine the impact of the audio-tutorial self-study programme on the knowledge and insight of science educators. The topic of electricity was addressed.

This chapter will deal with the findings of all the preceding chapters. It will also enable the researcher to arrive at some conclusions that will appeal for sound recommendations. Areas for further study are also suggested.

5.2. FINDINGS OF THE STUDY

5.2.1. Findings from chapter two

The literature review on the teaching and learning of electricity revealed that both educators and learners encounter very serious problems regarding the understanding of concepts thereof.

According to research literature learners' experience and cognitive factors have a negative bearing on their performance in electricity (see par. 2.6). They know little about electricity and their reasoning is not scientific enough to enable them to make sense of what they are learning in electricity.

Research also revealed that the educators encounter problems with the understanding of concepts of electricity. Most of the educators are poorly qualified. They lack purposefulness in their teaching of electricity. They experience difficulties with the language used as their medium of instruction. They also mention that the textbooks are irrelevant and they cannot conduct experiments (see par. 2.6).

There are far-reaching problems with the teaching and learning of electricity in the secondary schools of South Africa.

5.2.2 Findings from Chapter Three

Literature revealed that not much has been done in the area of in-service education and training for science educators (see par. 3.9). The same goes for the in-service programmes specifically designed for the teaching of electricity.

It has been documented that science educators are positive to the idea that some formal in-service programmes is necessary if they are to teach the new science syllabuses or learning programmes effectively (see par. 3.10). It is important that science in-service programmes should be developed and implemented in secondary schools.

The in-service providers should be drawn from colleges of education, technikons and universities. The non-governmental organizations and the private sector should also work in partnership with the Department of Education to provide in-service education to schools, particularly for the science subjects/learning areas.

The programmes intended for in-service education and training bring disruptions to secondary schools because science educators have to stay away from their classes in order to attend the planned workshops.

Generally the in-service programmes for science educators are minimal or non-existent in some education districts/provinces.

5.2.3 Findings from Chapter Four

5.2.3.1. The biographical/first questionnaire

Although many science educators (64%) have adequate experience with the teaching of science it is disturbing to find that close to a quarter (24%) of the respondents lack it.

The majority of respondents (76%) are appropriately qualified to teach science in secondary schools, but 24% of them is qualified to do so in primary schools. These educators with the primary school teachers' qualifications (SPTD) are teaching Science in secondary schools.

Many respondents (68%) specialize as science educators, but (32%) teach it at secondary schools although it is not their area of specialization.

Only a few (4%) of the respondents are registered with the institutions of higher learning with the purpose of improving their knowledge of science. The rest (96%) are either doing nothing, reading literature or waiting to be called to science workshops.

It was interesting to notice that only a few (12%) of the respondents mentioned that they attend science workshops. The others do so sometimes or they never attend any science workshop. Few respondents (24%) are either indifferent, have no experience of or find the teaching of electricity in relation to other topics/divisions of science difficult. They also mention that electricity had confusing calculations. Nonetheless, the majority (76%) find the teaching of electricity in relation to other science topics/divisions of science very interesting, lively, practical and easy.

Just more than half (52%) of the respondents feel that the learning of electricity in relation to other topics/divisions of science is understandable, interesting, easy and enjoyable. The others (48%) mentioned that they know nothing about the learning of electricity in relation to other science topics/divisions of science. They also mentioned that learners have no basics in electricity. They went further to say that learners experience difficulties with the learning of electricity in relation to other topics/divisions of science.

Nearly half of the group of respondents (44%) do not bother to prepare for electricity lessons. Some (20%) said they do so to a lesser extent. It follows that the majority of the respondents attend their electricity classes without preparing for the said lessons.

Only a few respondents (8%) indicated that they often use teaching aids when developing lessons in electricity. The rest (92%) showed that they tend not to use any teaching aids for electricity lessons, or do so to a very less extent. The majority of those who use teaching aids for lessons in electricity prefer the electricity kit above other teaching aids (see Table 4.9).

The majority of respondents indicated that it is possible to conduct experiments when teaching about electricity (see Table 4.10). Contrarily, they also showed that they seldom conduct experiments in electricity (see Table 4.11).

Only a few respondents are comfortable with their teaching of electricity. The others have various reasons for not indulging with electricity (refer to par. 4.8.1.1.12).

5.2.3.2. The statistical/second questionnaire

The effect size (d) showed that the difference between the tests is of practical significance (refer to par. 4.8.1.2). This means that the introduction of the audio-tutorial self-study programme for electricity had a high impact on the knowledge and insight of science educators.

5.3. CONCLUSIONS

The literature study showed that there are serious problems with the teaching and learning of electricity (see Chapter Two and par. 5.2.1).

Chapter Three further revealed that less or no in-service programmes were put in place to correct the imbalances referred to in the preceding sentence.

The chapters on the literature review confirmed that the science educators' knowledge and insight of electricity is wanting.

Although science educators are generally positive about the introduction of some formal in-service programmes for purposes of improving their teaching, the empirical study (see chapter four) enabled the researcher to arrive at the following conclusions for the schools (educators) who took part in the study:

- Under-qualified educators are teaching science in secondary schools.
- Educators who did not specialize in science are allowed to teach it in secondary schools.
- Science workshops are pretty scarce, if there are any. Most science educators never attend any science workshop.
- Science educators are not interested in improving their knowledge and insight of the subject/learning area.

- Educators and learners respectively experience difficulties with the teaching and learning of electricity.
- Educators present lessons in electricity without having prepared for them.
- Most of the science educators do not use teaching aids when developing electricity lessons.
- Many science educators are not comfortable with the teaching of electricity.

All the findings mentioned above could be a manifestation of why science is highly failed, more than any other subject/learning area, at secondary schools within the Republic of South Africa. They also point to the fact that the knowledge and insight of science educators leaves much to be desired.

Finally, the audio-tutorial self-study program has a practically positive impact on improving the knowledge and insight of science educators, on electricity. Improving the knowledge and insight of science educators on electricity, which covers a large area of the science syllabus, will definitely do so to the entire subject/learning area as well. The audio-tutorial self-study programme on electricity can be used to ensure the successful implementation of the outcomes-based education system in South African secondary schools.

5.4. RECOMMENDATIONS

5.4.1. Recommendations for the teaching practice of Science (electricity)

These are the recommendations for improving the general teaching practice which could have a higher pass rate as a spin-off at secondary schools:

- Science educators, and educators in general, should be correctly placed at schools. Criteria for their placement should include, among others, their qualifications and their areas of specialization.
- In-service programs should be developed and rigorously conducted for science educators, with special attention given to electricity.
- Science educators need to be regularly appraised so as to overcome the problem of going to classes without having prepared. This exercise will also address the dilemma of developing science/electricity lessons without teaching aids.

5.4.2. Recommendations relating to the empirical study

The following recommendations are based on the findings of the empirical study:

- The audio–tutorial self-study programme for the teaching and learning of electricity should be used so as to improve the understanding of electricity, thereby improving the pass rate in science in secondary schools.
- Audio–tutorial self-study programmes should be developed for other topics/divisions of Science.
- Audio–tutorial self-study programmes should be developed for other subjects/learning areas.
- The provincial Departments of Education should encourage the use of the audio–tutorial self-study programme in secondary schools of the Republic of South Africa.

5.5. SUGGESTED AREAS OF FURTHER STUDY

The study under review focused on the influence of an audio–tutorial self-study programme on the knowledge and insight of science educators. The research was conducted with specific reference to the science educators' knowledge of and insight into electricity.

The findings in this study point to the fact that a lot of research needs to be done on the following:

- The influence of an audio–tutorial self-study programme on the knowledge and insight of science learners.
- The influence of an audio–tutorial self-study programme on the knowledge and insight of science educators on the other topics/divisions of Science.
- The influence of an audio–tutorial self-study programme on the knowledge and insight of learners on the other topics/divisions of Science.
- The influence of an audio–tutorial self-study programme on the knowledge and insight of both the educators and learners of other subjects/learning areas.

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Appendix 1

P.O. Box 1330
Bothaville
9660

July 27, 1998

To: Principals of secondary schools
Heads of Department (Natural Science)
Physical Science educators

Dear colleagues,

Re: Empowerment of Physical Science educators.

It has been uncovered that Physical Science is one of the 'killer' subjects in our secondary schools of Kgotsong, i.e., learners dismally fail it. Do you concur? Hopefully, **yes!**

To address the imbalance, all science educators at your school are cordially invited to participate in an exercise that aims at their empowerment in this regard.

I therefore humbly request all the science educators at your school to attend the workshop scheduled as follows:

- (1) Date: *To be arranged with individual schools.*
- (2) Time: 14h00-14h30
- (3) Venue: Diphetoho Secondary School
- (4) Agenda:
 - (a) A brief account of the workshop
 - (b) Inputs-questionnaires
 - (c) Next workshop (the last one)

I hope that you will be interested in improving the teaching of science at your school

Kind regards,

Mlungisi Nyamane

Appendix 2

P.O. Box 1330
Bothaville
9660

November 24, 1998

To: Principal
Head of Department (Natural Sciences)
Physical Science educator

Dear colleague

Re: **Physical Science workshop.**

Your school is cordially invited to participate in a second (last) workshop that aims at empowering science educators.

The participants will receive copies of workshop material at the end of the session. This translates into the fact that your school will *only* acquire the audio-tutorial material for the grades in which it will be represented. For practical reasons, *four educators* will be required for your school to acquire the aforementioned sets of audio-tutorial self-study teaching/learning aids.

The workshop will take place under these:

- (a) Date: November 26, 1998
- (b) Time: 08h00-11h00
- (c) Venue: Diphetoho Secondary School
- (d) Program: Available at the workshop

I once again hope that you will honour this invitation and you will assist in the transformation of our education.

Kind regards,

Mlungisi Nyamane

Appendix 3

BIOGRAPHIC QUESTIONNAIRE

All the participants, i.e., science educators present, are kindly requested to respond to the questions that follow underneath. It is further important that the respondents should not write their names on the questionnaire.

1. For how many years are you teaching science? _____.

2. What are your qualifications? _____.

3. Is Physical Science one of your specialization subjects? Yes/No.

4. What do you do to improve your knowledge of Physical Science?

5. How often do you attend science workshops? Never/Sometimes/Regularly

6. How do you experience the teaching of Electricity in relation to other topics/divisions of Physical Science?

7 How do you experience the learners' learning of Electricity in relation to other topics/divisions of Physical Science?

8. To what extent do you prepare for Electricity lessons?

9. To what extent do you make use of teaching aids when presenting electricity lessons?

10. What type of teaching aids do you mainly use in electricity lessons?

11. Is it possible for you to conduct experiments when teaching electricity? Yes/No.

If "No". Why?

If "Yes". How often?

Every lesson/Once a week/Seldom.

12. Give any comments on the teaching of electricity.

Appendix 4

Educator No: _____

Grade 8

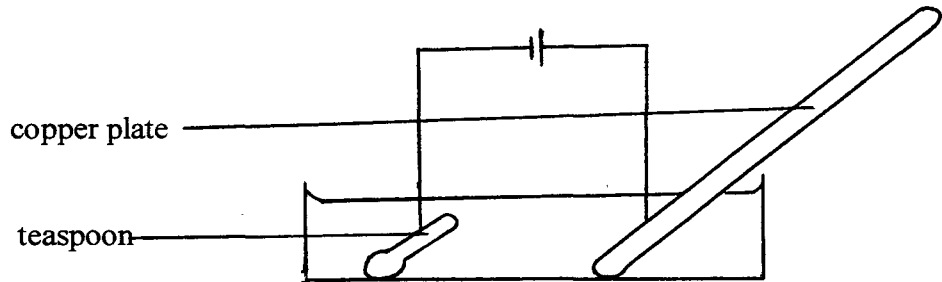
Time: 20 minutes

Questions

Choose the correct answer or complete where needed.

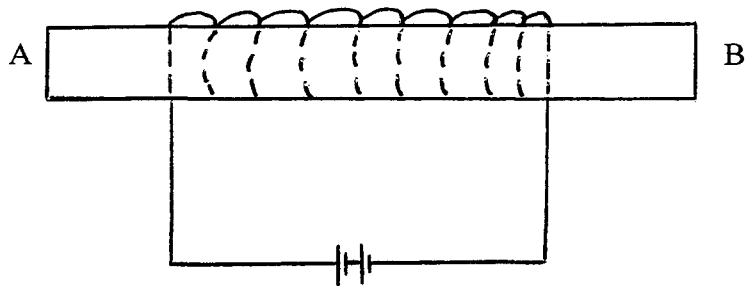
1. The current in a closed circuit is *visible/invisible*.
2. An electric circuit is said to be closed when the switch is *on/off*.
3. To form a battery _____ poles of a cell are connected.
4. A red mark on a terminal of battery indicates _____.
5. The connecting wires of a circuit convey _____ from the cell or a battery to an appliance, e.g. A motor, heater or bulb.
6. Substances like copper wire allow electric current to flow in it and are therefore called _____.
7. Name one practical use of a voltmeter.
8. A bulb is designed to glow at a voltage of 3V. What will happen if it is connected to a:
a: (i) 9V battery?
(ii) 1,5V torch cell?
9. A stronger current transfers _____ than a weak one.
10. The amount of energy carried by the current in a circuit can be increased by connecting cells in *parallel/series*.
11. Consider a battery of two torch cells and three 2V bulbs. Connect first one bulb, then two bulbs in series and the three bulbs in series to the battery. Observe the brightness of the bulb every time.
(i) What do you expect to find?
(ii) Explain your observation.
12. Draw three light bulbs connected in parallel.
13. The higher the resistance of the element of an electric heater the more _____
Will be transferred to it by an electric current in it.
14. What supplies the current (energy) to houses, street lights and electric trains?

15. A metal teaspoon is clipped to a crocodile clip and submerged in a copper sulphate solution. The clip is connected to the negative terminal of a torch cell. A small copper plate attached to the positive terminal is also submerged in the solution. The teaspoon and the plate do not touch each other.



What will happen to the teaspoon?

16. The presence of a magnetic field near a current carrying copper wire can also be established with _____.
17. What is the difference between an electromagnet and a permanent magnet?
18. Current is passed through a solenoid connected to a battery. The magnetic north pole of the electromagnet will be at A/B?



TOTAL: 20

Appendix 5

Educator No: _____

Grade 9

Time: 23 minutes

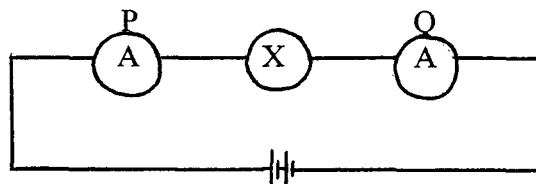
Questions

Complete or choose the correct answer where applicable.

1. You hold a neon lamp near a charged Van de Graaf generator and it lights. Describe the closed circuit the lamp is part of.
2. Substances that can be charged electrostatically by rubbing are *conductors/insulators*.
3. The positive charge on an atomic nucleus is equal to the total _____ of the electrons in the atom.
4. Electric charge cannot be _____.
5. Explain why a metal like copper conducts electricity so well.
6. To charge an electroscope positive, one has to touch the brass disk with _____ charged object.
7. Name the unit of electric current strength.
8. What is the amount of charge passing through in 30 seconds if the current in it is 4A?
9. Two ammeters P and Q are connected as shown in a circuit consisting of a battery and a bulb.

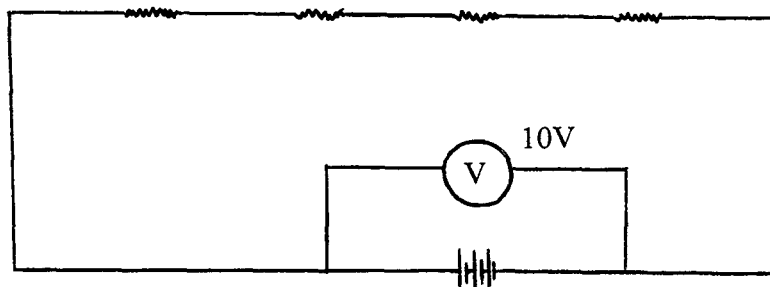
The reading on ammeter P will be:

- (a) larger than that on Q.
- (b) Smaller than that on Q.
- (c) The same as that on Q.



10. A voltmeter connected to a battery reads 12V. What can we deduce from this reading?
11. First one, then two and then three bulbs are connected in series to a battery. What will happen to the current in the circuit with increase in number of bulbs?
12. Resistance is measured in _____.
13. What is the function of a resistor in a circuit?
14. Mention one reason why scientists connect cells in series.
15. If the energy supplied to one coulomb of charge, by a series connection of cells, is compared with the energy supplied to one coulomb, by the same cells connected in parallel, it will be found that the series connection supplies:
 - (a) More energy.
 - (b) The same amount of energy.
 - (c) Less energy.
 - (d) More or less, depending on the current.

16. In a circuit sketched below the voltmeter reading is 10V and all four resistors are similar.



- (i) What will the voltmeter reading across each resistor be?
(ii) How much energy will be transferred to each resistor by one coulomb of charge?
17. What precautions would you take when replacing the blown fuse of a TV set?
18. Which two wires, inside the three-core electric cable attached to an overhead projector, form part of a closed circuit?
19. What will happen if too many appliances are worked from the same three-pin socket?
20. There is a current of 10A in a conductor. The charge passing a point in the conductor in 5s is
(a) 10C
(b) 5C
(c) 50C
(d) 2C
21. A charge of 30C flows past a point in a circuit in 10s. The magnitude of the current is
(a) 300A
(b) 1/3A
(c) 3A
(d) 30A
22. There is a 2A current in a bulb connected to a 12V battery. The resistance of the bulb is
(a) 24
(b) 6
(c) 2
(d) 12

TOTAL: 23

Appendix 6

Educator No: _____

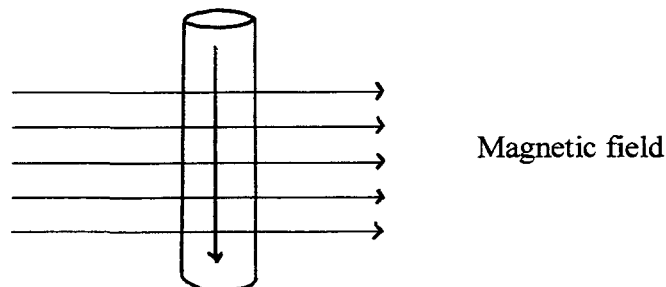
Grade 10

Time: 25 Min.

Questions

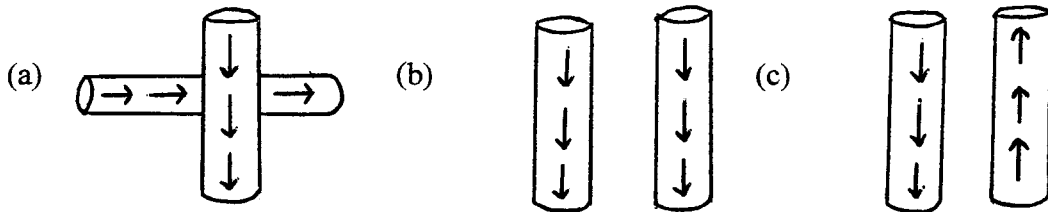
Complete or choose the correct answer where applicable.

1. In any electric appliance _____ energy is converted to other forms of energy.
2. Current is regarded as a flow of _____ charge.
3. One uses the relation: amount of charge = current X _____.
The relation in symbols is $Q =$ _____.
4. Why does a bulb glow when there is current in it? It glows because
 - (a) Charge is converted to light by the bulb.
 - (b) The charges transfer energy to the bulb.
 - (c) Current is consumed by the bulb.
 - (d) Energy is consumed by the bulb.
5. On a bulb is printed 12V. What does this mean?
6. The number of joules of energy transferred by one coulomb of charge when it moves from one point to another in a circuit is called the _____.
7. Emf is associated with the *loss/gain* of energy by a charge.
8. The resistance a battery offers to the flow of charge through it is called the _____.
9. A potential difference of a hot tray is necessary to maintain a current of 2A. The resistance of a hot tray is _____.
10. A fuse is an application of the _____ effect of an electric current.
11. Which rule does one use to determine the direction of magnetic field lines around a current-carrying conductor?
12. A piece of iron is inserted in a current-carrying solenoid. What will happen to the solenoid's magnetic field?
- 13.



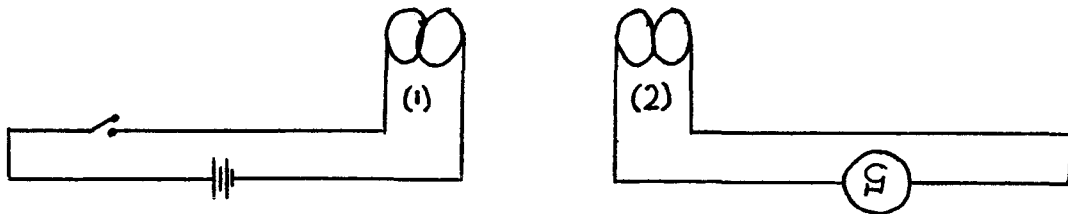
A current-carrying conductor is placed in a magnetic field as sketched above. In which direction will the conductor move?

- (a) To the left. (c) Out of the paper, towards you.
 (b) To the right (d) Into the paper, away from you.
14. Consider the following three configurations of current-carrying conductors.



The force between the conductors is attractive in: (a), (b) or (c).

15. Electromagnetic induction is the phenomenon in which a changing magnetic field induces an _____.
16. Two coils are set up close to each other as sketched below. Coil 1 is connected to a battery and a switch and coil 2 to a galvanometer.



If the switch is closed the galvanometer needle will

- (a) Momentarily show a reading and return to zero.
 (b) Show no reading, because there is no battery in its circuit.
 (c) Be deflected and continue to show a reading.
 (d) Move to and fro.
17. The function of any transformer is to
 (a) Produce electric energy.
 (b) Convert energy.
 (c) Produce a direct electric current.
 (d) Increase or decrease voltage.
18. The secondary of a transformer gives _____ energy.
19. In a step-down transformer the primary voltage is _____
20. A current of 4A flows in a conductor. The amount of charge flowing past a point in the conductor in 20s is
 (a) 80C (c) 5C
 (b) 0,2C (d) 24C
21. Three resistors with resistance 1Ω , 2Ω , 3Ω respectively, are connected in series with a 6V battery (Ignore the internal resistance of the battery). Calculate:
 (a) The total resistance of the resistors.
 (b) The current flow in the circuit.
 (c) The potential difference across the 2Ω resistor.
 (d) The energy transferred to the 2Ω resistor in 20s.

TOTAL: 25

Appendix 7

Educator No: _____

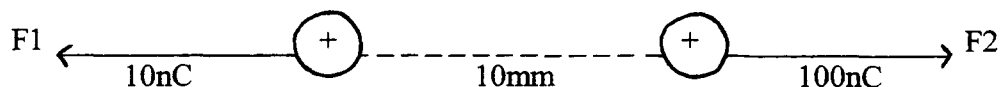
Grade 12

Time: 26 minutes

Questions

Give the correct answer or complete where needed.

- Two positive charges of 10nC and 100nC are 100mm apart. The forces on the two charges are denoted by F1 and F2 respectively.



Calculate the magnitude of the forces F1 and F2.

- Name any type of force that you have encountered with in physics.
- Explain what an electric field is.
- An electric field line gives (Choose the correct answer/s)
 - The direction of the force on a positive test charge.
 - The magnitude of the force on a positive test charge.
 - Both the magnitude and the direction of the force on a test charge.
 - The magnitude and the direction of the force on any charge.
- Why is an electric field line always perpendicular to the surface of a charged conductor?
- What is the force exerted on a 10C charge in an electric field with strength 10N.C?
- Draw a rough graph of electric field strength E against distance r from a negative point charge Q.
- What does it mean when one says the potential difference between two points in an electric field is 200V?
- Complete: the conventional current is regarded as a flow of _____ charges in a conductor.
- The sketch below shows a cross-section of two parallel current-carrying conductors. The currents are directed towards you.

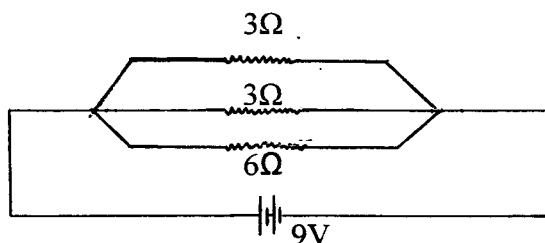


Draw the magnetic field lines of the two current-carrying conductors.

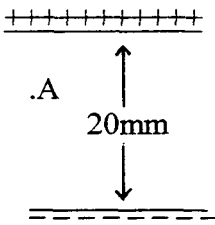
11. If you compare the relations between distance and force in the equation representing Coulomb's law to $F = \frac{kQ_1Q_2}{d^2}$, what is the difference?
12. The formula $F = \frac{kQ_1Q_2}{d^2}$ is used to define the _____ (name the unit).
13. What is the primary function of any electric circuit?
14. Name one source of emf.
15. Why do scientists define quantities like resistance, emf and potential difference?
16. Is the resistance of a resistor a constant, like the mass of a body?
17. The table below gives the results of an experiment where the current in a conductor was measured at different voltages.

Voltage(V)	Current(A)
2,0	0,26
3,0	0,38
4,0	0,50
5,0	0,62
6,0	0,74

- (a) Draw a graph of voltage against current.
- (b) Why do all points not lie precisely on a straight line?
18. Three resistors of 2Ω , 3Ω , and 6Ω are connected in parallel and to a 9V battery.



- Neglect the internal resistance of the battery and calculate the smallest current in a branch.
19. The potential difference across a light bulb is 220V. We can deduce that one coulomb of charge, when going through the bulb will transfer _____.
20. Choose: ESCOM generates AC/DC.
21. What is the magnitude of the repulsive force between two bodies with charges of $10\mu\text{C}$ and $100\mu\text{C}$ respectively if the bodies are 10cm apart? ($k = 9 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$).
- (a) $9 \times 10^{10} \text{ N}$
- (b) $9 \times 10^9 \text{ N}$
- (c) $9 \times 10^8 \text{ N}$
- (d) $9 \times 10^2 \text{ N}$

22. A point charge of magnitude $3 \times 10^{-9} \text{C}$ experiences a force of $12 \times 10^{-6} \text{N}$ at a point A in an electric field. The magnitude of the electric field strength at A is
- $3,6 \times 10^{-1} \text{V.m}$
 - $0,25 \times 10^{-3} \text{V.m}$
 - $4 \times 10^{-3} \text{V.m}$
 - $4 \times 10^3 \text{V.m}$
23. A small oil droplet A of weight $3,2 \times 10^{-13} \text{N}$ carries 5 electronic charges. The droplet is between two flat parallel, horizontal plates as shown in the diagram. The plates are 20mm apart. The potential difference required to keep the droplet in equilibrium is
- 2 000V
 - 3 200V
 - 5 000V
 - 8 000V
 - 20 000V
- 
- $(e = 1,6 \times 10^{-19} \text{C})$
24. Two circular coils each of radius $7/22 \text{m}$, consist of a single winding of copper wire each. The coils are placed opposite each other so that the distance between the windings is 1mm everywhere. What is the magnitude of the force that the coils exert on each other if they each carry a current of 4A?
- $6,4 \times 10^{-3} \text{N}$
 - $6,4 \times 10^{-2} \text{N}$
 - $6,4 \times 10^3 \text{N}$
 - $6,4 \times 10^4 \text{N}$
25. When 2C of charge flow through a resistor, the charge transfers 3J of energy to the resistor. The potential difference across the resistor is
- 1,5V
 - 2V
 - 3V
 - 6V

TOTAL: 26

Appendix 8

EVALUATION FORM

- (a). How did you find the set of questions that was issued at the beginning and end of the session (e.g. difficult, easy, etc.)?

- (b). If your school happens to be in possession of this audio-tutorial self-study programme, will you use it for revision only, or for teaching as well?

- (c). How much time would you allocate to the learners for using the audio-tutorial self-study programme?

- (d). Is the programme suitable for the actual development of the lessons on electricity or is it strictly for purposes of revision? Elaborate.

- (e). In your opinion, will the audio-tutorial self-study programme enhance your teaching of electricity? If so, how?

- (f). Mention anything that you do not like about the employment of the audio-tutorial self-study programme in the teaching of electricity.

(g). What are the merits of an audio-tutorial self-study programme in the teaching of electricity?

(h). Will your school be interested in the other audio-tutorial self-study programmes developed for Physical Science concepts?

(i). Pen down any other information about the use of an audio-tutorial self-study programme in the teaching of electricity.
