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The influence of High School Physics Teachers' beliefs about Physics and Physics Education on alternative conceptions in electromagnetism: A Lesotho study

by

MAKOMOSELA QHOBELA

A RESEARCH REPORT

submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE
(by coursework and research report)

in the

SCHOOL OF SCIENCE EDUCATION

of the

UNIVERSITY OF THE WITWATERSRAND

MAY 1996

ABSTRACT

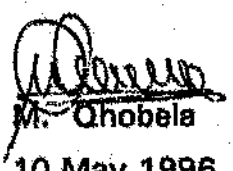
This study was designed to investigate beliefs of Physics Teachers, in Lesotho, about Physics and Physics teaching and their awareness of students' alternative conceptions.

The study used three questionnaires as its research tools. The first questionnaire investigated beliefs of teachers about Physics concepts, particularly electromagnetism, and the teaching of those concepts. An 'index of agreement' was calculated to determine the tendency of responses. The second questionnaire investigated teachers' awareness of students' alternative conceptions, while the third investigated students' alternative conceptions. Teachers' predictions are compared with the students' answers.

The study shows some teachers having beliefs which can be grouped into two categories, namely constructivists and empiricists. There is however no clear separation between the two categories. The study also shows that some teachers are not aware of students' alternative conceptions, while some teachers had the same alternative conceptions as students.

DECLARATION

I declare that this is my own, unaided work. It is being submitted for the degree of Master of Science in Science Education in the school of Science Education of the University of the Witwatersrand, Gauteng. It has not been submitted to any other University.



M. Qhobela

10 May 1996

DEDICATION

This study is dedicated to my grandmother - 'Masetho Bereng

ACKNOWLEDGEMENTS

I firstly want to express my deepest thanks to my supervisor, Mr. Mike Stanton, and my co-supervisor, Dr. A. Zietsman, for their readiness to assist me at all times.

I am grateful to Mr. P. Fridjhon, of the Department of Statistics of the University of the Witwatersrand, for his readiness to assist with statistical techniques that were used in sampling and analysing data.

I am also grateful to teachers, and their students, for agreeing to complete the questionnaires at a time when no one would like to be disturbed by anybody. I am also grateful to 'Maletsela Letsela, 'Mammolaoa Koalepe and Talimo Moshoeshoe for agreeing to collect some of the questionnaires from teachers.

I also want to thank the Government of Lesotho, through its Ministry of Education's Department: National Manpower Development Secretariat, for its financial assistance without which it could have been very difficult to carry out this study.

My thanks are due to all my friends, relatives and everybody who kept praying for me and for giving me moral support. Special thanks to my friend, Selikane Makape, for his encouraging words - Botle ke ho boea le marumo. To him I say 'Tsoara u tiile Mofokeng'.

GOD BLESS YOU ALL

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GOD BLESS YOU ALL

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ABBREVIATIONS

COSC - Cambridge Overseas School Certificate

ECOL - Examination Council of Lesotho

LJC - Lesotho Junior Certificate

MOE - Ministry of Education

NCDC - National Curriculum Development Centre

NTTC - National Teacher Training College

NUL - National University of Lesotho

PSLE - Primary School Leaving Examination

STC - Secondary Teachers Certificate

WITS - The University of the Witwatersrand

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CHAPTER 1

BACKGROUND TO THE STUDY

1.1 General Introduction

1.1.1 Introduction

Over the last few decades there has been a noticeable lack of scientists, technologists and science teachers and yet there has been an increase in enrolment both at the primary and secondary schools (Lewin, 1992; Stoll, 1994). This situation has been more notable in developing countries than in developed ones. On the other hand there has been a strong need for science-based manpower both in the private and governmental sectors in developing countries (Stoll, 1994). The lack of science teachers has led to less qualified teachers taking over in teaching science subjects. This has led to fewer students taking science because sciences came to be understood as difficult. Stoll (1994) argues that '...the appeal of the teacher profession also declined, resulting in weaker students entering teacher education programs.' Research has been done to study the nature of the problem in terms of investigating the kind of knowledge teachers hold (Rollnick and Rutherford, 1990), and the strategies teachers employ, and to seek to find possible remediation strategies that can address those identified alternative conceptions (Rollnick and Rutherford, 1993).

This study adopts the constructivist theory of learning as its fundamental framework. The study is based in Lesotho. Thus the educational background, particularly of Science Education and teacher training, in Lesotho is discussed in Chapter 1. The constructivist theory is reviewed in Chapter 2 where the idea of alternative conceptions is discussed together with the issue of teachers' beliefs. The constructivist framework is used to develop a research tool which is discussed in Chapter 3. Chapters 4 and 5 deal with the analysis of the research results and Chapter 6 discusses conclusions and recommendations.

1.1.2 Aims

The study of alternative conceptions is more often directed towards a deeper understanding of internal and external factors that affect the learning and/or understanding of Science concepts. The study reveals the presence of preconceptions, some of which can be shown to be unscientific. It has a '...potential for revealing how students' knowledge is organised and, therefore, what the content of instruction intended to change it ought to be.' (Dykstra, Boyle, Monarch (1992)). The present study recognises the existence of alternative conceptions as shown by other researchers in different areas of Physics, particularly in electromagnetism. The question that is then crucial to answer is what factors contribute towards the formation of these alternative conceptions. The aim of this study is to investigate teachers' thinking, both about their subject (in this case Physics) and their students.

1.1.3 Rationale

There are many reasons for researching alternative conceptions. Over the last decade much work on alternative conceptions, looking at their causes, nature, and possible remediation, has been done. However the area of electromagnetism, which is most important in Physics, has not received much attention. The researcher comes from Lesotho where he has participated in a pre-entry course and has found students to have an unsatisfactory understanding of electromagnetism concepts. This study will add to the body of knowledge about alternative conceptions in general, but in particular to the area of electromagnetism in Physics. But most importantly it will call for more attention to be paid to towards electromagnetism, an understudied area in Physics Education. It is also hoped that this study will be of help to teachers. The study will, hopefully, alert teachers about the existence of alternative conceptions and their possible effects towards the teaching and/or learning process. It may also encourage teachers to choose teaching strategies that are in agreement with the constructivist theory of learning.

1.1.4 Statement of the problem

Studies done on alternative conceptions in Physics reveal that students hold a wide range of conceptions that are not scientifically accepted. They also show that these alternative conceptions occur world wide. Gilbert, Osborne and Fensham (1982) have shown that teaching which does not take these conceptions into account can end up with undesired outcomes. Therefore awareness of alternative conceptions should be critical in determining the strategies teachers employ in their teaching. Hewson and Hewson (1987) pointed out that '...research into teacher thinking points to the importance of understanding the relationship between how teachers think and what they do.' Teachers' beliefs about Physics and its pedagogy, and the strategies used in teaching, are supposed to have contributed to these unscientific ideas held by students. This research work addresses this problem, with particular focus on electromagnetism.

1.1.5 Research questions

The research questions that will be addressed in this study are the following:

(i) What beliefs about Physics and Physics teaching do high school teachers, in Lesotho, have especially about the teaching of electromagnetism topics taught at high schools?

(ii) What strategies do teachers employ to teach concepts of electromagnetism? and

(iii) Are teachers in high schools, in Lesotho, aware of students' alternative conceptions?

1.2 Background to Secondary Education in Lesotho

1.2.1 Introduction

This study investigates teachers' thinking by looking at their beliefs about their teaching and the conceptions which their students have. Such an endeavour requires the researcher to first look at the general educational background of

these teachers and the kind of Science Education they received. This is done with the realization that teachers entering their training programmes do so with specific conceptions concerning teaching (Weinstein, 1990). Hence the discussion of the general education in Lesotho and more specifically Science Education at the secondary level. The way teachers perceive their subject and the manner in which they teach may be influenced by the kind of training they receive. For that reason the teacher training programmes in Lesotho is worth discussing in some detail.

1.2.2 General Educational Background in Lesotho

Schooling in Lesotho is divided into three levels, namely primary, secondary, and tertiary. The Ministry of Education (MOE, 1994) quotes the *national goals for the primary level*, which lasts for seven years, to include the following:

* ensure permanent and functional literacy in Sesotho, English, and basic numeracy as a function for further learning and effective learning;
* help learners understand, appreciate and conserve their local national environment as well as to be aware of environmental interactions;
* encourage learners to investigate and think for themselves and to test hypotheses as well as to review their assumptions, thus laying a foundation for scientific thinking.

The medium of instruction at primary schools is Sesotho for lower classes, that is, from class one up to class three, and then English for upper classes, class four to class seven (MOE, 1985). However even at the upper classes teachers tend to use both Sesotho and English.

At this level, therefore, pupils are introduced to the school environment and also to the subjects they will meet at secondary level.

At the end of these first seven years of schooling the Examination Council of Lesotho (ECOL) conducts the Primary School Leaving Examination (PSLE) at a national level. Satisfactory performance in that examination qualifies a student

to continue to the secondary level. Those not managing to pass this examination either resit it the following year or leave the system at this point.

The *secondary level* takes five years and is divided into two stages. The first stage takes three years and the last, which is an O-Level, takes two years. During the first three years students are introduced to different subjects including science which combines Biology, Chemistry and Physics. At the end of this period students sit for the Lesotho Junior Certificate (LJC) examinations conducted by ECOL. Having passed this examination, the student then continues to the last two years. This is yet another exit point for those who cannot make it. The science subject is divided into different options including Biology, Chemistry, and Physics. At the end of this level students sit for the Cambridge Overseas School Certificate (COSC) examinations conducted under the auspices of the University of Cambridge in Great Britain. By the end of this five year period it is expected that a student is now ready to either continue to tertiary education or find some employment.

1.2.3 Science Education in Lesotho

Science Education in Lesotho starts as early as the primary level. At this level students are expected to be aware of general basic concepts in science. According to MOE (1985) the *aims of science at the primary level include*:

* To ensure that children develop intellectually by acquisition of necessary skills and attitudes that will enable:
    a) Pupils to make decisions to solve basic problems occurring in a rapidly changing world
    b) School-leavers to perform some simple scientific operations that will enable them to earn a living and become useful members of their society.
* To promote scientific literacy;
* To ensure sound foundation of basic scientific principles and facts in those who may later seek to make a career as scientists, science educators or technologists for the betterment of the economy of the

country and improvement of living standards.

Topics are introduced in the form of units from Class 1 to Class 7. At the end of Class 7 pupils are expected to have been introduced to concepts such as living and non-living things, soil, water, animals, plants, common substances, changes, air, simple machines, friction, heat, light, electricity, magnetism, and the solar system. This means, therefore, that as early as this level some basic concepts in Physics have been introduced. It is however crucial to note that the actual practice is by far below the expected levels at most schools. Middleton (1990) has noted that although the syllabus encourages teachers to use activity methods this does not happen. He explains this in terms of the lack of confidence of teachers and large class sizes. Poorly equipped classrooms and unavailability of laboratories and libraries should also be added to Middleton's (1990) list.

The Ministry of Education has a department, the National Curriculum Development Centre (NCDC), which, through its Science section, holds workshops and produces necessary teaching materials for teachers at this level.

At the secondary level students are introduced to further scientific concepts. The aims of science at the secondary level, at least LJC level, according to MOE (1986) include to:

* develop the scientific skills of observation, estimation, measurement, experimentation, construction, interpretation and analysis of data, inferring, hypothesising, predicting, scientific communication and thinking;
* be able to solve problems scientifically;
* acquire knowledge and understanding of basic scientific concepts and of the practical application and use of scientific equipment, in preparation for life and further training.

The syllabus includes the following sections of magnetism and

electromagnetism from Form A to Form E:

Form A: Magnetic attraction and repulsion: Poles, Magnetic field, Making magnets by stroking, Uses of magnets

Form B: Heating, lighting, chemical and magnetic effects of electrical current, Magnetic induction, Methods of making magnets by passage of electricity (electro-magnets), Comparison of permanent magnets and electromagnets, Uses of electromagnets

Form C: Study and carry out investigations using the electric bell as an application of electromagnets, The electric motor as an energy transfer device(e.g.lifting weights)

Form D: Simple phenomena of magnetism, including properties of magnets, magnetic induction, magnetic screening (shielding), Distinction between magnetic and nonmagnetic materials, Magnetic properties of iron and steel, Factors affecting the suitability of materials for use in permanent magnets and electro-magnets, Magnetic effect of an electric current, Nature of the magnetic field for straight wire, circular coil and solenoid, Practical application as in relays, loudspeakers, Behaviour of a coil carrying a current in a magnetic field, Moving coil instrument; D.C. motor, The phenomenon of electromagnetic induction, Qualitative experiments illustrating factors affecting the magnitude and direction of the induced e.m.f., Simple A.C. generator, The transformer (treated as ideal), Transmission of electrical energy, Advantages of high voltage transmission.

Form E: Review of the four years

Most schools, however, do not follow the Ministry of Education's Five Year Comprehensive Secondary Education Programme for the last two forms but rather follow the Cambridge Overseas School Certificate syllabuses, namely 5130 (5146) Additional Combined Science (Double Subject), 5124 (5142) Science (Physics, Chemistry), 5125 (5143) Science (Physics, Biology), 5126 (5144) Science (Chemistry, Biology). Like other developing countries, which at

one stage were under colonial rule, Lesotho has adopted with minimal changes a curricula similar to ones followed by its former colonial ruler, the United Kingdom (UK).

The NCDC has produced the Lesotho Junior Secondary Science materials to meet the needs of the national situation. These materials specifically address the issues of using more practical work, and of simplifying the language used in textbooks, so that learners can easily follow. Middleton (1990) has observed that 'Although there is an emphasis on practical work, especially at the LJC level, many pupils do not have the opportunity to do experiments because of the lack of equipment and consumables, the lack of confidence of their teacher, the time factor and the large class, ' ecially in the lower forms.'

The table on page (11) shows the structure of science education at the secondary level and the possible routes that a student can follow. It will be noted that at the lower level all students are expected to do science while at the higher level students have options. In most cases, however, it is the school administration that decides on which options to offer because of factors such as the availability of equipment and teachers.

1.2.4 Teacher Education

The training of Science teachers in Lesotho is done at two institutions, namely the National Teacher Training College (NTTC) and National University of Lesotho (NUL). Primary teachers are trained at NTTC and at a lower scale at NUL. At NTTC there is no special science training for primary teachers. They are trained to teach a wide range of subjects at a primary level. Science is offered as one of the subjects that these teachers have to do. Within one course of Science they are taught both content and teaching methods. The college prepares students up to a diploma level. As Howes and Stephens (1990) observed, this college trains teachers also on an in-service basis.

The secondary and high school teachers are trained at NTTC and NUL

respectively. The NTTC offers a three year certificate, the Secondary Teachers Certificate (STC), which qualifies a person to teach Science up to Form C. Student teachers are taught both Mathematics and Science (Physics, Chemistry and Biology) and their teaching methods. The course presently takes three years. NUL offers three programmes which enables a student to teach Science at high schools. The first is the Diploma in Science Education (Dip. Sc. Ed.). The programme requires its candidates to do one of the Science courses as a major and thus becomes his teaching subject at schools. This programme takes three years. The second, taking four years, is the Bachelor of Science Education (BScEd). The student takes two teaching subjects. The last is the BSc plus a Post Graduate Certificate of Education (PGCE). The candidate completes a normal BSc programme and then takes a one year training in education.

1.2.5 Problems facing science education in Lesotho

Lesotho, like other developing countries, faces severe problems which have serious implications for Science Education in the country. Kuhn and Rollnick (1993) have noted that the economy of Lesotho is weak. Because of this the infrastructure at schools is poor, that is, in some schools there are no laboratories and no equipment. This of course makes the teaching of Science very poor and encourages rote learning. Kahn and Rollnick (1993) observe that 'Post-independence expansion of the secondary system has not abated, there is a severe shortage of equipment and qualified science teachers and continued dependence on expatriate staff for the schools and for teacher support services.' Most of the qualified teachers leave the country for greener pastures in the Republic of South Africa. The remaining teachers are mostly less qualified. Middleton (1990) shows that they often have no confidence to teach certain topics and perform certain practical work. The other problem is that the curriculum has been adapted from the former colonial ruler, UK, and hence does not necessarily address the problems of the country. Kahn and Rollnick (1993) noted that Science syllabi remain academic and aimed at a minority of the students. The examinations, namely the O-level examinations, are mostly

controlled from the UK. Thus, the country has little control on its Science policy.

1.3 Conclusion

This research project investigates Lesotho science teachers' beliefs about Physics and its pedagogy and the strategies that teachers use in their teaching. The research assumes that these beliefs influence the strategies that teachers use in their teaching and that teachers may pass over their own alternative conceptions to their students.

The chapter discussed Science Education in Lesotho in terms of the kind of training these teachers get from their early days in school up to the tertiary level.

The teachers' thinking is investigated with constructivism as the framework of the research project. The literature review is done in the following chapter.

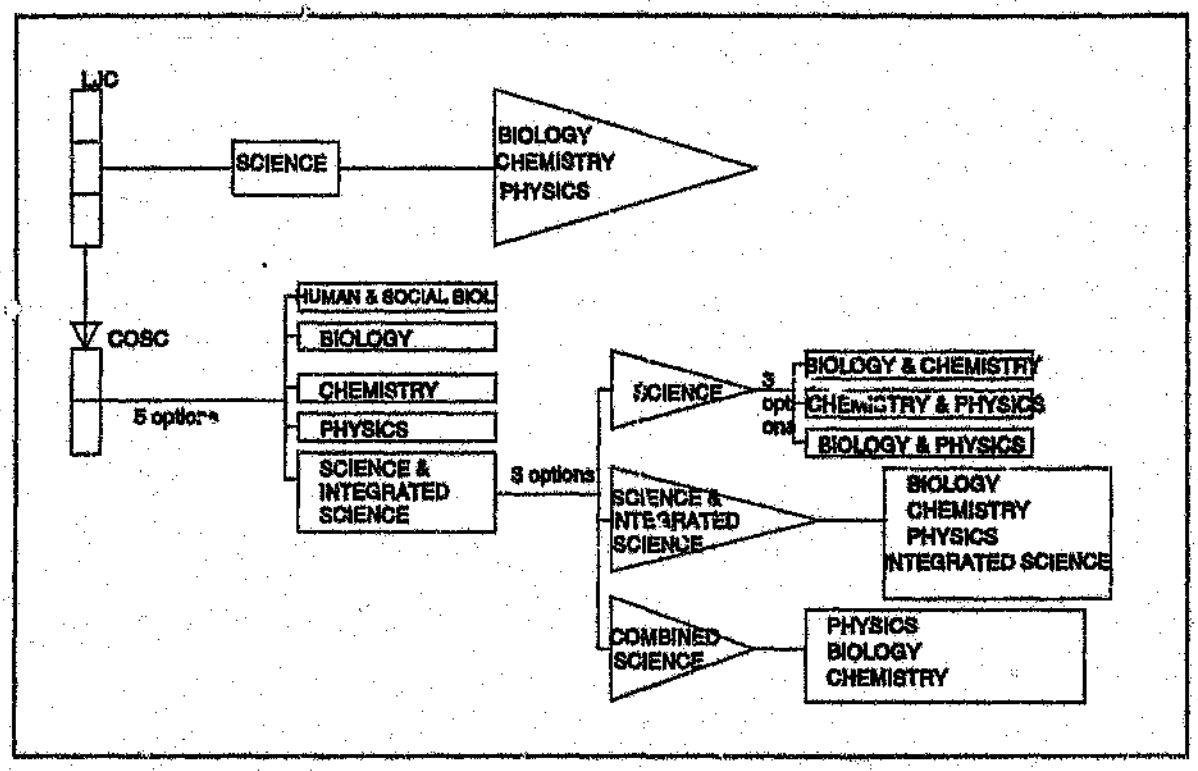


Diagram 1: Five Year Comprehensive Secondary Education Programme

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This research project investigates teachers' thinking and teachers' awareness of the existence of alternative conceptions. The research project has adopted the constructivist theory as the fundamental basis for non-traditional teaching in Science. Thus the following topics were found to be appropriate to be reviewed in this chapter:

* Concepts and concept acquisition
* Alternative conceptions
* Alternative conceptions in electromagnetism
* Beliefs in Science teaching and learning
* Teaching strategies in Science Education

The point of contention is that awareness of alternative conceptions influences teachers to adopt teaching strategies that are directed towards remediation of these conceptions. It is also maintained that such awareness can be measured from the beliefs teachers hold about their students' learning and the subjects they teach, in this case Physics.

2.2 Concepts and concept acquisition

Different researchers define 'concepts' differently. Novak (1977) defines concepts as 'inventions of man used to describe observed regularities in events'. Hewson (1982) studied definitions given by other researchers and concluded that '...all representations of facts and events are defined as concepts.' Howard (1987) defined concepts as '...mental representational of a category, which allows a person to sort stimuli into instances and non-instances.' Stanton (1990) argues that concepts are '...constructs of the human mind, organized around perceptions of objects and events.' Concepts are, therefore, mental understandings a person builds and holds about a particular phenomenon. A person, because of a wide range of factors such as experience and teaching/learning, comes across a phenomenon and mentally forms a picture. This picture remains a representation

of that particular phenomenon from which other pictures of other phenomena develop.

Concept formation starts from early childhood. For example, a child first starts to identify a person as a 'mother' or a 'father' and later as 'brothers' and 'sisters'. The process progresses and refines as the child gets older, but exactly how this occurs has been the subject of ongoing debate over the years. An earlier understanding was that concepts are influenced by the outside world. This inductivist view of science maintained that all knowledge is based on observation (Driver, 1983). The argument was that if under the same conditions one person can observe a phenomenon and that the same observation can be made by the next person then it can be concluded that that is the general behaviour. One of the basic assumptions in this view was that observations will not be influenced by other factors such as the observer's experience, and thus making it an objective process from which Science could be learnt. Because observation was seen to be so important, learners would observe a phenomenon and then from it deduce the general behaviour.

The inductivist theory was criticized on the basis that learning really takes place in the mind where '...theories are not related by induction to sense data, but are constructions of the human mind whose link with the world of experience comes through the processes by which they are tested and evaluated.' (Driver, 1983). The process where mind is the basis of all knowledge forms the fundamental tenet of constructivist epistemology. Watts and Pope (1989) argue that 'people are restlessly proactive - they set about interpreting their own world, they are not just passive recipients of someone else's knowledge.' This process takes place in someone's mind. Stanton (1990) argues that '... concept formation is a mental process and should be peculiar to the individual who is forming the concept.' It is this peculiarity of concepts that necessitates the study of how concepts are formed. The process of concept formation includes making sense of and interpreting the new situation the learner comes across. There must be a situation where there is a change from one idea, which might be a general one and not

necessarily scientifically accepted, to another, which might be a scientifically accepted one.

Understanding constructivism requires an understanding the earlier contributions of psychologists such as Piaget, Ausubel and others whose theories laid the foundation for the constructivist theory (Solomon, 1994; Stanton, 1990). These psychologists were not necessarily interested only in Science Education but rather in education as a whole. Piaget proposed a developmental learning theory where a child is seen to go through four stages of cognitive development. Driver (1983) summarises the Piagetain theory as being based on the '...view that children's knowledge of a progressively more objective kind is constructed through interaction with the environment.' Piaget uses two biological concepts, *assimilation* and *accommodation*, to show that a person assimilates new experiences and then accommodates it to the already existing knowledge. However, it should be noted that what is assimilated does not depend entirely on the environment but also on the experience of the person. Bliss (1995) explains the two terms as follows: 'Assimilation is the activity that permits the gradual incorporation of new ideas and information into a person's mental schemes; that is to say when people tackle new situations they try to incorporate the novelty of the outside world into what they already know and understand....Individuals do not submit passively to such constraints but adjust their thinking, their mental schemes, so that they can deal with these novel ideas and information. Thus, accommodation is the activity of modifying assimilatory schemes.' Driver (1983) and Stanton (1990) agree that what is crucial about the Piagetian theory is the fact that the learner constructs his knowledge through interaction with the environment and the resolution of the cognitive dissonance that may occur between expectations and observations.

Ausubel's Theory of Meaningful Learning assumes that the learner organizes and structures his own knowledge. Ausubel made a distinction between *rote* learning and *meaningful* learning where in the latter the learner relates the new knowledge to relevant existing concepts in his cognitive structure whereas, in the former no relevant concepts are available in the cognitive structure (Driver, 1983; Stanton,

1990). Stanton (1990) argues that the central issue in Ausubel's theory is the process of subsumption which involves an interaction at the interface between the subsumer, the existing or anchoring concept, and the new knowledge. This interaction results in an alteration of both the new knowledge and the subsumer.

From these theories we must assume that students come to classrooms with certain specific ideas already in place, and that these ideas are critical to their learning. This, coupled with the assumption that these ideas are developed mentally by an individual, forms the basic tenet of constructivism. Hewson and Hewson (1988) have summarised the constructivist picture as follows: 'learners actively construct their own new knowledge.... They do this by using their existing knowledge to interpret new information in ways which make sense to them. They build their own conceptual structures in which they incorporate empirical phenomena, concepts, and explanatory patterns.' The role played by instruction must, therefore, be that of reshaping these ideas, in the case where they are not consistent with scientific ones, or totally replacing them. According to the constructivist view of learning, learners construct their own meanings as they experience different phenomena. Fensham, Gunstone and White (1994) argue that this '...constructed meaning depends on the person's existing knowledge, and since it is inevitable that people have had different experiences and have heard or read different things, all have different ... meanings for any concept.' Science educators, therefore, have a responsibility of identifying existing knowledge with the aim of predicting possible(alternative) meanings. Such meanings will be of importance to the teaching/learning process that is to follow.

Not being aware of these possible meanings may result in undesired teaching/learning outcomes. Gilbert, Osborne and Fensham (1982) discuss possible arrangements of outcomes of science teaching between what they termed 'Teachers' Science' and 'Students' Science'. They show that there are at least five possible arrangements, namely

(i) the *undisturbed children's science outcome* where the 'Students' Science' view is not modified by 'Teachers' Science',

(ii) the *two perspective outcome* where the 'Teachers' Science' has been taken only for the purposes of evaluation, while the student holds on to his own 'Students' Science' to explain any other situation,

(iii) the *reinforced outcome* in which the 'Teachers' Science' viewpoint is used to explain a particular situation while the 'Students' Science' viewpoint remains internalised by the student,

(iv) the *mixed outcome* in which both 'Teachers' Science' and 'Students' Science' coexist and

(v) the *unified scientific outcome* where 'Teachers' Science' is completely accepted by the student, to form an acceptable scientific viewpoint.

This last outcome is the one for which any science educator should be aiming. In this outcome the 'Teachers' Science' which is scientifically accepted has been completely accommodated by the student.

Posner, Strike, Hewson and Gertzog (1982) suggest conditions under which the accommodation of new concepts can be achieved. Their theory is based on the understanding that the prior knowledge of people is of critical importance and that this process of knowledge construction is a mental one and peculiar to each individual (Stanton 1990). These conditions are: firstly, students must find *dissatisfaction* with their existing conception. That is, they must feel that their ideas lack the power to explain every situation. They must feel a need to find a new conception that can explain those situations that are not explained by their old ideas. Secondly, they must find the new conception *intelligible*. Students should be able to see how experience can be translated by the new conception to explain what is inherent in it. Thirdly, students must find the new conception *plausible*. They should realize that the new conception explains even those problems that were not explained by the old conception. They must find the new conception to be consistent under any test at any given time. Lastly, the new idea must be *fruitful*. Students must feel that because of this new conception they have more questions and have built up an interest to find out more about the related concepts. Thus the awareness by students of their own ideas and of others is of

critical importance to the constructivist theory.

Hashweh (1986) finds this theory lacking in emphasizing '...distinctions between the psychological processes leading to stability, those leading to change, and the distinctions between these psychological processes and the external conditions related to them.' He suggests three categories of factors that must be identified to explain the process of conceptual change. These categories are:

(i) Factors affecting persistence of preconceptions,

(ii) Factors effecting the acquisition of new conceptions, and

(iii) Factors affecting cognitive restructuring.

The three categories, suggested by Hashweh, includes both the psychological and external factors. These categories must be attended to equally to ensure the process of conceptual change.

There are other researchers, however, who feel that the constructivist theory has not attempted to address problems in Science Education convincingly. Linder (1993) studied Posner *et al.*'s theory and raises some criticisms. Linder argues that the problem of science teaching lies not with the fact that students often reflect alternative conceptions, but with the fact they do not develop new meaningful relationships with the new contexts that are being introduced to them. According to Linder there is a distinction between the mental-model perspective and phenomenographic perspective, where the former looks at conceptions as tangible inside-head constructs, and the latter looks at the same conceptions as being characterizations of categories of description reflecting person-world relationship. Thus, Linder concludes '...instead of depicting meaningful learning in terms of conceptual *change* we should consider depicting it in terms of conceptual *appreciation*....' Solomon (1994) observes two issues that shed light on the apparent weaknesses in constructivism. Firstly, in 1988 Millar raised the argument as to whether constructivism is a method of teaching or a coherent framework: this however had been noted in one of the earliest papers on constructivism by Driver and Easley (1978), so that the issue had not been resolved in the interverning ten years. Secondly, Solomon notes that at the third

conference on Misconceptions at Ithaca NY in 1993 the participants found themselves with no message to pass on to a follow-up meeting.

Osborne (1996) also raises some criticisms of constructivism. Osborne argues that the theory, because it concentrated on the resilience of the learners' beliefs and a social construction of reality, suffers serious epistemological flaws. According to Osborne the theory fails in that it leaves important aspects of how new knowledge is made. Secondly, because of the extent given to personal and social considerations over the obdurateness of the natural world, the theory fails to distinguish between real and theoretical entities. This, therefore, leads to an instrumentalist epistemology and a misrepresentation of the nature of science.

However, fully cognisant of the above criticisms, this research project takes constructivism as its basic framework.

2.3 Alternative conceptions

2.3.1 Defining alternative conceptions:

Most science educators and researchers have found that children hold ideas about scientific concepts that are not necessarily scientific (Shipstone, 1984). This observation has negated the prior notion that children come to classrooms with empty minds. Driver (1983) argues against this 'tabula rasa' idea and maintains that 'From the very earliest days in its life, a child develops beliefs about the things that happen in its surroundings.' Research has further shown that such ideas are not dependent on where the research is done but are universal.

There is disagreement about the use of the terms 'conception' and 'framework' in referring to students' ideas. Researchers such as Gauld (1988) use the term 'framework' to refer to students' understandings as ordered and schematic understandings of a concept. On the other hand, other researchers such as Dykstra, Boyle and Monarch (1992) and Stanton (1990) tend to use the term 'conception' to refer to students' knowledge about how the world works or how it is constituted. Both these terms refer to the ideas of students. Stanton (1990)

has noted that Hewson (1981) preferred the term 'conception' rather than 'framework' because the latter term suggests an organization of ideas rather than the ideas themselves. The same observation has been made by Abimbola (1988) who also argues why 'alternative conception' is a preferred term. However, researchers are in agreement that these ideas cannot or should not be referred to as 'misconceptions' because of the negative connotations of the word. Solomon (1994) observed the message of the first conference on Misconceptions in Science and Mathematics at Cornell University, Ithaca, NY was that 'The students' ideas were not to be considered wrong when compared with accepted ones of science, but only different.' The term 'misconception' has the implication that the idea is wrong. Thus the agreement that the term should not be used to refer to students' ideas. For the purposes of this research report the term 'conceptions' is seen to be appropriate. Thus, by 'alternative conceptions' it shall be referred to those student ideas that are not necessarily scientific.

2.3.2 General features of alternative conceptions:

Alternative conceptions have been shown to be world wide, to be held by students of all ages and not dependent on cultural backgrounds (Thijs and Berg, 1996; Driver, Squires, Rushworth and Wood-Ronbinson, 1994). Driver *et al.* (1994) also show that these conceptions are often universal and not necessarily idiosyncratic. Thijs and Berg (1996) discuss the universality of alternative conceptions in various areas of Physics such as mechanics, heat and temperature, light and electricity. They show that all over the world students harbour the following alternative conceptions:

* In mechanics:
    - (a) Associating force and motion
    - (b) Associating force with a single agent
    - (c) Not differentiating various aspects of motion
* In heat and temperature:
    - (a) Temperature is taken to be an extensive variable rather than an intensive one
    - (b) Lack of distinction between heat and temperature

(c) Perception of heat as material (caloric fluid like Lavoisier)

*In light:

(a) Light is conceived as a source e.g. an electric bulb, an effect e.g. patch of light, or state e.g. brightness

(b) Light is not recognized as a physical entity existing in space between its source and the effect it produces

(c) For luminous objects, vision is explained as light coming to the eye; for non-luminous objects, however, an 'eye is active' model is used

* In electricity:

(a) Many students seem to believe that the same amount of current is supplied by a battery independent of the circuit connected ('Constant supply of current'), and that the current is 'used up' as it flows through the bulb ('Current consumption').

(b) Instead of a way of reasoning where all parts of a circuit are interrelated and influence one another, many pupils think that a change in circuit has only local or sequential ('downstream') consequences.

(c) Clashing currents: In a circuit there are two opposing currents which clash in an appliance or lamp.

Students' ideas have found to be resistant to change. Hashweh(1986) notes that students ideas take the form of procedural knowledge. Solomon (1992) shows that procedural knowledge is embedded in mental programmes and allows people to talk about one thing while doing the other. It is this nature of knowledge that makes students' ideas difficult to change. Students' ideas are also made resistant to change by their origin. For example those ideas that are the result of observation and experience will be difficult to be remediated. Some examples of alternative conceptions that are resistant to change have been given by Thijs (1992):

(a) In a rest situation, no force (or only the force of gravity) are present;

(b) when an object moves at a constant speed, a force is acting in the direction of the motion, which is necessary to overcome counterforces;

(c) a force exerted on an object is imparted to that object as an acquired "impetus";

(d) the impetus of a body will gradually weaken, for example, through friction or gravity; and

(e) an increasing velocity requires an increasing force in the direction of the motion.

Kuiper (1994) studied students' ideas on force from a sample of students from Zimbabwe, The Netherlands, Botwana, Lesotho, Swaziland and Mozambique. The study concluded that 'Though the frequencies with which various incorrect ideas are found might be somewhat different from one country to another, the types of ideas are the same, as are the occurrences of the various clusters of students identified earlier.' This study shows that alternative conceptions are common across cultures even though cultural background will later be shown to be one of the causes of these conceptions.

2.3.3 Origin of alternative conceptions

Students' ideas have been reported to be caused by a wide range of factors that seem to be common to all topics in science, particularly in Physics. Researchers such as Driver *et al.* (1994) and Head (1986) discusses common origins of children's conceptions. Amongst these are experience and observation, language and cultural influence, and textbooks and traditional teaching.

(a) Observation and Experience: Shipstone (1984) and Head (1986) observe that children learn through handling, and that this exercise starts as early as childhood, even before any formal teaching of the relevant subject matter. Driver *et al.* (1994) argues that 'Children's science conceptions are not idiosyncratic nor are they in many cases heavily culturally dependent. They are shaped by personal experience with phenomena.' Hashweh (1986) also support this view. Hashweh argues that most of the preconceptions

students have are a result of experience in interacting with the world. According to him preconceptions take the form of procedural knowledge and because of this alternative conceptions influenced by experience and observation will be difficult to correct. Andersson (1986) suggests a theory which in principle is influenced by the experiences and observations that students make about the world. He argues that in students' observations and experiences there is a common core, an *experiential gestalt of causation*. Its components are agent, instrument and object. According to Andersson in an experiment where students are asked to form an electromagnet the '...battery is the agent, the current is the instrument and the bolt is the object....'

(b) Language and culture: Driver *et al.* (1994) argue that children have, because of language, different ways of thinking and imagination. The crucial role played by language is also observed by Curtis and Millar (1988). According to them '...the learning of abstract scientific concepts depends both on the child's ability to use language to explore his/her existing conception and on the richness of the word-and the idea-associations which the child has with the particular scientific ideas involved.' Gilbert *et al.* (1982) argue that students mostly make sense of what they read or hear about science by using the everyday interpretation of the word. The study of Johnstone and Cassels (1978) also support this view. They found that words which give more problems are not necessarily those that are purely technical but rather those which are in use in normal English language and having specific meanings in science. According to Head (1986) the problem lies with the use of metaphors since metaphorical speech causes confusion because some words may be common to both everyday life and science. Sanders (1988) has noted that one of the problems of language facing Science Education is the fact that words have different meanings even within different scientific disciplines.

Baker and Taylor (1995) reviewed literature on the effect of culture on the

learning of science. They conclude that '...the personal construction of meaning in science is related to the linguistic background of the learner, and to the compatibility of the learner's language with that of science education.' They further conclude that the cultural background of each student has a significant effect on their way of learning and understanding scientific concepts. Thus, the language used both in teaching and in textbooks has direct impact on the nature of the conception a student forms about a particular scientific concept.

(c) **Traditional teaching strategies:** Recent research studies reflect that teachers also hold alternative conceptions (Rollnick and Rutherford, 1990). Jegede (1995) argues that in the African situation teaching is authoritative. He maintains that 'This locus of authority of knowledge is *transferred* into the classroom where the science teacher is seen as the *elder* who *"knows all"* in matters relating to scientific facts, processes, principles, and laws'(emphasis added). Thijs and Berg (1996) notes Prophet's (1988) observation that in Botswana pupils' learning is unreflective and by rote, that they want clear instructions of what they have to do, and that teachers view themselves as authority figures whose word is not to be questioned. It should therefore be expected that teachers can transfer their alternative conceptions to students.

Head (1986) discusses, amongst other factors, the confusion brought about by analogies in science teaching and in textbooks. Head's argument is that analogies remain true within certain limits but teachers and textbooks fail to iterate this phenomenon explicitly to students. Jimenez-Aleixandre (1992) notes that children do not make possible transfer of knowledge to new situations because, amongst other reasons, the lack of attention paid by teachers and textbooks to pupils' own explanations for natural phenomena.

(d) **Other causes:** The three causes discussed above are by no means the only causes. Baker and Taylor (1996) has shown that in addition to culture and

language the traditional explanation, or what other researcher. such as Jegede (1995) refer to as the African view, plays a crucial role in understanding and learning of science, especially in non-Western countries. Head (1986) identifies other features of alternative conceptions. These are the peer culture and the innate origin of some ideas. Eylon and Ganiel (1990) studied students' reasoning patterns in solving problems related to electrostatics. They concluded that students fail to identify the relationship between the microscopic and macroscopic variables and that because of this apparent failure students end up with inconsistent reasoning.

2.4 Students' alternative conceptions in Electromagnetism

Many researchers (Shipstone, 1984; Kuiper, 1994; Watts, 1983; Thomaz, Malaquias, Valente, and Antunes, 1995) have reported that children have a wide range of alternative conceptions in Physics. However relatively few studies have been made specifically in the area of electromagnetism.

Finley (1986) conducted a study which was aimed at determining the extent to which the intended learning was achieved and what conceptual change had occurred after students watched a television programme about magnets. The study looked at the ideas of second-grade students on magnets and magnetic interactions. It reported that some students did not use the intended words such as 'attract', 'repel' and 'magnetic', even though they were in one way or another introduced to them, and emphasis put on the correct usage of the words. It also showed that prior to watching the programme on magnets some of these students compared the strength of the magnet with its size. Erickson (1994) studied ideas of approximately 120 pupils from the Province of British Columbia. He found that younger pupils do not know that a magnet has poles which suggests the possibility that these pupils may not use words such as 'repulsion'. Arons (1990) argues that many children have experienced attraction in playing with magnets and nails, paper clips and so on but are astonished to observe repulsion between two magnets. Arons (1990) further claims that '...one finds expectations such as the repulsion of positive electric charges by north magnetic poles, attraction or repulsion of

stationary charges by the magnetic field around a current carrying wire, and a variety of other nonexistent effects.' He puts the blame on the failure of instruction and warns that '...many students have not developed, in prior experience, sufficient familiarity with electrical and magnetic phenomena to distinguish operationally between them.'

Selman, Krupa, Stone and Jacquette (1982) conducted a study whose purpose was to explore the concepts and thought processes that children of different ages bring to scientific phenomena. They found that students at age 3-9 years explain electromagnets in terms of the wire while older students referred to electricity as the source. These children explain electricity as something in the battery that can go through the wire. Selman *et al.* (1982) study's results may be compared with the Andersson (1986) study. Andersson (1986) reported that students think that if an electromagnet is made with an insulated wire the insulating plastic will not allow contact between the wire and the iron core so that the iron will not become magnetic.

Thus, like in other topics in Physics, the above cited literature provides evidence that students do hold alternative conceptions in electromagnetism. Research does show that the reported alternative conceptions are universal. Herrmann (1991) purports that most students have problems in solving problems related to magnetic field distributions. He puts the blame on teaching.

2.5 Beliefs in Science teaching and learning

The term 'belief' has been defined differently by various researchers. For the purposes of this report Koballa and Crawley's (1985) definition has been adopted. Koballa and Crawley (1985) define the word 'belief' as '...the information that a person accepts to be true....'. Ernest (1989) uses the word to include conceptions, values and ideologies. On the other hand Koballa and Crawley (1985) define 'attitudes toward science' as '...a general and enduring positive or negative feeling about science ' In discussing Koballa and Crawley's definition, Riggs and Enochs (1990) show that while attitudes may be looked at as '...general positive

or negative feeling toward something' they may be '...formed on the basis of beliefs, and both attitudes and beliefs relate to behavior.'

Because of the difficulty in defining what is or what is not 'true' in the social sciences, because of the nature of these disciplines and the processes of teaching and learning, beliefs are, therefore, personal constructs. Nevertheless research shows that there can be *common* beliefs about particular phenomenona, while there might also be many factors that result in people developing *specific* beliefs. Research does show that prospective teachers come for their training with well developed sets of beliefs about what teaching is all about. Weinstein (1990) argues that research reveals that '...preservice teachers enter preparation programs with confidence in their ability to teach ... and a lack of appreciation for the complexity and uncertainty of the teaching-learning relationship.'

The relationship between teachers' beliefs and the process of teaching/learning is an important one, for it is likely to determine the kind of learning that is likely to result. This view is supported by Rich (1990) who writes '...teachers hold beliefs not only about the wisdom and efficacy of specific practices. They also maintain educational beliefs of a more ideological nature that may be directly or indirectly related to teachers' decision making.' Hewson, Kerby, and Cook (1995) further support this view by arguing that the thoughts that teachers have about the content and students they are to teach influence the way they will teach.

Much research has been done to study beliefs of both teachers and students in Science Education. These studies have shown that both teachers' and students' beliefs can influence the teaching/learning process. Pomeroy (1993) investigated beliefs about the nature of science held by a sample of scientists, secondary science teachers and elementary teachers by attempting to establish if there is any differences between how these different samples view the nature of science and Science Education. The study revealed that traditional views of science were expressed mostly by scientists, then by secondary science teachers and least by elementary teachers. The same trend was observed regarding the traditional views

c' Science Education. The study further found that there was a correlation between beliefs about science and science education. Cronin-Jones (1991) studied the influence of science teachers' beliefs on curriculum implementation. The study identified four major categories of beliefs, namely beliefs on how students learn, beliefs on teachers' roles in the classroom, beliefs on the ability levels of students and beliefs on the relative importance of content topics. The study concluded that teachers' beliefs have influences on the curriculum implementation process. Yore (1991) studied teachers' attitudes towards and beliefs about science reading and textbooks. The results of this study revealed that teachers have intuitive beliefs about science reading although they seemed to lack knowledge about many accepted cognitive and metacognitive reading skills. Brickhouse (1989) examined teachers' philosophies of science and their influence on classroom instruction. The results illustrated that these philosophies were consistent with the teachers' instruction.

The studies reviewed above are in agreement with Rich's (1990) conclusion that 'Since teachers' beliefs about specific pedagogical practices are heavily grouped in their personal educational experiences (Guskey, 1986), there is good reason to assert that teachers' ideological beliefs are related, directly or indirectly, to their instructional planning and decision making.'

However, it is noted that other studies have shown negative results. Lederman and Zeidler (1987) showed that science teachers' conceptions do not necessarily affect their classroom behaviour but they would expect other factors such as curriculum constraints and administrative policies to have such influence.

2.6 Teaching strategies in Science Education.

Constructivist theory suggests that students have ideas prior to instruction and that these ideas are often significantly different from the ones that are scientifically accepted and are surprisingly resistant to change (Hewson and Hewson, 1989). The theory calls for teachers to be aware of students' conceptions in order to be able to address them. Ignorance, on the side of teachers, of students' conceptions

can result in undesired teaching/learning outcomes. Researchers in Science Education argue that students' conceptions are of critical importance to the process of teaching and learning. Driver *et al.* (1994) say 'Teachers need to be aware of pupil's existing ideas, of the learning goals and also of the nature of any difference between the two, when they are planning and implementing teaching.' This is in agreement with Ivowi (1986) who maintains that 'Teachers ability to detect misconceptions in their students is ... an essential condition for any possible corrections that may be achieved through instruction.' Studies have been undertaken to find out if teachers are aware of students alternative conceptions.

Berg and Brouwer (1991) studied teachers' awareness of students' alternative conceptions in the area of force and gravity and their teaching strategies used to address these conceptions. The results of that study showed that teachers were relatively unaware of the alternative conceptions students had prior to teaching. It also showed that some teachers had those alternative conceptions themselves. Teachers' strategies reflected in this study were mainly expository, demonstration of the desired conceptions, analogies and questioning coupled with general discussion. The study further revealed that teachers did not meet the conditions suggested by the Posner *et al.*'s (1982) theory of accommodation. Sequeira, Leite and Duarte (1993) reported on the attitudes of science teachers in Portugal towards students' alternative conceptions and the use of teaching strategies chosen to address these conceptions. The study reported that there were some teachers who were aware of these alternative conceptions and their possible negative effects towards students' learning. But on the other hand there were some teachers who were not aware of the existence of alternative conceptions and their possible effects. However even those teachers who were aware of these alternative conceptions did not select strategies that fitted well within the constructivist perspective of science teaching and learning. These studies confirm the results of Arons (1981) and Watts and Zylbersztajn (1981) which indicated that teachers may not be aware of students' alternative conceptions.

Hashweh (1996) conducted a study to ascertain whether or not teachers holding

constructivist beliefs

(a) are more likely to detect student alternative conceptions;

(b) have a richer repertoire of teaching strategies;

(c) use potentially more effective teaching strategies;

(d) report more frequent use of effective teaching strategies; and

(e) highly value these teaching strategies compared with teachers holding empiricist beliefs.

The study showed that, in general, constructivism had a positive influence in all five catagories.

Hashweh had categorised his sample into four groups, namely learning constructivists, knowledge constructivists, learning empiricists and knowledge empiricist. *Learning constructivists* reflect the view that knowledge is constructed by individual. They are aware of students' ideas and their critical role towards the learning process. They acknowledge that teaching must confront students' alternative conceptions. *Learning empiricists* do not believe that students develop ideas in science on their own, and are not aware of the existence of alternative conceptions.

Knowledge constructivists, amongst others, view the aim of science as being to develop theories to understand the world. They believe that scientific knowledge is tentative and invented. *Knowledge empiricists* view the aim of science as collecting facts about the world. They believe that scientific knowledge is objective, permanent and discovered and emphasise the role of observations.

This study, however, showed that the catagories were not mutually exclusive.

Hewson and Hewson (1987) have noted that it is important for teachers to be aware of the role played by students' existing ideas in understanding new material. The possible threat, as illustrated by Hashweh (1996), is that teachers not subscribing to the constructivist ideology are likely not to be aware of students' alternative conceptions, and as a result employ teaching strategies that do not

foster meaningful learning. Studies like Berg and Brouwer (1991) also reveal that teachers have similar alternative conceptions as their students. If this is the case then it might be expected that teachers' classroom behaviour and their teaching methods will be authoritarian rather than constructivist. Some teachers are likely to '...rely on textbooks, emphasize memorization of facts, limit students verbal participation in class....' (Stoddart, Connell, Stofflett and Peck, 1993). Secondly, they are likely to pass over their unscientific ideas to students.

However, it is noted that other researchers in Science Education do not think that 'good science teaching' has to be that which is totally governed by the constructivist theory. Wildy and Wallace (1995) observed that good teaching can be influenced by a number of themes, namely teacher confidence, the structure of the discipline, student motivation, trust, and the cultural context of teaching.

2.7 Conclusions

Constructivism has been found to be an important and fundamental basis for Science Education since the theory can then be used to distinguish between traditional versus nontraditional methods of teaching, as well as to define traditional and nontraditional beliefs about teaching. This chapter showed that children hold alternative conceptions in all areas of Physics including electromagnetism. It also raised the fact that teachers do hold beliefs about the learning of their students and about the subjects they teach. The methods which some teachers employ in their teaching does not follow constructivist principles.

The above literature findings, namely that teachers hold beliefs about their teaching and that their teaching may be at odds with the constructivist theory, are used to develop the research instrument to be discussed in Chapter 3.

CHAPTER 3

RESEARCH DESIGN

3.1 RESEARCH PROJECT

3.1.1 Introduction

The previous chapter discussed the theoretical framework of this study, namely *constructivism*, the fundamental tenet of which is the understanding amongst science educators and researchers that students come to classrooms with already well established ideas about different phenomena, and that these ideas are critical to the teaching/learning process because of their possible influence on the accommodation of new material. The aim of this study is to find out whether teachers are aware of such constructivist ideas, and to what extent this influences their teaching, the learning of their students, and teachers' beliefs about Physics and Physics Education and effective teaching strategies. This chapter discusses the methodology employed to establish data which is to be used to achieve this aim. The research tool used to collect data in this study is a questionnaire.

3.1.2 Sample

The sample consists of one high school Physics teacher from each of 21 different high schools in Lesotho. These schools are chosen from those schools who offer the following combinations of science subjects, as indicated on diagram 1 (page 11): (i) Physics only, (ii) Physics with Chemistry or Biology, and (iii) Combined Science. A list of schools registered by the end of 1994 was obtained from the Ministry of Education in Lesotho. The 21 schools were chosen such that 14 were in the lowlands of the country while seven were in the highlands. This was done with the realization that the situation in both the lowlands and highlands are different in terms of, amongst others, availability of equipment, stability of teachers, number of students and infrastructure in general. The researcher also estimated that in general high schools in Lesotho might be spread in the ratio 2:1. Having divided the schools in these two categories they were then chosen

randomly.

Each of the 21 Physics teachers were asked to complete Questionnaire 1, shown in **Appendix A**, which consists of two sections. **Section A** concerns the background of teachers, while **Section B** investigates the teachers' beliefs. Section B consists of two sub-sections. The first sub-section consists of 24 statements with a six-Point Likert scale given for teachers to indicate the appropriate degree of agreement with each of the 24 statements. The second sub-section is an open ended section where teachers are asked to explain their responses to each statement.

The second part of the study is based on **Questionnaires 2 (Appendix B)** and **Questionnaire 3 (Appendix C)**. Questionnaire 2 was given to 10 of the 21 high school Physics teachers, of which two of them were in the highlands. These are the teachers who agreed to participate in this part of the study. In this questionnaire there are five multiple choice questions where teachers are asked to

(i) tick the correct response,

(ii) choose options that are likely to be chosen by students, and

(iii) explain why they think students will choose that option.

Then the same questions were given to about 200 students from those classes that were taught by teachers who had agreed to participate in this part of the research project. However the questionnaire given to students, (Questionnaire 3; Appendix C, only asked them to tick the correct response.

3.1.3 Questionnaires

Three questionnaires were developed as indicated above. **Section A** of Questionnaire 1 was developed by the researcher and aims at establishing both the qualification and experience of teachers taking part in this study. The section will give information as to whether, given the size of this sample, teachers in Lesotho's high schools are all qualified to teach science, in particular Physics, at high school level and will also indicate teaching experience. Some of the statements of **Section B** have been adopted with minor changes from Pomeroy (1993), while

others have been developed by the researcher. The statements are designed to test the beliefs of teachers on two categories, namely teaching methods in Physics and students' knowledge (with special emphasis on electromagnetism).

Questionnaires 2 and 3 comprise five questions. Some of these questions have been developed by the researcher while some were adapted from Andersson (1986) and Stanton (1993). The main purpose of these questionnaires is to establish whether teachers are aware of the alternative conceptions students hold. Briefly these questions were designed to ascertain the alternative conceptions:

Question 1:	Current flowing in a conductor creates an *electric* field around the conductor. A stationary positive *charge* will either be attracted or repelled by the *magnetic* field around the current carrying conductor
Question 2:	A stationary positive charge is repelled or attracted by north magnetic poles
Question 3:	Attraction is sufficient test for whether a material is a magnet or not.
Question 4:	The presence/absence of *insulation* on a current-carrying wire will/will not allow a core to be magnetised.
Question 5:	a stationary small charged insulator can be repelled by a very large, uncharged stationary conductor

3.1.4 Data Analysis

The study is looking at the existence of traditional or non-traditional beliefs of teachers in Lesotho's high schools towards electromagnetism and its pedagogy, teaching strategies. For this purpose questions in Questionnaire 1 are divided into the following categories:

* **Students' knowledge**

  Traditional teaching vs Non-Traditional teaching
  (statements 1, 15, 18 and 21)
  Teachers' view of electromagnetic concepts

(statements 9, 11, 12, 13, 16, 20 and 24)

* **Teaching Methods:**

  General methods

  (statements 3, 4, 7, 8, 14, 23)

  Use of experiments

  (statements 2, 5, 6, 10, 17, 19, 22)

The data from this questionnaire is then analysed in two ways. Firstly, there is a *quantitative* analysis where the responses are firstly grouped per statement. Then an *index of agreement (IA)* is calculated as follows:

$$IA = \frac{\Sigma ni}{3N}$$

where *n* is the number of teachers choosing one of the six points on the Likert scale, *i* is a multiplier corresponding to the point on the scale as follows: 1 (strongly disagree) corresponds to -3, 2 to -2, 3 to -1, 4 to +1, 5 to +2 and 6(strongly agree) to +3. *N* is the total number of teachers responding to that statement. Division by 3 was done to confine *IA* within the range -1 and +1.

If *IA* is *negative* the sample is assumed to *disagree* with the statement, but if IA is *positive* the sample *agrees* with the statement.

The responses are then categorised according to what each statement is testing and the same procedure as above is followed to calculate *IA*. The value of *IA* is interpreted as above.

The qualitative data is analysed, for each category, by looking at those statements which the researcher found to be agreeing or disagreeing with statements in each

category. The view expressed by the respondent is taken to represent their belief about the issue in question.

The multiple choice questions in Questionnaire 3 are analysed by using a computer program of the Physics Department at the University of the Witwatersrand designed for such purposes. The same data from Questionnaire 2 is analysed by hand by the researcher since these are only ten respondents. The qualitative data from the same questionnaire is analysed by looking at explanations given by respondents to justify their predictions.

3.2 PILOT STUDY

3.2.1 Introduction

Test construction is an important step in performing research since it guarantees the kind of data that the research instrument is likely to produce. It is therefore crucial, even before doing the actual study, to be able to answer questions such as whether the questions are asking for what the researcher wants to establish, and if they do so at the right level. It is also important to establish whether they are consistent in what they ask. These questions of *validity* and *reliability* of questionnaires are crucial. Gay (1981) argues that 'A test is not valid per se; it is valid for a particular purpose and for a particular group.' Comparing the questions with the research aim and target sample was therefore important. A pilot study was therefore conducted.

3.2.2 Pilot Sample

Three male qualified high school teachers were asked to participate at this stage. Two of these teachers were Physics teachers at the Lerotholi Polytechnic's pre-entry course in Maseru. One of them holds a BSc(Ed) degree while the other holds a BSc and a BscHons in Mathematics. The third teacher teaches at the Lesotho Telecommunications Training School and holds a BSc(Ed) degree. Science teachers of senior secondary classes in Lesotho hold these degrees as has been shown in Chapter 1. The three teachers, one way or the other, have experience of high

school teaching and are therefore aware of high school Physics syllabuses. Thus, these teachers represented the population of teachers in Lesotho's high schools satisfactorily. It is, however, acknowledged that some schools may be have less qualified and experienced teachers.

The questionnaires were also given to four experts. Two of these experts hold PhD degrees in Physics and are lecturers at the University of the Witwatersrand. The other two are working as lecturers in the School of Science Education of the same university.

3.2.3 Procedure

The three teachers were given Questionnaires 1 and 2 (Appendices A and B) and asked to

* Respond to all questions;
* Explain whether the questions were clear to them and will probably be to somebody else;
* Indicate any problem they saw with any of the questions

The two Physics experts were to study the second questionnaire and then

* Indicate if there was a correct response for every question
* Indicate any problem they can see with any particular question

The other two science education experts studied the two questionnaires and were asked to make any comments or recommendations.

3.2.3 Analysis

For **Questionnaire 1** the following were studied from the responses of the above "experts":

* whether the questions/statements would be *understood* by teachers. This would be deduced from the responses of the three teachers.
* whether there was any likelihood of a particular question being misinterpreted by respondents. This would be deduced from the experts comments and from the responses of the teachers.

For **Questionnaire 2** the following information was found to be necessary:

* whether the question has one and only one scientifically correct answer. The responses of the scientists was given priority at this stage. Also the purpose of the questions were to be considered for each case.
* whether the other options are possible. The experts' responses together with the teachers' responses would be helpful.

The "experts" agreed that most of the statements in the first questionnaire were clear and that most teachers would understand them and would therefore be able to respond. However two statements were found to be problematic and were accordingly discarded from the list. That left the questionnaire with 24 statements. The second questionnaire was found not to have serious problems except that a few changes regarding wording had to be made.

3.3 LIMITATIONS OF THE STUDY

The nature of this study and the place where it was to be administered compelled the use of questionnaires as its research tool.

Sax (1979) discusses problems relating to the use of questionnaires as a research tool. *Firstly*, the motivation of the respondent is difficult to check. At the time when data collection for this study had to be started, the teacher's union had called for a strike to press for their demands for better working conditions. That strike lasted for approximately two and half months. The administration of the first questionnaire had to be delayed, and then the researcher was limited to those schools which were fully and/or partially functioning. He later visited those that had been closed with the hope of seeing teachers at their homes if need be. This strike had obviously lowered the morale of teachers, and it is possible that in normal working conditions they might have given different information. The use of questionnaires in this study had no way of establishing this factor.

Secondly, Sax (1979) argues the problem of sampling. If all questionnaires are not all returned that causes a possibility of a biased sampling. Because of this and the problem of motivation discussed above the researcher had to go to the schools.

This was done with the realization of Gay's (1981) argument that 'Attempting to travel to each respondent in order to administer the questionnaire is generally impracticable and eliminates the advantage of being able to contact a large sample.' However because of the conditions at Lesotho's high schools at the time each respondent had to be visited. That on its own did not interfere with the sample and sampling method used. Although there are some advantages, the presence of the researcher when respondents complete the questionnaire might have a negative influence, as respondents feel pressurised.

The *third* problem Sax(1979) discusses concerns the issue of mailing the questionnaire. Sax argues that there is an assumption made to the effect that respondents are literate. Researchers often assume that teachers will understand what they are expected to do. It became clear, whilst running these questionnaires, that this assumption is not correct. Some teachers wanted to discuss the questionnaires with other science teachers and give 'theoretically' correct information. In such cases the respondent is not necessarily providing the researcher with what he does but rather with what 'theory' tells him to do. In one school the respondent refused to explain why he was choosing those points, arguing that he was only reporting what other members of the science department were deciding on. It was therefore decided to ignore this teacher and school, and choose another comparable school.

Questionnaires are certainly not the perfect tool. In some cases the respondent just writes 'Not necessarily'. The intentions of such statements can only be assumed. In other cases the explanation given clearly does not agree with the choice of the respondent. The researcher is then compelled to make his/her judgement. Thus in some cases conclusions may be based on information the respondent may not have intended to give.

3.4 CONCLUSION

The study hopes to collect data on beliefs of a sample of teachers from Lesotho's high schools. These beliefs are about their teaching methods and students'

knowledge. Equally important data concern the awareness of these teachers about the conceptions students hold in electromagnetism, which is to be compared with the actual students responses. This data is analysed and interpreted in chapters 4 and 5 respectively.

CHAPTER 4

TEACHERS' BELIEFS

4.1 Introduction

The importance of knowing how teachers think has been discussed by many educationists (e.g. Pajares, 1992). They argue that teachers' beliefs influence their teaching practices. This study is looking into this. Hence the first questionnaire asked respondents to indicate, using a Likert scale, their agreement with a statement and then explain their choices. These responses are analysed in this chapter. It should be noted that not all 21 respondents explained their choices to all 24 statements, but the majority did.

Of the 21 teachers whose responses are analysed in this study 16 were trained teachers. Four of these teachers had not been trained to teach Physics at COSC level: Two were Chemistry and Biology teachers, one had STC and one was an agriculture teacher. The five untrained teachers did however major in Physics in their BSc. The teaching experience (in Physics) of these teachers ranged from two months to twenty years.

4.2 Quantitative data

Table 4 (page 41) shows the responses of teachers on the 24 belief statements in Questionnaire 1. In order to find the general trend of responses, an 'index of agreement' *(IA)* was calculated. A negative index shows a disagreement with the statement while a positive one shows an agreement.

The table reflects that twelve statements (1, 3, 5, 6, 8, 11, 15, 18, 21, 22, 23, 24) had *IA* in the range -0.3 to +0.3. This indicates that, in general, respondents had mixed feelings or no concrete agreement or disagreement with the statement. In such cases it may not be advisable to conclude that teachers hold any specific belief. In some other cases (e.g. statements 2, 7, 10) a clear pattern is shown. Therefore this sample, in some statements, reflects either a traditional view or a

Table 4 - Index of Agreement for statements 1 to 24.

Statements	1	2	3	4	5	6	Total No. Responses (N)	Index of Agreement
1	2	4	2	1	10	2	21	+0.175
2	14	6	0	1	0	0	21	-0.841
3	2	5	5	6	1	1	20	-0.167
4	4	8	3	2	4	0	21	-0.333
5	2	2	4	3	8	2	21	+0.175
6	2	7	3	2	3	4	21	-0.048
7	0	0	1	0	11	9	21	+0.762
8	5	5	2	4	4	0	20	-0.267
9	6	7	2	4	1	1	21	-0.397
10	0	0	0	0	6	15	21	+0.905
11	0	4	2	7	6	2	21	+0.238
12	7	6	1	2	4	1	21	-0.333
13	0	0	0	4	11	4	19	+0.667
14	0	1	1	4	11	4	21	+0.556
15	3	4	2	3	6	2	20	+0.033
16	0	2	0	5	7	6	20	+0.550
17	11	7	0	0	0	2	20	-0.683
18	4	4	5	2	2	2	19	-0.228
19	1	0	0	3	9	3	16	+0.563
20	8	5	2	2	2	1	20	-0.450
21	5	2	3	2	6	3	21	+0.016
22	4	4	4	3	4	2	2	-0.111
23	3	2	3	4	6	1	19	+0.053
24	1	5	2	7	3	2	20	+0.067

non-traditional view.

Tables 4(i), 4(ii), 4(iii) and 4(iv) which follow present the same information as Table 4, but with the index of agreement calculated for different categories, namely traditional teaching, views of electromagnetism, general teaching methods and use of experiments respectively. Table 4(i) shows a negligible *IA*. These teachers, therefore, hold a mixed belief about teaching in general and in particular about electromagnetism. That is, some teachers reflect a traditionally inclined belief while others reflected a rather non-traditional belief.

Table 4(i) - Index of Agreement for catagory: traditional teaching

Responses	1	2	3	4	5	6	N	Index of agreement
No. of Responses	14	14	12	8	24	9	81	0.00411

Likewise, Table 4(ii) also show a very small *IA*. Thus teachers even here hold a mixed belief about electromagnetism. There are those with a constructivist view and others with a non-constructivist view. It is to be expected, therefore, that in classrooms, in Lesotho, some teachers use traditional and authoritarian methods of teaching where emphasis is put on students obeying and accepting the facts as they are told by the teacher, while others use fairly constructivist methods.

Table 4(ii) - Index of agreement for catagory: views on electromagnetism

Responses	1	2	3	4	5	6	N	Index of agreement
No. of Responses	23	27	14	26	36	16	142	0.0211

Tables 4(iii) and 4(iv) shows a similar trend as the above two cases. These tables reflect a mixed feeling about teaching methods and the use of experiments. Thus some teachers hold constructivist views while others hold non-constructivist views in these catagories as well.

Table 4(iii) - Index of Agreement for catagory: general teaching methods

Responses	1	2	3	4	5	6	N	Index of agreement
No. of Responses	23	32	14	21	26	6	122	- 0.153

Table 4(iv) - Index of Agreement for catagory: use of experiments

Responses	1	2	3	4	5	6	N	Index of agreement
No. of Responses	44	30	13	10	26	18	141	-0.210

The sample in this part of the study reflects the existence of beliefs amongst the teaching force in Lesotho. These beliefs are either traditional or non-traditional. The sample further reflects contradicting beliefs about effective teaching methods to be used in teaching electromagnetism. Some teachers tend to believe that traditional methods, such as lecturing, are the most effective, while others tend to indicate a negative belief about such methods.

4.3 Qualitative data

As noted in chapter 3, the statements were developed to reflect either a constructivist view or a non-constructivist view. Thus, for analysis, the responses are categorised in terms of whether the respondents agree or disagree with the statement.

A complete list of all responses to every statement is given in **Appendix D**. In the discussion that follows we have omitted

* responses where there is no useful information given, e.g. 'Not necessarily'.
* responses that are too vague or badly worded to decide the intentions of the respondent.
* responses that are a repetition of a response given by another teacher.

4.3.1 Students' knowledge

4.3.1.1 Traditional Teaching vs Non-Traditional Teaching

Four statements were used to test the beliefs of teachers about effective teaching. These statements are:

1. If there must be a choice between the understanding of concepts, and facilitating the process of self-discovery, then the teacher should rather emphasize the concepts.

15. For students to understand the concept of the magnetic field they must understand Fleming's rules.

18. One of the things that make the concepts of 'magnetic' and 'electric' fields so difficult is the absence of formulae to explain them at Ordinary Level Physics.

21. There is really a need for students to master all the formulae in electromagnetism because it is difficult to learn Physics without mastering such formulae.

Responses from teachers who agree with statement 1

> T7 - Emphasing the concepts as a means to try to open the pupils to discover them themselves actually helps them to better understand these concepts other than when they are just said out and explained to them.
> T10 - This will help students to get better understanding of the subject and also build interest and confidence in them.

These teachers are agreeing that concepts must be emphasised in order to ensure better learning. Thus, according to T10, this will give students confidence and interest in learning science. The belief underlined here is that *emphasising concepts results in better understanding of those concepts.* However, the following teachers choose to emphasise concepts for the following reasons.

> T9 - The concepts should be emphasized even in self-discovery can only be limited by equipment
> T20 - There is lack of equipment for necessary activities and also discovery learning needs a lot of time.

Both see lack of equipment as a major problem, while T20 also argues against self discovery because it is so time consuming.

The common thing about all these teachers' responses is that *teaching should concentrate on emphasising concepts rather than letting students discover things for themselves.* They believe that doing so enhances the learning process and encourages students to learn. It appears that there might be a whole range of

reasons that teachers may cite in support of this perception.

Responses from teachers who agree with statement 15:

> T11 - In connection with electric currents Fleming's rule are very helpful as these is no formula for concluding or some thing.
> T14 - If the rules are understood the concept will understood.
> T22 - This is absolutely correct, demonstration with the left and right hand rules paves way for their understanding.

These responses connect two things, namely understanding of rules and concepts. T11 says that the rules are very helpful and there are no formulae for making conclusions. In other words, T11 believes that after teaching the teacher should summarise the lesson by giving students some rules for future reference. T14 and T22 clearly state that 'understanding of rules helps to understand concepts'. In other words, *teaching should concentrate on teaching rules which in turn will make the understanding of concepts easier.*

Responses from teachers who agree with statement 18:

> T6 - Formulae may help to enhance the understanding from experiments
> T15 - Some simple formulae will be always helpful
> T13 - Students believe that dealing with physics means dealing with formulae.
> T10 - Formulae are really not available but with the help of experiments examples and applications students can understand.

Like the above situation a belief is expressed that formulae play an important role in the understanding of concepts. T6 reflects the importance of formulae in Physics, that is, making concepts easier to understand. Although T10 acknowledges the absence of formulae he thinks the use of experiments and examples can help understanding to some extent.

Responses from teachers who agree with statement 21:

> T2 - Formulae display relationship between quantities very easily.
> T10 - Formulae or mathematical calculations throw more light on

physics problems and hence should be mastered.
T21 - Equations help to remember the factors involved and how they are related.
T7 - Formulae are basically summaries of the concepts dealt with in a topic so understanding them actually makes it easier for one to understand the topic.

These teachers express the feeling that formulae facilitate understanding of the relationship between quantities and as T10 puts it they 'should be mastered'. T7 agrees with T11 (in statement 15 above) that formulae are '...summaries of the concepts dealt with....' The following responses bring another dimension of this belief.

T11 - Formulae and theories work 'hand in' glove.
T16 - Physics is all about formulae and using them.

These responses show the importance of formulae teachers give in the teaching of Physics. T16 expresses this belief categorically, that is, 'Physics is all about formulae and using them.'

Some teachers appear to hold strongly to the above views (e.g teachers T11, T10 and T21). These are traditional views of science teaching where the whole process of teaching/learning centres around knowing facts and being able to master and use formulae to solve problems.

Not all teachers, as is to expected, agreed with all of these statements.

Responses from teachers who disagree with statement 1

T12 - Emphasizing the concepts brings rote learning while self discovery brings in concrete learning and adventure in the world of Physics.
T6 - Emphasis on concepts may at times lead pupils to memorise.
T13 - Students believe that the teacher emphasize the most important concepts.

These teachers raise the fear that emphasising concepts does not foster what Ausubel calls 'meaningful learning' but rather promotes 'rote learning'. T12

compares the advantage of using self discovery and the disadvantage of emphasising concepts. By implication both T6 and T13 believe that students tend to 'memorise' whatever teachers emphasise. The following teachers express the advantage of self discovery

> T5 - Discovery is the best method of making students appreciate learning science.
> T19 - The process of self-discovery promotes original thinking and makes young scientists.
> T22 - When a student is allowed to discover a concept by himself the retention is evalasting, than when the concept is emphasized upon.

The core of these statements is that of *making the learning of science interesting to students and thus encouraging them to find more by themselves.* T5 alludes to making students 'appreciate learning of science' while T19 talks of 'promoting original thinking'. These teachers seem to recognise students ability to learn (in this case Physics) by themselves.

Responses from teachers who disagree with statement 15

> T5 - Flemings rules deal with the motor or generator. Magnetic field is a property of magnets anytime.
> T9 - The magnetic field can be understood very clearly without these rules at High school level.
> T4 - I think they ought to learn about magnetic field before learning Fleming's rules.
> T20 - The rules help to determine the directions in electromagnetic induction. Direction of current or field say, so it does not interact with the learning of magnetic field.

These responses show that some teachers believe that the learning of concepts must come before the learning and use of rules. They express the feeling that the concept of 'magnetic field' can be taught with no reference to these rules and students will still understand.

Responses from teachers who disagree with statement 18

> T5 - We don't need formulae to explain concepts. We use formulae to apply concepts.

T9 - The formulae do not make things clear they only help in calculations. So the problem is experimenting.

The feeling expressed by these teachers is that understanding of concepts does not depend on understanding of formulae. T9 implies that the understanding of 'magnetic' and 'electric' fields is made difficult by the apparent problem in doing experiments. Similar sentiments are expressed by those disagreeing with statement 21.

Responses from teachers who disagree with statement 21

T9 - The students should master the concepts not formulae.
T20 - I think understanding the physical phenomena is more important so that pupils can use the formulae meaningfully.
T13 - Students may master the formulae without knowing what they are doing or looking for.

These teachers believe that students must master concepts rather than formulae, i.e. understanding of concepts must come before the introduction of formulae. T13 warns that it is possible that students know, and can use formulae, without understanding of the concepts. Thus it may be concluded that these teachers believe that *teaching must concentrate on teaching of concepts rather than emphasising rules and formulae.*

The above discussion reflects the existence of two categories of teacher in Lesotho, namely those that can be said to hold non-traditional beliefs about teaching and those holding traditional beliefs. The results agree with Pomeroy's (1992) study where both categories were observed amongst both secondary science teachers and elementary teachers.

4.3.1.2 Teachers' views of electromagnetic concepts

Seven statements were used to test the beliefs of teachers concerning electromagnetic concepts. These statements are:

9. Electromagnetism is the most difficult subject in Physics, and the most

difficult to teach.

11. Students understand the difference between the 'electric' and 'magnetic' fields.
12. It is impossible to demonstrate the factors affecting the magnitude of the emf induced in electromagnetic induction.
13. Students understand the concept of the magnetic field.
16. Distinguishing between the magnetic properties of iron and of steel is easy for students.
20. The transformer is the most difficult topic to teach in electromagnetism.
24. Electric motors confuse students.

Statement 9 gives the picture of the general beliefs of teachers. The following agree with it

> T3 - Due to lack of equipment and limited syllabus - careful not to go beyond the expected.
> T17 - Because it depends on the availability of equipments.
> T20 - This is because there is no equipment to perform necessary experiments to make pupils see and believe what they are told.

According to these teachers electromagnetism may not be difficult but it is certainly difficult to teach because of the absence of equipment. Without practicals it may be difficult to teach electromagnetism. The following express a different view point

> T6 - Most teachers find it abstract
> T19 - A students has to think well to understand the concepts. Many students find it hart to understand the laws of e.m. induction.

These teachers find this topic abstract. Thus their teaching may be affected by this belief. T19, by implication, seem to think that students need to put in extra effort to understand this topic.

Responses from teachers who disagree with statement 9

> T2 - Nuclear physics is more difficult.

T15 - There are more difficult topics viz radioactivity, electronics, etc.
T4 - I think its easy because it can be shown with simple materials, e.g. a torch cell, a wire and a small compass.
T5 - It is infact facinating to students.
T16 - With adequate equipment, electromagnetism can be fun and is not necessarily the most difficult to teach.
T13 - Because a lot of experiments which can be easily done enable the teacher to pass concepts to them.
T10 - The topic seems abstract to students at first but students tend to love it and consider it the easiest in the end.

Teachers such as T2 and T15 feel that there are other topics in Physics that are more difficult compared to electromagnetism. Others feel that this topic is made easy by availability of equipment to do experiments (T4, T13). T10 feels that students tend to enjoy this topic. Regardless of the various reasons teachers may give they seem to all agree that this topic is easy to teach and for students to understand underlying concepts.

The beliefs of teachers are thus divided on this general issue. The remaining statements refer to specific concepts in electromagnetism.

Responses from teachers who agree with statement 11

T20 - The terms themselves are self-explanatory and if explained well students should not have problems in understanding the two. Electric implies charges in contrast with magnetic.
T21 - The causes (source) quite different except the pattens may look alike.
T10 - Experimentally the effects of these fields are understood by students. Students know their existence and how differently they function.

Teachers feel that students are aware of the 'origin' and 'existence' of both 'magnetic' and 'electric' fields. T10 feels that students know the difference between these fields in terms of their effect. T20, however, suggests that '...if explained well students should not have problem....' Thus he feels that students will not have any problem in differentiating between both fields if taught well.

Responses from teachers who agree with statement 12

> T5 - It is difficult to get magnets of different strengths. Also to move the coil at different speeds in the field and detect the current.
> T13 - Because factors affecting the magnitude cannot be seen or be demonstrated.

These teachers in principle accept that it is difficult to do demonstrations showing factors affecting the magnitude of the e.m.f. induced. T13 claims that this is due to the abstract nature of these factors. T5 connects the problem to the absence of teaching aids or equipment for performing practicals, and T4 and T3 concur:

> T3 - Lack of needed equipment
> T4 - All it requires is the right apparatus and correct method(s).

Availability of equipment to perform both demonstrations and experiments appear to be determining factors for these teachers. It is noted, however, that T4 also makes reference to 'correct *teaching* method(s)' which could be used.

Responses from teachers who agree with statement 13

> T9 - This one can be understood as the effects of its presence are clear.
> T10 - Students appreciate the existence of magnetic field and how it functions.
> T18 - Concepts of the magnetic field is the basic idea which needs to explain e.m. induction. Besides that it is a very simple concept in magnetism.
> T17 - They have done this experiment at lower levels.
> T20 - This is because magnetic field can be defined with words clearly.

Teachers believe that this concept is understood for various reasons. Some teachers (T9 and T10) think that students know of the effects of the magnetic field and are aware of its existence, while T20 feels that they should understand because it can be 'defined with words'. T18 considers this to be a 'very simple concept' while T17 alludes to the fact they are expected to have met this concept in the lower classes. Other teachers, however, believe that experiments play an important part in students' understanding of magnetic fields.

T4 - It can easily be shown using a permanent magnet and iron filings.
T11 - Students seemed to understand by aid of experiment and their informal knowledge of action of magnets.

According to these teachers students should be allowed to do experiments on magnetic fields. T4 suggests that students understand this concept if allowed to do experiments using permanent magnets and iron filings and thus observing the patterns formed. T11 acknowledges the influence of 'informal knowledge'.

Responses from teachers who agree with statement 16

T14- Since students will be knowing the difference between iron and steel.
T22 - At senior levels it is not a problem because the percentage of carbon in both iron and steel gives them easy access to their differences in properties.
T20 - This is under the condition that there is use of a simple activity to reinforce the understanding.

Teachers (T14 and T22) are of the view that students know that both steel and iron are of different chemical structure. Then because this understanding students are able to distinguish their magnetic properties. T20, however, thinks that this understanding is enhanced by use of a simple activity.

Responses from teachers who agree with statement 20

T7 - It is not easy for the pupils to understand the stepping up and down of the transformer and this makes it not that easy to teach.
T9 - It is difficult because this emf on the secondary coil is induced and it is hard to understand.
T16 - Sometimes students find it difficult to understand especially because we never do practicals on transformers.

Teachers feel that students do not understand this topic because of the lack of equipment and the abstract nature of the topic. T9, and hence T7 by implication, seem to suggest that the main problems lie in the understanding of the concept of induction. Thus teaching this topic becomes problematic. T13 raises a different reason for the same view:

T13 - Students takes time to understand the difference between d.c. and a.c. so this makes transformers difficult.

Teaching problems revert back to difficulties with pre-requisite knowledge about d.c. and a.c.

Responses from teachers who disagree with statement 24

T15 - They enjoy the expts on electric motors.
T17 - This can be shown to students or demonstrate.
T22 - With thorough basic background on A.C. and D.C.'s motors the student is at safely to watch whatever is required in electric motors

Performing experiments and/or demonstrations appear to be an important factor to these teachers. T15 feels that students enjoy doing experiments on electric motors while T17 feels that demonstrations can be used to explain the concept. Therefore this must be an easy concept which is well understood by students. But T22 stresses that students need to understand a.c and d.c. beforehand.

The general picture in this section is that teachers feel that these concepts of electromagnetism are, to some extent, easy and as a result students understand them well. Understandably their teaching should be influenced, to some degree, by this understanding. However there are some teachers who maintain that these concepts may not be that easy to students.

Responses from teachers who disagree with statement 11

T6 - Mostly they confuse the two
T22 - it indeed poses a strong confussion when these two fields are introduced but with time and through explanations as well as emphasis on direction of flows. This is over(?)
T7 - They slightly confuse the two and it does take them time to make a difference.
T19 - Most students understand mag. field. But tney cannot understand electric fields.
?=what followed was no longer legible

These teachers acknowledge that the difference between the two field concepts

is not clear to most students. T19 feels that students only understand the magnetic field but not the electric field. The following teachers express views that might have implications for their teaching:

> T9 - This are not vissible so they are not very clearly demonstrable
> T11 - Students tended to confuse the concepts. In fact they interchange them without reasons in most cases.
> T13 - Because the properties of electric field enable the students to realise that electric field is due to current.

T9 refers to concepts as not being *visible* and hence not demonstrable. The problem which T9 faces is that many concepts in Physics are not visible but nethertheless they are to be taught. T11 uses the phrase '...they interchange them without reasons in most cases'. T11 cannot see why students do not understand these two concepts *that are clearly different and understandable*. Clearly he fails to see the problems affecting the learning of students. T13 says '...electric field is due to current.' All these teachers reflect some degree of non-constructivist teaching.

Responses from teachers who disagree with statement 12

> T7 - It is easy to arrange such an experiment especially at High school level.
> T18 - It is not impossible - for e.g. increase the no. of turns of coil, use a powerful magnet, insert the magnet with more quickly will help to show the above idea.
> T20 - With well designed activities and suitable apparatus effective demonstrations could be done.

These teachers do not believe that it is impossible to demonstrate these factors experimentally.

Responses from teachers who disagree with statement 13

> T6 - Some find it as something in heaven.
> T14 - Not all will understand it at a go but they need basics.

Clearly these teachers feel that not every student understands the concept of the

magnetic field. However, T14 suggests that to understand, students need to be given 'basics'.

Responses from teachers who disagree with statement 16

> T11 - Some students tend to confuse them.
> T16 - Sometimes it is not so easy for them to understand.
> T18 - It is not quite easy - Most of the students think that there is no difference between iron and steel.

According to these teachers students tend to think that steel and iron are the same materials. Thus because of this confusion they confuse their magnetic properties.

Responses from teachers who disagree with statement 20

> T11 - Most of my students showed enough understanding in transformers.
> T12 - It is easy because there are many physical situations the transformers are used.
> T14 - If electromagnetism is understood there is no way students can fail to understand transformers.
> T19 - The most difficult topics are A.C. and D.C. If a student has understood A.C. he can easily understand transformer.
> T20 - As interesting as it is, the topic is not difficult especially if it is taught to pupils with a good background in electromagnetic induction.
> T10 - It is rather the easiest topic. Students easily understand the concepts and the calculations involved.

Teachers feel that transformers are easy for students to understand. However, pre-requisite knowledge must be understood. According to them (e.g. T14, T19 and T20) understanding these prior concepts paves the way for understanding of transformers. T10 sees transformers as the 'easiest topic'. By implication these teachers see transformers as easy to teach.

Responses from teachers who agree with statement 24

> T2 - More especially if they cannot distinguish concepts of a.c. generator well.
> T12 - There is a tendency for students to a.c generators as if they are

also motors.
T5 - Especially if they have not understood electromagnetic induction. They confuse the two fleming rules.
T14 - Some may be confused if they did not understand electricity and its concepts.
T11 - Too many underlying concepts, lack of teaching equipment.
T20 - This is in a case where there are no apparatus to help students see what is really happening.

Some teachers, e.g. T2 and T12, feel that students tend to confuse electric motors with generators while others, such as T5 and T14, feel that the problem lies with prior knowledge. There are other teachers who feel that one of the contributing factors is the lack of equipment (e.g. T9, T11 and T20).

The above discussion reflects a polarisation of beliefs of teachers about students' knowledge. Some believe that students easily understand electromagnetic concepts, so that there are few teaching difficulties. They believe that teaching always results in desired outcomes. However other teachers believe that electromagnetic concepts are not easily understood by students.

4.3.2 Teaching Methods

4.3.2.1 General methods

Six statements were used to investigate teachers' beliefs about effective teaching methods in Physics, particularly in electromagnetism. These statements are:

3. A big weakness of discovery activities in electromagnetism is the difficulty in getting the children to come up with the right answers.
4. Because of the amount of specific information to be taught in electromagnetism, at least 50% of the course should be given using the lecture method.
7. When teaching electromagnetism the teacher must first find out what ideas students already have.
8. Students do not know any thing about electromagnetism, so the teacher needs to tell them all the basic facts.
14. Electromagnetic induction can best be understood by students if teachers

use demonstrations in their lessons.

23. Because it may not be possible to do experiments with transformers, the equation $V_p/V_s = N_p/N_s$ should just be given to students(where N_p is the number of turns on primary coil, N_s the number of turns on secondary coil, V_p is the voltage(pd) across the primary coil, V_s is the voltage across the secondary coil).

Statement 7 was used specifically to test the beliefs of teachers about the fundamental tenet of constructivism which has direct impact on the choice of teaching methods. Almost every teacher, who responded, agreed with statement 7, thus accepting that in teaching electromagnetism students' ideas must first be identified. Responses are as follows

> T14 - Since they will be taught of the known to the unknown
> T7 - This makes it easier to the teacher to best present the topic to the students in such a way that will help them to best understand it (when the teacher already knows their minds)
> T10 - This will draw the attention of the students to the lesson. The teacher will also know where exactly to start from.
> T18 - This helps the teacher to formulate the method for introducing the concept effectively.
> T20 - This help a teacher to know the level of the pupil and if they have the required prerequisite knowledge. The teacher can introduce the concept from the right place.
> T11 - Electromagnetism is the topic which builds up on some other concept. Therefore it is very important to know the prerequisite knowledge of the pupils.
> T9 - It is of utmost importance to find how much students already know to avoid boring them.

According to these teachers, teaching has to start from the already existing knowledge of students. This helps students to then move from the known to the unknown. Teachers also feel that this will help them to choose appropriate teaching methods (T18). The following responses further show the advantages of knowing students' knowledge before the introduction of a new topic.

> T4 - This will give the teacher an insight as to which areas will require strong emphasis during his teaching
> T16 - This will enable him to structure the work in such a way that

their misconceptions can be rectified.
T19 - This helps the students to memorise the idea which they may have forgotten. It also encourages creative thinking.

It is suggested that knowing students' ideas helps the teacher to address those ideas that need particular attention, either because they are completely wrong or partially wrong (T4 and T16). T19 raises two issues which seem contradictory, i.e. encouraging 'memorization' and 'creative thinking'.

Statements 3, 4, 8, 14 and 23 were used to test teachers beliefs about the teaching of electromagnetic concepts.

Responses from teachers who agree with statement 3

T7 - If the concepts have not been properly emphasized to them, then they will of course have difficulty in getting the right answers.
T12 - This because the field causing the effect cannot be seen and also the electron concept is difficult for students to stick to.
T5 - And also getting the apparatus which work
T13 - Most of the time they don't trust themselves so it's not easy for them to come up with the right answer.

T7 feels that if concepts are not understood by students, then they are less likely to come up with correct answers if allowed to do self discovery activities. Thus discovery activities should be supported by some form of prior knowledge. Some teachers (e.g. T12 and T5) feel that the problem lies with the fact that the concepts in electromagnetism are mostly abstract and the absence of apparatus makes it difficult for students to find correct answers on their own. T15 had this to say:

T15 - In such cases the students will be told to repeat the experiments.

Obviously T15 would like to maintain that students should always come up with right answers or, if not, they should repeat the whole experiment.

Responses from teachers who agree with statement 14

T7 - Pupils can better understand the concepts if they are demonstrated to them when possible.
T14 - Demonstrations in Physics put forth the best understanding of topic not only electromagnetic.
T20 - This is because demonstration is the best teaching method which gives pupils a chance to observe hence improve their understanding.
T12 - This because there are facts which cannot be just comprehended by students by belief but by seeing.
T13 - Demonstrations enable the students to figure out what is going on so teaching becomes easy.
T21 - Precise to the point and no waisting of a lot time

Teachers T7 and T14 think that demonstrations in science teaching simplify the concepts thus making it easier for students to understand them better. T20 considers demonstrations as the best teaching method. The following, even though they are agreeing with this statement, have a differing view:

T2 - Applicable in the case where apparatus are few, but students should do experiments.
T4 - In situations where materials are hard to find, demonstrations can be used. But I believe guided experiments are the best.
T9 - In addition to this the students should do some experiments on their own.

These teachers feel that demonstration is the best method if there is no equipment. However if equipment is available then the best approach will be to let students do experiments.

Responses from teachers who agree with statement 4

T2 - In the case of lack of apparatus and explanation should be done to reinforce concepts.
T18 - Theoretical knowledge is essential to perform the experiments acurately.
T19 - In electromagnetism it is difficult and also time consuming for a student to discover ideas by himself.

Three reasons are advanced for using the lecture method - the need for a strong theoretical framework, the time wasted in discovery activities, and the lack of apparatus.

Responses from teachers who agree with statement 8

> T22 - This is indeed acceptable. By given them the basic facts they are equipped to research and enrich their knowledge further.
> T7 - Telling then the basic facts actually helps in building a strong foundation of electromagnetism which will help them to best understand follow the following presentation of the topic
> T14 - The concepts should be understood so that facilitating can be easy
> T13 - Students become aware of the things concerning electromagnetism if they are told of the basic concepts.

Telling facts has advantages according to these teachers. It helps to form a strong foundation upon which future learning can be based (T7 and T22). It also makes students realize some of the things they were not aware of (T13). Thus these teachers feel that students must be told basic facts about electromagnetism to facilitate their learning.

Responses from teachers who agree with statement 23

> T5 - They have almost always understood it especially when they are comfortable with radios from maths lessons.

This particular teacher does not see any problem with giving students equations as long as they have had necessary skills, from mathematics for example, to be able to handle such equations. Thus, to him what might be important is the ability to solve problems. There are other teachers who feel that there must be an explanation going along with the giving of equations.

> T7 - Through explanation has to proceed the giving of the equation so that they should understand all what they means.
> T13 - At least an understanding is required for the student to accept the equation.
> T18 - Without the basic ideas about the transformers will give the students confusion.

There are also those who feel that it is correct to give students equations because equipment is limited and difficult to get.

> T6 - If transformers are not available

T19 - Transformers are expensive and also they get damaged very often.

Some feel that transformers are difficult to understand, but with a well prepared lecture method students will understand the equations.

T17 - Because it is a difficult topic in physics
T20 - With a well prepared lecture method the concept can be learned very well.

The following teacher feels that students at this level should have enough skills to perform necessary calculations even without doing any experiments. That is, equations can be given to students since they will understand the theory without any problem.

T10 - Physics students should be able to do such calculations and they should know the formula even if they don't go through the experiment.

Agreeing with these statements reflects a traditional way of looking at students, although these teachers gave a feeling that they are aware of students' ideas. They seem to suggest that traditional methods of teaching, such as lecturing, can be used to teach effectively in science. Not all teachers however agreed with these statements.

Responses from teachers who disagree with statement 3

T3 - Though I have not done the expts with my students due to lack of equipment I don't consider the above mentioned as a weakness.
T4 - If the teacher makes sure before hand that the magnets are in good condition, then it is often not difficult for the students to come up with the right answer.
T9 - If they have had enough experimentation they certainly can come up with correct answers.
T10 - With close supervision from the teacher, students can be able to overcome such difficulties.
T11 - In discovery activities students tend to pay much attention to important points.

Teachers believe that in discovery activities students are able to come up with right answers. However T10 feels that in order to do so students need some

supervision from teachers. T4 feels that prior preparation from the side of the teacher benefits students. T11 feels that the advantage of discovery methods is to make students concentrate particularly on important points. T16 has a different opinion:

> T16 - It is not always the case and even if children fail to come up with right answers, the teacher will have the task of showing them why they wrong.

He expresses the responsibility of the teacher in the event that students are not able to come up with the correct answer. That is, the teacher should explain to students where they went wrong and probably convince them why that is wrong. T20 feels that it is not the aim of discovery activities to come up with the right answer:

> T20 - Children do not necessarily need to come with right answers but they need to be given a strong idea through well designed activities.

T20 seems to suggest that discovery activities should not be directed towards getting correct answers as such, but rather towards giving students an appreciation of scientific methods.

Responses from teachers who disagree with statement 14

> T10 - Some of the concepts are not easy to explain to the understanding of the students through mere demonstrations without experiments.
> T11 - Some students may not understand the underlying concepts because demonstrations are done in too big groups.

Demonstrations, as a teaching method, are thought not to be convenient for two reasons: electromagnetic concepts are difficult to be understood by mere demonstrations, and secondly demonstrations are often done to groups that are too big. T10 seems to be more comfortable with the use of experiments as the best teaching method.

Responses from teachers who disagree with statement 4

> T7 - It is not good rushing to finish whatever has to be offered to these pupils before their final examinations. The lecturing method is a disadvantage since they are battling with the language with understanding the material itself.
> T10 - Teachers normally use the method of exposition in this branch of Physics because of lack of sufficient teaching aids.
> T9 - This could only depend on individual teacher not that there is a lot of material to be taught.

The feeling these teachers express is that the lecture method will not help students. T7 feels that the issue of medium of instruction remains a problem to most students and thus affects their speedy understanding of concepts. The lack of equipment is cited as a factor that compels other teachers to use 'exposition methods'. T9, however, thinks that this is an issue which is at the discretion of teachers. The following teachers have a different view:

> T4 - I believe in making students perform experiments to discover for themselves how ordinary magnetic materials are made into magnets by passing electricity through them and also see that they behave like permanent magnets.
> T11 - Experience have proved that students are confused in learning electromagnetism. Practicals and experiments can usually bring more understanding in Physics.
> T5 - This topic requires practicals and even use of models to show, say, that field lines are not on a single plane.
> T14 - Electromagnetism is a practical topic hence 50% lecture method will be a waste of time since student will not make sense of the taught.
> T16 - This is a purely practical topic and whenever possible lecturing should be kept minimum.
> T20 - I think practical methods should be employed whenever possible. The only reason for not doing exp is lack of equipment.

The teachers' explanations emphasise the belief of teachers towards practical work. They think that electromagnetism is a difficult and abstract topic which must be simplified as much as possible (T4 and T11). Because of this abstract nature of electromagnetism, T14 finds using the lecture method to teach 50% of the syllabus as a waste of time, presumably because students will not be following. Thus where possible teachers should use practicals more often.

Responses from teachers who disagree with statement 8

> T4 - I discovered that students had seen electromagnetism in their everyday lives but did not know that it was electromagnetism
> T10 - Students know something about the subject but they may not be aware of that fact. Few examples and applications will help.
> T5 - At COSC, students already have some idea about electromagnetism
> T17 - Because they have done this topic at lower level.
> T9 - This depends on the backround of the students not that they do not know
> T15 - They know. What is needed is an introduction for recollection.
> T16 - Students need not be told everything as they may find somethings for themselves if given a chance.

Teachers realize that students already know something about electromagnetism before any lesson. Such knowledge might have been obtained from their previous lessons or everyday observations. T4 and T10 feel that students know something but may not be aware of it. Therefore the role of teaching should be that of making them aware of this knowledge and reshaping it.

Responses from teachers who disagree with statement 23

> T9 - Just giving the equation will lead to memorizing not understanding so experimenting is still the best method.
> T11 - It is possible to do experiments using coil of different turns. That is students should not necessarily be only given formulae.
> T12 - There are already build transformers of various turn ratio and even simple ones can be made to simplify the formula
> T21 - Experimental set-ups even help to make students appreciate efficiency of it.

These teachers believe it is possible for students to do experiments on transformers. T12 feels that transformers are available for practicals at this level. T9 warns that giving equations runs the danger of students not really knowing the concepts but rather memorising them.

These teachers, therefore, are divided on their beliefs about effective teaching methods. Some are clearly non-constructivist, while others reflect some degree

of constructivism. It is however difficult to clearly separate these catagories. The section that follows looks at the beliefs of these teachers about the use of experiments in Physics classrooms.

4.3.2.2 Use of experiments

Seven statements were used to test the beliefs of teachers about the use of experiments in teaching electromagnetism. These statements are particularly testing teachers' beliefs on the importance of experiments in their teaching. The statements are:

2. Because students do not like experiments on the design and use of permanent magnets and electromagnets I simply do not let them do such experiments.
5. A big problem in teaching electromagnetism today in that it is so expensive to do meaningful laboratory experiments at all levels.
6. In performing experiments in electromagnetism, the best learning is likely to take place if students are able to work alone.
10. Experiments help students to better understand electromagnetic concepts such as 'magnetic field' and 'magnetic induction'.
17. Having fun or structured play with magnets in Physics lessons is a waste of time.
19. My students enjoy doing practicals on a. c. generators.
22. It is not advisable to allow students to do practicals on transformers because transformers are very dangerous to work with.

All teachers who responded to statement 2 disagreed with it. Some of those teachers felt that experiments make the learning of concepts easier:

> T2 - Students learn better when doing experiments
> T14 - Students learn best by doing rather than by being told
> T3 - Because it is through experiments that students learn more effectively and the way the teacher introduces it.
> T7 - Experiments are on their aim, the best was of making the students understand theory and the concepts involved.

T20 - Experiments generally form part of learning which interest pupil most and reinforce their understanding of concepts.
T12 - To get the concept of another metal attracting another is difficult to explain without a physical example.

The above responses express the view that the best way students can learn Physics is by doing experiments. The view that experiments simplifies abstract concepts has been implied (T12). There is another category of teachers who feel that students enjoy doing experiments and that is the best way they learn, that is, by doing:

T4 - They actually enjoy doing experiments.
T9 - The students like experiments a lot it could only be that they sometimes do not have enough time or equipment.
T11 - In general students seem to have great interest in experiments.
T17 - Because students like playing with magnets and like to do experiments.

There is another group of teachers who feel that it is the responsibility of the teacher to make sure that students enjoy doing experiments, by trying to make them as enjoyable as possible:

T10 - The teacher should try whatever means possible within his capacity to let students know and accept the importance of these expts.
T16 - This will not help them understand the concept, so if they do not like the experiments a teacher has to try and make them more interesting.
T18 - Experiments must be performed by the students with the assistance of the teachers. It helps the students to catch up the concept easily.

Responses from teachers who disagree with statement 5

T4 - Improvised laboratory material can help solve this problem
T22 - Improvisation supersedes the cost involved, if any at all. Magnets and magnetic materials are readily available hence as well as electricity low cost is involved.
T13 - At least demonstrations can do a lot to students, so using available materials experiments can be done.
T19 - Apparatus for expts on electromagnetism can be got at low prices.

The feeling expressed by some teachers (T4 and T22) is that it is possible to perform some basic experiments by using inexpensive locally available materials. This requires teachers to put in some minimal effort. T13, however, seems to feel that in the absence of such cheaply available material, teachers can still resort to demonstrations.

Responses from teachers who agree with statement 6

> T2 - But teacher has to be around to clarify where problems arise
> T16 - Students should work under close supervision of the teacher as they may sometimes try dangerous things.

Although these teachers agree that students working alone in practicals are likely to reflect the best learning, they also feel that the help of the teacher from time to time is necessary. T16, however, seems to be sceptical that if students are left alone they might try 'dangerous' things, so they must be closely supervised by the teacher. Other teachers express other advantages of letting students work alone.

> T9 - This is so because students should be able to discusses things on their own.
> T13 - Because they are able to discover some concepts which enable them to understand what they are doing.
> T14 - Since they will see most of the things by themselves and they will come up with questions to the teacher.
> T7 - I agree with this because if they are able to work on their own those they all the opportunity to adventure into things they might have not had the chance to realise under my direct control.
> T10 - The student will get full knowledge and understanding of the experiment from his own observations and conclusions.

The responses above express the view that when students are working alone they are able to discuss and understand concepts because they can directly observe things that should challenge their understanding of the concepts. T7 implies that the presence of the teacher can, at times, have a negative influence on students' ability to perform experiments and make observations.

Responses from teachers who agree with statement 10

> T6 - They learn from what they see.
> T9 - They can never be understood if they have never been seen.
> T15 - Only through experiments they can find it themselves.
> T22 - Yes indeed. What the eyes see is retained in the brain for a longer time than what is heard with the ears.

The teachers feel that students hardly understand unless they see things. T9's argument is even stronger; i.e. *if concepts '...can never be seen.' they '...can never be understood'*. Thus, according to T9, unless students perform experiments they may not be expected to understand the concepts. The following had other reasons:

> T7 - Even though we don't perform experiments at this school because of inadequate facilities, experiments do help students understand concepts.
> T10 - Experiments make students get those physical concepts which seem so abstract and imaginitive.
> T11 - This are rather abstract concepts which without aid of experiment its very difficult for students grasp the concepts.
> T13 - Because students start to compare the magnetic field of the permanent magnets and electromagnetic field.
> T17 - What the students have done is not easy to forget.
> T20 - These are concepts that pupils cannot imagine or see around hence why an experiment can reinforce the understanding.

As with the other statements above, the view is once more expressed that experiments simplify the abstract nature of electromagnetic concepts and hence make the understanding of such concepts easier. T16 sees the importance of experiments from a completely different ground; that of culture. However, it is not clear whether he feels that electromagnetic concepts cannot be *explained* by the African (Basotho) culture, or that students from these cultures will not have any idea about these concepts because they do not exist in their culture:

> T16 - These concepts do not exist in our culture so without experiments students may not understand nor belief.

Responses from teachers who disagree with statement 17

T18 - It is not a waste of time provided that if you have enough time to spend.
T19 - It is not a waste of time. It creates a deep liking for subjects.
T6 - Playing does help students to learn.
T4 - Students learn more this way
T11 - This is the most important part of learning as what one does is not easy to forget.
T9 - In most cases students understand things better if they have had time to play with such ideas.
T13 - Students know what they have done than what they are told of.
T10 - Constructive fun or structured play will help make students understand the lessons.
T22 - When you organise a structured play or fun students easily adapts and understands faster as well as retain all they have learnt in the process.
T15 - It will create more interest in them if we have some fun to.
T16 - This will promote the students interest while they are also learning.

Teachers feel that playing with magnets is helpful to students, and is not necessarily a waste of time. However T18 says this is only the case if the teacher has 'enough time to spend'. Others, T6, T11 and T22, feel that such play helps students to retain what is learned longer. T15 and T16 think that this also helps to increase the interest of students. Thus, these teachers believe that structured plays are important to the teaching/learning process.

Responses from teachers who agree with statement 19

T10 - They are excited to know that such simple experiment can lead to the production of electricity.
T13 - Because they are supprised of how a.c. can be used to do a certain job.
T6 - They find them as attractive machines.
T12 - This because they are kept on the alert by the way the e.m.f. causes the pointer of galvanometer to deflect.
T9 - Students enjoy doing experiments on everything provided there is enough equipment.
T22 - They do not always enjoy it but about 70% of the students have intentions to further in science enjoy it especially the club members
T14 - Since they practice that has been lectured.

Teacher T10, and T13 by implication, feel that students are interested by seeing

electricity being produced by such simple experiments. T22 feels that students are influenced by their intentions for future studies. Generally these teachers feel that students enjoy practicals. However T14 seems to believe that students must do practicals in order to verify what they have already learned.

Some teachers believe that experiments interest students but they (teachers) do not conduct such experiments because of lack of equipment:

> T4 - I have had to do demonstrations in this topic due to lack of apparatus.
> T5 - I think they would enjoy that if they had the chance - We did not have strong magnets and sensitive galvanometer.

Responses from teachers who disagree with statement 22

> T4 - Lab transformers are not dangerous to work with
> T6 - They are not dangerous students should first be shown how it works.
> T18 - Simple transformers are not dangerous, even the students can design of.
> T3 - Because teachers wide knowledge of dangers can provide a safe surrounding.
> T10 - With the close supervision of the teacher students can safely perform such practicals.
> T15 - Not very dangerous as we can help them and be with them.

Teachers believe that students can do experiments on transformers, i.e. transformers are not dangerous (T4, T6 and T18). Others (T3, T10 and T15) feel that with the help of the teacher and strict supervision students should be able to do such experiments. T3 believes that teachers do have a wide knowledge of possible dangers.

The above discussion once more underlines the importance some teachers give to experiments in their teaching. That is, these teachers believe that the best teaching method in Physics education is the use of experiments. The following discussion reflects a completely different view. Some teachers do not show such emthusiasm for letting students do experiments.

Responses from teachers who agree with statement 5

> T7 - I agree with this because these equipments/apparatus a really expensive
> T10 - Experiments on electromagnetism are so expensive that schools can't afford. Authorities should try to provide the necessary equipments or apparatus for such experiments.
> T11 - There is a lack of apparatus particularly at COSC level but JC level the apparatus is not that expensive.
> T14 - The apparatus use are not available in most schools hence expensive
> T17 - Because many schools have no laboratory and no equipment.

These teachers admit that equipment is expensive and that schools cannot afford electromagnetism equipment. Therefore such experiments are not done at their schools. T10 makes a plea to 'authorities' to help schools with necessary equipment.

Responses from teachers who disagree with statement 6

> T4 - Working in groups helps students in that it enables them to discuss their observations and share the often difficult task of drawing conclusions from observations.
> T20 - Learning in most cases take place effectively in group work discussions.
> T19 - Most students are more active when they do groupwork. A student does not like to stay in lab alone.
> T3 - Because at secondary level their knowledge is too very little regarding the topic

According to these teachers learning is effective if students work in groups, i.e. it helps them to share ideas. T3, however, feels that students should not work alone because at this level their knowledge is '...very little regarding the topic.'

Responses from teachers who agree with statement 19

> T15 - It is a difficult expt to perform at ordinary level.
> T17 - Some are afraid of electricity being choked.

T15 feels that a.c. generators are difficult for students, while T17 fears the dangers of doing practicals at this level.

Responses from teachers who agree with s atement 22

> T2 - It is better be handled by the teacher for fear of high voltages that may result.
> T7 - If transformers are mishandled during the experiments they can harm the students because of their effect on the voltage of the current.
> T14 - Since students like to touch hence they may injure themselves if not cause death.
> T17 - Afraid of being choked. They can just be shown and explained to them. Voltage is very high
> T11 - Demonstration should be preferred here.

These teachers are agreeable that some experiments can be dangerous. T11, and T17 by implication, suggest, as an alternative method, that the teacher should rather do demonstrations.

The above results reflect [illegible]t issues. Firstly, different views about teaching methods are in[illegible]achers can be divided into categories depending on their beliefs about effective teaching methods. We agree with Hashweh (1996) who catagorise teachers as learning constructivists, learning empiricists, knowledge constructivists and knowledge empiricists. We also agree that the categories cannot easily be separated: indeed they are not mutually exclusive. Secondly, different teaching methods - such as lecture, experimentation, discovery - have been reflected, but the use of experiments has proved to dominate the choice of these teachers.

4.4 Conclusion

This chapter reveals the following:

i) Physics teachers in Lesotho reflect both non-constructivist as well as constructivist beliefs about Physics teaching and Physics itself. Traditionalists belief that Physics is strictly bound by rules and facts that must be known by the student. Some teachers showing traditional views believe that for students to understand they must know rules and formulae because of their importance to the understanding of concepts. These teachers believe that Physics is a body of known facts that must be

accepted by their students. Teachers are seen as having this knowledge, and their fundamental role is to tell it to their students, who in turn must accept it.

ii) The study reflects that some teachers are aware, to some extent, of the possible ideas of students, while others *may not be aware*. Those teachers who seem not to be aware of students' alternative conceptions tend to think that students relatively easily understand concepts. Therefore there is really no reason why students cannot understand such 'easy' concepts.

iii) The study also reflects teachers' beliefs about effective teaching methods. There are some teachers who seem to believe in traditional methods, such as lecturing, because, among other things, the subject is difficult and students must be given more basic knowledge. Others seem to believe that there is no other way except to use experiments. Likewise they also reflect a belief that electromagnetic concepts are abstract and the only way to understand them is by use of experiments.

CHAPTER 5

TEACHERS' AWARENESS OF ALTERNATIVE CONCEPTIONS

5.1 Introduction

In this chapter an analysis of data obtained from the second and third questionnaires is made. Ten teachers, with a total of 235 students, agreed to participate in this part of the study.

The chapter discusses teachers' predictions of their students' responses. This analysis assumes that if teachers are unable to predict responses of most of their students, or predict incorrectly themselves, then they cannot be aware of the possible responses of their students. This then means that they are not aware of students' ideas, and hence of possible alternative conceptions held by students. This further means that such teachers are unlikely to be using constructivist strategies since they fail to appreciate the fundamental tenet of the constructivist theory, i.e. each learner comes to classroom with already existing ideas about a specific phenomenon.

The analysis in this chapter is done by looking at both the quantitative and qualitative data independently of each other.

5.2 Quantitative data

The tables to be discussed in the following pages summarise both the teachers' and students' responses on the second and third questionnaires respectively. The tables show the percentage of agreement between each teacher and his/her students for each of the five questions. Each question is analysed by two tables (e.g. Question 1 by Tables 5.1(i) and 5.1(ii)). The *first table* shows the following:

a) responses of the teacher, i.e. the response that he THINKS is correct,

b) his prediction of students answers, and

c) the answers of his students.

The *second table* compares the teachers' predictions of students' answers and the

actual responses that students chose most.

For Question 1, Tables 5.1(i) and 5.1(ii) (page 76) reflected the following. **Table 5.1(i)** shows that teachers D, F and G did not predict possible answers of students. Teachers B and H predicted that most of their students would choose the 'correct' answer (i.e. the students would give the same answer as the teacher). However *none of the teachers chose the correct answer!* This indicates the possibility that students *are taught what is not scientifically acceptable*. This in turn implies that some of the alternative conceptions that students have are due directly to poor teaching.

Table 5.1(ii) reflects five teachers (B, C, E, F and H) correctly predicting the possible choices of students while others either could not predict or predicted incorrectly. The students, and likewise their teachers, think that a stationary positive charge will move because of the force due to magnetic field created (though there is an indication, in Question 2, that some may be thinking that it is electric field). The alternative conception held is that there is force experienced by the charge which either pushes or pulls the charge.

Question 2 was not entirely different from Question 1. In both cases the charged body is placed in magnetic field. **Table 5.2(i)** (page), as in Table 5.1(i) reflects not all teachers being able to predict their students' answers. Two teachers (B and E) feel that most of their students will choose the same answer as they do. It also shows all teachers, except three, answering this question correctly. Seven out of the ten teachers were now able to answer the question correctly. This is probably due to the fact that in Question 2 the magnetic fied is very obvious, while this is not so in Question 1. Teachers seem not to realise that a current-carrying conductor sets up a *magnetic* field around it.

Table 5.2(ii) (page)reflects three teachers (B, C and I) predicting the responses of their students correctly. The other teachers either could not predict or predicted incorrectly. This table reflects that even though these teachers do not agree on the direction of movement of the charge they all agree that students are going to

Table 5.1: Analysis of Question 1

Table 5.1(i)

School	No Students	Teacher's Answer	Teacher's Prediction	Students' responses (as %)							
				-	a	b	c	d	e	f	g*
A	17	c	e	5.9	0.0	0.0	0.0	**41.2**	11.8	23.5	17.6
B	26	c	c	0.0	3.8	7.7	**34.6**	15.4	23.1	3.8	11.5
C	27	d	f	0.0	0.0	3.7	18.5	7.4	29.6	**37.0**	3.7
D	38	c	–	2.6	5.3	5.3	**44.7**	10.5	13.2	18.4	0.0
E	45	f	d	0.0	24.4	8.9	11.1	**26.7**	15.6	6.7	6.7
F	5	d	–	0.0	**40.0**	0.0	0.0	20.0	20.0	0.0	20.0
G	20	–	–	0.0	10.0	0.0	**45.0**	5.0	20.0	10.0	10.0
H	25	d	d	0.0	16.0	4.0	28.0	**32.0**	4.0	8.0	8.0
I	17	a	f	0.0	11.8	5.9	17.6	5.9	**35.3**	11.8	11.8
J	15	d	f	6.7	6.7	0.0	26.7	20.0	6.7	**33.3**	0.0

Key: – No response
* Correct response
Bold type indicates most frequently chosen response

Table 5.1(ii)

School	No Students	Teacher's Prediction of most likely responses	%students answering as teacher predicted	Most frequent responses given by students (as %)
A	17	e	11.8	d (41.2)
B	26	c‖	34.6	c
C	27	f‖	37	f
D	38	-	*	c (44.7)
E	45	d‖	26.7	d
F	5	-	*	a (40.0)
G	20	–	*	c (45.0)
H	25	d‖	32	d
I	17	f	11.8	e (35.3)
J	15	f‖	33.3	f

Key: – No Prediction by teacher, therefore no % calculated (*)
‖ Indicates agreement between prediction and students' most common response

Table 5.2: Analysis of Question 2

Table 5.2(i)

School	No Students	Teacher's Answer	Teacher's Prediction	Students' responses (as %)							
				-	a	b	c	d	e	f	g*
A	17	g	d	5.9	0.0	0.0	41.2	0.0	0.0	0.0	**52.9**
B	26	g	g	0.0	7.7	3.8	26.9	11.5	11.5	7.7	**30.8**
C	27	g	c	0.0	14.8	0.0	**44.4**	7.4	7.4	11.1	14.8
D	38	g	–	2.6	0.0	0.0	**52.6**	13.2	5.3	5.3	21.1
E	45	d	d	0.0	11.1	0.0	33.3	8.9	2.2	0.0	**44.4**
F	5	d	–	0.0	**60.0**	0.0	40.0	0.0	0.0	0.0	0.0
G	20	–	–	0.0	0.0	5.0	**55.0**	20.0	0.0	0.0	20.0
H	25	g	b	0.0	0.0	8.0	**52.0**	8.0	12.0	12.0	8.0
I	17	g	c	0.0	5.9	5.9	35.3	41.2	5.9	0.0	5.9
J	15	g	d	0.0	0.0	0.0	33.3	20.0	13.3	0.0	**33.3**

Key: – No response Bold type indicates most frequently chosen response

* Correct response

Table 5.2(ii)

School	No Students	Teacher's Prediction of most likely responses	% students answering as teacher predicted	Most frequent responses given by students (as %)
A	17	d	0	g (52.9)
B	26	g‖	30.8	g
C	27	c‖	44.4	c
D	38	–	*	c (52.6)
E	45	d	8.9	g (44.4)
F	5	–	*	a (60.0)
G	20	–	*	c (55.0)
H	25	b	8	c (52.0)
I	17	c‖	35.3	c
J	15	d	20	c/g (33.3)

Key: – No Prediction by teacher, therefore no % calculated (*)

‖ indicates agreement between prediction and students' most common response

think that the charge will move.

Questions 1 and 2 show an alternative conception, held by both students and their teachers, that a *magnetic field attracts/repels a stationary charge.* It also reflects a possibility that teachers, like their students, fail to see current as a source of magnetic field. This implies that the teaching process may have contributed to the acquiring of alternative conceptions.

For **Question 3, Table 5.3(i)** (page 79) shows that all teachers, except one, were able to predict students' answers. Three teachers (A, F and H) think that their students are going to choose the correct response. All these teachers, except two, agree on the correct answer. The other two teachers reflected the alternative conception that attraction can be used as a test of whether a material is a magnet or not.

Table 5.3(ii) (page 80) shows four teachers failing to predict correctly the responses of the students with two of them (A and F) predicting that their students are going to answer correctly. The table shows that in all ten schools most students chose option 'b'. This shows clearly an alternative conception that *attraction can be used as a test for whether a material is a magnet or not.*

The response to Question 3, therefore, reflects that some teachers are not aware of the possible responses of their students. It also shows the existence of alternative conceptions, held by both teachers and students, that attraction can be used as a test of whether a material is a magnet or not.

For **Question 4, Table 5.4(i)** (page 80) shows all teachers, except one, predicting the students' responses. It is once again noted that teachers A, B and F believe that most of their students are going to choose the option they consider to be the correct answer. The table also reflects four teachers answering this question correctly.

Table 5.3: Analysis of Question 3

Table 5.3(i)

School	No Students	Teacher's Answer	Teacher's Prediction	Students' responses (as %)							
				-	a	b	c*	d	e	f	g
A	17	c	c	0.0	0.0	**100**	0.0	0.0	0.0	0.0	0.0
B	26	c	b	0.0	0.0	**76.9**	7.7	15.4	0.0	0.0	0.0
C	27	c	b	0.0	0.0	**92.6**	3.7	3.7	0.0	0.0	0.0
D	38	c	-	0.0	0.0	**84.2**	2.6	13.2	0.0	0.0	0.0
E	45	b	d	0.0	0.0	**88.9**	4.4	6.7	0.0	0.0	0.0
F	5	c	c	0.0	0.0	**80.0**	20.0	0.0	0.0	0.0	0.0
G	20	c	b	0.0	0.0	**90.0**	5.0	5.0	0.0	0.0	0.0
H	25	b	b	0.0	0.0	**88.0**	12.0	0.0	0.0	0.0	0.0
I	17	c	b	0.0	0.0	**64.7**	23.5	11.8	0.0	0.0	0.0
J	15	c	b	0.0	0.0	**53.3**	40.0	6.7	0.0	0.0	0.0

Key: – No response
* Correct response
Bold type indicates most frequently chosen response

Table 5.3(ii)

School	No. Students	Teacher's Prediction of most likely responses	% students answering as teacher predicted	Most frequent responses given by students (as %)
A	17	c	0	b (100)
B	26	b‖	76.9	b
C	27	b‖	92.6	b
D	38	-	*	b (84.4)
E	45	d	8.9	b (88.9)
F	5	c	20	b (80.0)
G	20	b‖	90	b
H	25	b‖	88	b
I	17	b‖	64.7	b
J	15	b‖	53.3	b

Key: – No Prediction by teacher, therefore no % calculated (*)
‖ Indicates agreement between prediction and students' most common response

Table 5.4: Analysis of Question 4

Table 5.4(i)

School	No Students	Teacher's Answer	Teacher's Prediction	Students' responses (as %)							
				-	a*	b	c	d	e	f	g
A	17	a	a	5.9	**52.9**	0.0	11.8	29.4	0.0	0.0	0.0
B	26	c	c	0.0	11.5	**53.8**	30.8	3.8	0.0	0.0	0.0
C	27	b	a	0.0	22.2	18.5	**51.9**	7.4	0.0	0.0	0.0
D	38	a	-	2.6	15.8	**52.6**	21.1	7.9	0.0	0.0	0.0
E	45	b	c	0.0	20.0	24.4	26.7	**28.9**	0.0	0.0	0.0
F	5	a	a	0.0	20.0	20.0	**60.0**	0.0	0.0	0.0	0.0
G	20	a	b	0.0	25.0	**45.0**	25.0	5.0	0.0	0.0	0.0
H	25	b	a	4.0	0.0	20.0	**76.0**	0.0	0.0	0.0	0.0
I	17	b	a	5.9	5.9	23.5	**64.7**	0.0	0.0	0.0	0.0
J	15	b	a	0.0	26.7	**46.7**	26.7	0.0	0.0	0.0	0.0

Key: – No response

Bold type indicates most frequently chosen response

* Correct response

Table 5.4(ii)

School	No. Students	Teacher's Prediction of most likely response	% students answering as teacher predicted	Most frequent responses given by students (as %)
A	17	a‖	52.9	a
B	26	c	30.8	b (53.8)
C	27	a	22.2	c (51.9)
D	38	-	*	b (52.6)
E	45	c	26.7	d (28.9)
F	5	a	20	c (60.0)
G	20	b‖	45	b
H	25	a	0	c (76.0)
I	17	a	5.9	c (64.7)
J	15	a	26.7	b (46.7)

Key: – No Prediction by teacher, therefore no % calculated (*)

‖ Indicates agreement between prediction and students' most common response

Table 5.4(ii) (page 80) reflects only two teachers (A and G) predicting correctly. Students tend to choose two options 'b' and 'c', thus reflecting that they think that one of the solenoids will become a magnet while the other does not. This shows an alternative conception that a solenoid can only result in a permanent magnet if there is contact between the wire and the core or visa versa. (If a wire is covered with insulation then they believe such 'direct contact' is impossible)

Table 5.5(i) (page 82) shows one teacher not predicting the possible response of students for Question 5 and four choosing the option they think is correct as the one that the majority of students are going to choose. Three teachers failed to choose the correct option. However, it is to be noted that option 'c' can be argued to be marginally correct if the charge is assumed to be very close to the conductor.

Table 5.5(ii) (page 82) reflects three teachers not predicting students' responses correctly. The majority of students from all ten schools chose option 'g' as the correct answer. Thus, the majority of students think that there is no effect due to the conductor which can cause any motion.

The five pairs of tables reflect a failure of some teachers to predict the responses of their students. They also show the existence of alternative conceptions held by both teachers and students. It should be noted, however, that although the analysis here is done only on teachers' predictions, and the responses mostly given by students, the first tables also reflect other possible alternative conceptions. That is, further analysis of students' responses is likely to reflect more students' ideas that are likely not to be scientifically accepted.

Tables 5.6(i) and 5.6(ii) (page) summarise these data for the 10 schools whose teachers agreed to participate in this section and their 235 students. The tables compares the predictions and answers of teachers with responses of students and the percentage of students, taught by teachers responding in a particular way.

Table 5.5: Analysis of Question 5

Table 5.5(i)

School	No Students	Teacher's Answer	Teacher's Prediction	Students' responses (as %)							
				-	a	b	c	d	e	f	g*
A	17	c	g	11.8	17.6	0.0	5.9	17.6	0.0	5.9	**41.2**
B	26	g	g	0.0	3.8	0.0	11.5	11.5	3.8	0.0	**69.2**
C	27	c	g	0.0	7.4	3.7	22.2	18.5	7.4	3.7	**37.0**
D	38	g	-	2.6	0.0	2.6	34.2	0.0	2.6	7.9	**50.0**
E	45	g	c	0.0	4.4	6.7	2.2	2.2	6.7	0.0	**77.8**
F	5	g	g	0.0	20.0	0.0	20.0	0.0	0.0	0.0	**60.0**
G	20	g	g	0.0	0.0	5.0	25.0	5.0	5.0	0.0	**60.0**
H	25	g	g	8.0	8.0	4.0	28.0	4.0	0.0	4.0	**44.0**
I	17	c	g	0.0	5.9	0.0	23.5	5.9	0.0	0.0	**64.7**
J	15	g	d/c	0.0	0.0	0.0	20.0	13.3	0.0	0.0	**66.7**

Key: – No response
* Correct response
Bold type indicates most frequently chosen response

Table 5.5(ii)

School	No Students	Teacher's Prediction of most likely responses	% students answering as teacher predicted	Most frequent responses given by students (as %)
A	17	g‖	41.2	g
B	26	g‖	69.2	g
C	27	g‖	37	g
D	38	-	*	g (50.0)
E	45	c	2.2	g (77.8)
F	5	g‖	60	g
G	20	g‖	60	g
H	25	g‖	44	g
I	17	g‖	64.7	g
J	15	d/c	13.3/20.0	g (66.7)

Key: – No Prediction by teacher, therefore no % calculated (*)
‖ indicates agreement between prediction and students' most common response

Table 5.6: Analysis of the Questions

Table 6(i) - Comparison of teacher's *prediction* and students' choice

Question No.	% predicting - teachers								% of students taught								% choosing - students							
	-	a	b	c	d	e	f	g	-	a	b	c	d	e	f	g	-	a	b	c	d	e	f	g
1	30	0	0	10	20	10	30	0	26.8	0	0	11.1	29.8	7.2	25.1	0	1.3	11.1	4.3	25.1	18.3	17.4	15.3	7.2
2	30	0	10	20	30	0	0	10	26.8	0	10.6	18.7	32.8	0	0	11.1	0.9	6.4	2.1	41.7	12.8	6.0	4.3	26.0
3	10	0	60	20	10	0	0	0	16.2	0	55.3	9.4	19.1	0	0	0	0.0	0.0	83.8	8.9	7.2	0.0	0.0	0.0
4	10	60	10	20	0	0	0	0	16.2	45.1	8.5	30.2	0	0	0	0	1.7	18.7	32.3	36.6	10.6	0.0	0.0	0.0
5	20	0	0	10	0	0	0	70	22.6	0	0	19.1	0	0	0	58.3	2.1	5.1	3.0	18.7	7.2	3.4	2.6	57.9

Table 6(ii) - Comparison teacher's *choice* and students' choice

Question No.	% choosing - Teachers								% of students taught								% choosing - students							
	-	a	b	c	d	e	f	g	-	a	b	c	d	e	f	g	-	a	b	c	d	e	f	g
1	10	10	0	30	40	0	10	0	8.5	7.2	0	34.5	30.6	0	19.1	0	1.3	11.1	4.3	25.1	18.3	17.4	15.3	7.2
2	10	0	0	0	20	0	0	70	8.5	0	0	0	21.3	0	0	70.2	0.9	6.4	2.1	41.7	12.8	6.0	4.3	26.0
3	0	0	20	80	0	0	0	0	0	0	29.8	70.2	0	0	0	0	0.0	0.0	83.8	8.9	7.2	0.0	0.0	0.0
4	0	40	50	10	0	0	0	0	0	34.0	54.9	11.1	0	0	0	0	1.7	18.7	32.3	36.6	10.6	0.0	0.0	0.0
5	0	0	0	30	0	0	0	70	0	0	0	26.0	0	0	0	74.0	2.1	5.1	3.0	18.7	7.2	3.4	2.6	57.9

Table 5.6(i) shows that in the first two questions teachers reflected no agreement as to which option majority of students are likely to choose. They however reflect an agreement to the effect that students will think that the charge will move. The table also shows that students tended to agree that the charge will move but they do not agree on the direction of motion. These responses, at least to this extent, reflected an agreement between teachers' predictions and students' answers. However, as will be indicated below, teachers also had the same alternative conception that the charge will move. For Question 2, however, students reflected some tendency of agreement that there will be a motion away from the magnet. In Question 3 the majority of students reflected an understanding that W should be a magnet, thus reflecting an understanding that attraction can be used as a test for whether a material is a magnet or not. The predictions of teachers and the response of students for this question did not tally very well. The comparison of the percentage of students taught and of the responses of students clearly reflects that some teachers did not predict correctly. For Question 4 students tended to agree that one of the set-ups is going to be a magnet. This did not tally well with the predictions of teachers who thought that the majority of their students would choose the correct answer. For Question 5 students agree that there will be no motion. Like for question 3, the percentage of students taught shows that there are some teachers who did not predict correctly.

The table, therefore, shows two questions (3 and 5) where predictions of the teachers agree with the responses of their students. However, even in these cases the percentage of students taught reflects that some teachers predicted incorrectly.

Table 5.6(ii) compares the teachers' answers with the students' answers. Three questions (1, 4 and 5) show similarities between the teachers' answer distribution and the students' answers distribution. That is, where teachers tended to show a possibility of the existence of alternative conceptions, students equally reflected the same tendency. The table, therefore, highlights the possibility that some of the alternative conceptions are transferred from the teacher to his/her students during

the teaching/learning process.

Table 5.7 (page 86) compares the predictions of the ten teachers. It shows that some teachers were able to correctly predict students' ideas whereas others were not. The table reflects three teachers not being able to predict students' ideas correctly and only one teacher satisfactorily predicting students' ideas. The other teachers either predicted two or three cases correctly, which does not reflect satisfactorily the awareness of students' answers. Thus nine of the ten teachers could not be said to be aware of their students' possible responses in this study. Teacher B, the only teacher reflecting awareness of students' possible responses, thought that his\her students were going to choose what (s)he thought was the correct answer, except in one case.

The sample of teachers in this study has reflected that they could not all predict the possible responses of students, and so seem not to be aware of students' ideas. It is also highlighted that both teachers and students hold similar alternative conceptions in this topic.

Table 5.7: Analysis of predictions for each teacher

Teachers	Question 1	Question 2	Question 3	Question 4	Question 5
A	✗	✗	✗	✓	✓
B	✓	✓	✓	✗	✓
C	✗	✓	✓	✗	✓
D	✗	✗	✗	✗	✗
E	✗	✗	✗	✗	✗
F	✗	✗	✗	✗	✓
G	✗	✗	✓	✓	✓
H	✓	✗	✓	✗	✓
I	✗	✓	✓	✗	✓
J	✓	✗	✓	✗	✗

Key: ✗ - Did not predict correctly ✓ - Predicted correctly

5.3 Qualitative data

Teachers were asked to explain why they thought students would choose the options they (the teachers) indicated. Their explanations are discussed below for each question. Some of the views express clearly a lack of awareness of students' ideas while others reflect some degree of awareness of these ideas.

For **Question 1** the teachers had the following views. Only teacher B thought that his students would choose **option 'c'**. This is his explanation:

> B1. Unlike charges attract. The charge will be attracted towards the conductor

The response ackowledges the existence of two different charges in the question. Since current is flowing in the conductor teacher B assumes that students are going to think that the conductor is charged *negatively* and as a result the positive charge is going to be *attracted*. The alternative conception reflected is that *when current flows in a conductor then at any moment the conductor is either negatively or positively charged.* B, however, also thinks that this option is the correct answer. The explanation given could be the reason why he thinks so. The majority of students answered as he predicted. If these students chose this option for the reason given by their teacher, then there is the distinct possibility that the alternative idea was obtained from the teaching/learning process.

Option 'd' was chosen by two teachers and these were their explanations:

> E1. Without considering the movement of charge in the conductor, the repulsion force will be assumed perpendicular in the object C
> H1. Like charges repel as +ve charges the direction of repulsion is away from the wire

According to teacher H, students will think that the flow of current will cause the conductor to be *positively* charged and thus result in the charge being repelled. Like B above, H chose as his correct option the same option as he thought the students would choose. Thus similar comments apply. According to E, students will not consider the movement of charge in the conductor. This implies that the

movement of the charge inside the conductor is found to be crucial in determining the direction of motion of the positive charge outside the conductor.

Only teacher A thought that students would choose option 'e':

> A1. They might think that because I is -ve charge. So it have an opposite direction to +Q

Teacher A states that students regard current as a flow of negative charges in the conductor, and that they therefore will think that the positive charge *must* move in the opposite direction.

Three teachers thought their students would choose option 'f':

> C1. Because the direction shown by the arrow may lead them to think that q is going to be repelled in the same direction
> I1. This is likely to be chosen by many students because they know a negative terminal or charge will be created at the end of the conductor hence the positive charge will be attracted northwards.
> J1. They will assume that motion is in same direction as the current

Teacher C thinks that the arrow showing the direction of current in the question will mislead students, while teachers I and J think that the flow of current will be used to indicate a possible direction of motion of the charge. Teacher I thinks that students might think that at the end of the conductor there will be negative charges created which will in turn attract the positive charge. That is, students will think that because electrons move inside the conductor there has to be a point where they stop and at that point the charge will be negative.

Three teachers did not predict responses of their students. However they gave the following explanations:

> D1. Positive charge attracts the electrons
> F1. They will guess. We have used the idea of a 'free' north pole in a magnetic field and not a +vely charged particle
> G1. N/A since I have never taught this topic

Teacher D was perhaps explaining why he considered option 'c' to be the correct

answer for this question. This is similar to the responses of B and H, i.e. the flow of current causes the conductor to become either negatively or positively charged. Teacher F hints at a possible confusion between charges and magnetic poles, or that students take over ideas from magnetism directly into electrostatics.

Thus teachers generally agree that students are going to think that *the charge will move*. The idea of 'Unlike charges attract and like charges repel' seems to be the main argument that teachers thought their students will use. The feeling is that *when there is a current in a conductor, it charges the conductor either negatively or positively*. Some teachers use the same reasoning to justify their 'correct answers'.

For **Question 2** the responses were as follows. There were two teachers choosing **option 'c'** and their explanations were as indicated below:

> C2. Magnetism has effect on electricity not realising that the magnet is stationary
> I2. Students may think a negative charge may be induced at the end of the magnet close to the positive charge and will attract the positive charge in that direction.

Teacher I believes that students will think that the charge will be attracted as a result of the negative charge induced at the end of the magnet. Teacher C simply thinks that students will assume that the magnet is going to attract the positive charge. Students furthermore think of the charge as 'electricity' (which may be interpreted to mean 'current').

Only teacher H chose **option 'b'**:

> H2. They may think of the motor effect created on a moving current in a magnetic field

Teacher H thinks that students may think of the motor effect. The direction of motion of the charge will then be determined by using Fleming's rule. He agrees with C above that students are likely to think of charge in terms of moving charge.

Option 'd' was chosen by three teachers:

> A2. They will assume that +Q will be repelled by the north pole of a magnet.
> E2. Since the force of repulsion considering the quality of charge induced, the repulsion will be absolute as they are not consecutive
> J2. They are likely to assume that the motion of charge will be such that it is in the same direction as the lines of forces(from N to S).

According to teacher J, students may consider the direction of magnetic field lines, and that there is a force pushing the charge in the direction of the magnetic field. The other two teachers feel that students assume that positive charge will be repelled by the north pole. According to E, students assume that there is a charge induced which will result in the repulsion. Because E chose this option as the correct answer it seems he regards the notion of an induced charge as plausible.

Teacher B predicted that students would choose option 'g':

> B2. These is an ordinary magnet and will have no effect on a charge placed near it.

Teacher B thinks that students are going to choose this option because they know that the magnetic field has no effect on the charge. B is confident that students will answer correctly.

Three teachers did not predict their students' responses. Their explanations are as follows:

> D2. Magnet attracts magnetic substances only (not insulator)
> F2. Same as in 1 above*(i.e. students will guess)*
> G2. N/A since I have not yet treated this topic

Teacher D explains why the option he chose is the correct one, i.e. magnets only attract magnetic substances. He emphasises that the charge is an insulator and so it will not be attracted.

All teachers, except four (B, D, F and G), predicted that their students think that

the charge will move. The reasons given by these teachers nevertheless indicate that students think that the two situations, i.e. Questions 1 and 2, *are different*. Some teachers also reflect the same alternative conception.

For **Question 3** the predictions were as follows.

The majority of teachers thought that their students would choose option **'b'**. The' xplanations were as follows:

> B3. They only know that unlike poles attract and hence the fact that W is attracted to N of M. This means it is a magnet with its S pole facing the N pole of M. (They won't easily be able to realise that not only magnets are attracted or repelled, but even a magnetic material can be attracted by a magnet).
> C3. They may think of the concept that the 'like poles repel and unlike poles attract'
> G3. Because they only know that for a magnet like charges repel and unlike charges attract. They may not be aware that any magnetic material is attracted but repelled unless it is a magnet of like charge.
> H3. Like poles repel therefore applying unlike poles attract each other
> I3. The attract will occur to the students that W is a magnet with its south pole facing the north pole of the magnet M
> J3. They may assume that it is a correct since they know that unlike poles attract. N- pole attract S - pole.

These teachers agree that students think that because the magnetic object W is attracted then it must be a magnet. Teachers B and G emphasise that their students may not know that attraction is not a sufficient test of whether a material is a magnet or not. This may imply that the problem could result from teaching where this idea was not dealt with. Teacher H chose this option to be the correct response: this reflects that some teachers hold the same ideas as students. In this question teachers reflected some degree of awareness of possible students' answers.

Two teachers thought that their students would choose option **'c'**:

> A3. They know that attraction does not only occur between two magnets

F3. They know that to test for a magnet we look for repulsion between the magnet and material to be tested

The teachers feel that their students 'know' that attraction does not only result between two magnets. This could imply that these teachers discussed this issue in class. But looking at the responses of students it does not seem like students really knew this. This therefore reflects that these teachers were not aware of possible students' responses.

Option 'd' was chosen only by teacher E:

E3. Since the polarity is not indicated. They may believe option d is the right option

This teacher feels that the issue of polarity is crucial for students to correctly answer this question. He feels that the 'attraction' observed is insufficient information.

One teacher did not predict students' possible responses. The explanation given only explains why he thinks option 'c' is the correct response:

D3. Repulsion is the only test for magnet. Magnet attracts magnetic substance

Responses to this question reflect that some teachers were aware of possible students' responses while others were not. They reflect the possible influence of teaching/learning on the acquisition of alternative conceptions. They also reflect that some teachers hold the same alternative conceptions as held by students.

For Question 4 the following are the predictions of teachers. The majority of teachers opted for option 'a' as the response which most of their students are going to choose. Their reasons are as follows:

C4. Because the current is applied in a similar manner in both cases
H4. They will not think of the difference between insulated and uninsulated wire as uninsulated wire touches the iron core in B it will conduct electricity instead of been magnetised

> I4. Students may not be able to understand that the insulation of the wire is necessary for magnetisation in the above arrangement.
> J4. They may think that as long as the wire wound around the bar that will become a suspect.

These teachers think that students will think that the two set-ups are similar and attach no importance to the insulating material. The argument raised by teacher H is only relevant if the core has a lower resistance than the wire. It should be noted that all four of these teachers thought 'b' was correct, i.e. they think that the wire must be insulated (which is an alternative conception). Teachers A and F gave the following reasons, which confirm the existence of this alternative conception.

> A4. Making an electromagnet does not consider the insulation or no insulation they have seen
> F4. They will assume that there is no contact between the uninsulated coil and the soft core

They feel that their students know that the insulation is not that important in order to magnetise the core; i.e. that students know that as long as they can get current flowing around the coil then the core will be magnetised. Thus they believe that their students would answer correctly.

Only teacher G thought that the majority of students would choose option 'b':

> G4. This is because the description given in a text book talks about 'insulated copper wire'. Therefore if they are not cautioned about it in class then they are likely to think that B will not be a magnet since the wire is not insulated.

This teacher feels that most students will get this question wrong because of the description given in the textbook. The impression textbooks give is that the insulation is necessary and without it the core will not be magnetised. He further suggests that teaching must take care of this explanation otherwise students will be misled.

Two teachers predicted that most of their students would choose option 'c':

> B4. Wire A is insulated hence it won't be easy for magnetism to be induced in that material
> E4. If they assume insulation as prevention of the flow of current then their thoughts could be likened to that of d

Teacher B believes that students think of the insulated wire as an obstacle for magnetisation. However teacher B himself considered 'c' as the correct option, so has the same alternative conception. Teacher E's response is contradictory: he either wanted to choose option 'd' as indicated in the explanation, or 'c' as indicated by his choice of option.

Only teacher D was not able to predict the responses of students. His explanation is as follows:

> D4. Current passing through the insulated wire and the other wire

This teacher, as in the other questions, is explaining why he thinks option 'a' is correct.

This question, like others, reflected some teachers not being aware of possible responses of their students. It also reflects some teachers holding the same alternative ideas as their students.

For **Question 5** all teachers except one were able to predict the responses of their students. One teacher thought that students would choose option 'c' and the explanation given is as follows:

> E5. Considering the neutrality of the conductor he may assume that there can not be any impact due to this

There is a contradiction in what this teacher is saying since the option stated there is motion towards the conductor and the explanation says there is no motion. Another teacher, J, was not decided as to which option between 'c' and 'd' students will take. The explanation is as follows

J5. Because q is positively charged it would move such that it is attracted by a conductor or repelled by a conductor.

The explanation, however, does not indicate why students would think that the positive charge either will be repelled or attracted. It can only be assumed that this teacher thinks that students would think that there will be charge induced in the conductor which will either repel or attract the positive charge q.

The majority of teachers thought that their students would choose option 'g'. The following explanations come from the three teachers who thought that this option was *incorrect*:

A5. They might not see that the charge +Q which cause -ve charge to move to its side so that it can be attracted.
C5. They will not think of attraction due to induced charges
I5. Students may not be able to know that negative charge will be induced close to the positive charge to attract the positive charge towards it.

These teachers think that students are unaware of a charge induced on the conductor which will cause attraction or repulsion. The above discussion, in 5.1, proved these teachers to be correct. The following explanations are given by those teachers who thought that this is the *correct* response:

B5. The conductor is neutral hence it won't affect the charge in any way
F5. They should guess that there is no field around an uncharged body
G5. Because they know that movement is the result of the force felt by the object.
H5. They may not recall electrostatic induction in C to cause opposite charge net to q

Teacher B explains why this option is the correct one. The other teachers agree that students are going to think that there is no force which the charge will experience as the conductor remains uncharged.

One teacher did not predict the students' responses. The explanation given explains why option 'g' is the correct one:

D5. Uncharged conductor does not attract positively charged insulator

The above discussion of the explanations given by teachers reflects that there are teachers who are, to some extent, aware of possible responses students are likely to give while others are not. This study interprets the unawareness of the students' responses to mean that the teacher is not aware of the students' ideas. The discussion has also reflected that there are teachers who hold alternative conceptions and that the same conceptions are held by the students. This observation is interpreted as an indication that there are some alternative conceptions which are due to the teaching/learning process.

5.4 Conclusion:

This chapter reflects the following.

i) There are teachers who could not predict students' responses or who were not aware of their students' possible responses. This means that some teachers are not aware of students' ideas about concepts in electromagnetism. This implies that some teachers are unaware of the existence of alternative conceptions that their students hold.

ii) The sample of high school students in this study from Lesotho also reflects the existence of alternative conceptions on electromagnetic concepts as indicated in Chapter 2. The study also reflects that some teachers had the same alternative conceptions. This means that some of these alternative conceptions which students have could have been transferred from teachers to students. This therefore verifies that some of the alternative conceptions are caused by the teaching/learning process.

This chapter, therefore, suggests that the teaching strategies used by these teachers do not remediate unscientific ideas that students hold, but rather promote those that already exists or even introduce new ones. Such teachers use non - constructivist strategies that pay no attention to already existing students' ideas.

CHAPTER 6

FINDINGS, IMPLICATIONS AND RECOMMENDATIONS

6.1 Introduction

The aim of this study, as discussed in Chapter 1, was to investigate teachers' thinking about their subject (Physics), and their students. This was done by investigating beliefs of teachers on two main categories, namely

* Students' knowledge - divided into the following sub-categories:
    i) Traditional Teaching vs Non-Traditional Teaching
    ii) Teachers' view of electromagnetism
* Teaching Methods - divided into the following sub-categories:
    i) General Methods
    ii) Use of experiments

The study addressed the following research questions:

i) What beliefs about Physics and Physics teaching do high school teachers, in Lesotho, have especially about the teaching of electromagnetism topics taught at high schools?

ii) What strategies do teachers employ to teach concepts of electromagnetism?, and

iii) Are teachers in high schools, in Lesotho, aware of students' alternative conceptions?

The sample consisted of high school Physics teachers from Lesotho.

6.2 Findings

The findings of this study endeavour to answer these research questions.

Answering Research Question (i) - Teachers' beliefs

In Chapter 4 we concluded that:

Physics teachers in Lesotho reflect both non-constructivist as well as constructivist

beliefs about Physics teaching and Physics itself. Traditionalists believe that Physics is strictly bound by rules and facts that must be known by the student. Some teachers showing traditional views believe that for students to understand, they must know rules and formulae because of their importance to the understanding of concepts. These teachers believe that Physics is a body of known facts that must be accepted by their students. Teachers are seen as having this knowledge, and their fundamental role is to tell it to their students, who in turn must accept it.

Although these belief categories are reflected in this study it is not possible to draw a separation line between teachers falling in either of them. For instance a teacher would show a non-constructivist belief in statement 1 (If there must be a choice between the understanding of concepts, and facilitating the process of self-discovery, then the teachers should rather emphasize the concepts.) and a completely different view in statement 15 (Electromagnetic induction can best be understood by students if teachers use demonstrations in their lessons.).

We therefore conclude that

* Some teachers, in Lesotho, hold constructivist beliefs about Physics and Physics teaching while others hold empiricist beliefs.
* Empiricist believe that students must know rules and formulae in order to understand Physics concepts. They view Physics as a body of well known facts which must be accepted by students without questioning. They also see themselves (teachers) as having this knowledge, and their fundamental role as being to tell students this knowledge. These teachers reflect a 'tabula rasa' notion where students are assumed to have 'empty minds' which must be filled with unquestionable knowledge of the teacher.
* Constructivists believe that students need to understand concepts, rather than an emphasis on rules and formulae. They believe that Physics is a dynamic subject where what is known can be challenged.

Answering Research Question (ii) - Teaching strategies

In Chapter 4 we concluded that:

The study also reflects teachers' beliefs about effective teaching methods. There are some teachers who seem to believe in traditional methods, such as lecturing, because, amongst other things, the subject is difficult and students must be given more basic knowledge. Others seem to believe that there is no other way except to use experiments, especially for electromagnetic concepts which are so abstract.

Teachers are divided about which strategies they would use to teach different concepts in Physics, particularly electromagnetism. Some teachers opted for empiricists strategies while others opted for constructivist strategies. Empiricists believe in teaching methods which emphasise concepts so that students can understand better.

We therefore conclude that:

* Some teachers, in Lesotho, tend to use teaching methods that are non-constructivist while others prefer to use teaching methods that are in line with constructivism.
* Non-constructivist believe that Physics concepts are difficult and therefore must be lectured to students in order to give them more basic knowledge. Thus, emphasising concepts was more important to them.

Answering Research Question (iii) - Awareness of Alternative Conceptions

The following conclusion was made in Chapter 5:

There are teachers who could not predict students' responses or who were not aware of their students' possible responses. This means that some teachers are not aware of students' ideas about concepts in electromagnetism. This implies that some teachers are unaware of the existence of alternative conceptions that their students hold.

We also concluded in Chapter 4 that:

The study reflects that some teachers are aware, to some extent, of the possible

ideas of students, while others *may not be aware*. Those teachers who seem not to be aware of students' alternative conceptions tend to think that students relatively easily understand concepts. Therefore there is really no reason why students cannot understand such 'easy' concepts.

We therefore conclude that:

* Some teachers in Lesotho's high schools are not aware of the existence of students' alternative conceptions
* Because of this, it seems logical to assume that teaching in some high schools does not address these ideas.

In Chapter 5 we also noted that:

The sample of high school students in this study from Lesotho also reflects the existence of alternative conceptions on electromagnetic concepts as indicated in Chapter 2. The study also reflects that some teachers had the same alternative conceptions. This means that some of these alternative conceptions which students have could have been transferred from teachers to students. This therefore verifies that some of the alternative conceptions are caused by the teaching/learning process.

Amongst the alternative conceptions reflected by both teachers and students the following could not be found in the literature

> *When there is a current in a conductor, the conductor is charged either negatively or positively.*

According to this, if electron current is considered then the conductor will be charged negatively and if conventional current is considered then the conductor is charged positively.

It was also noted in chapter 5 that the teaching strategies used by these teachers do not remediate unscientific ideas that students hold, but rather promote those that already exists, or even introduce new ones. Such teachers use non-constructivist strategies that pay no attention to already existing students' ideas.

Concluding remarks

Answering the three research questions reflect a link between teachers' thinking and their practice. The study shows that:

* There are teachers who have empiricists beliefs and some who hold constructivist beliefs.
* Teaching in some high schools is dominated by the use of empiricist teaching strategies.

6.3 Implications and Recommendations

The intention of this study is not to attempt to generalise the present findings, but rather to get an idea of the possible situation regarding teachers' thinking in Lesotho. The answers to the above research questions has implications for researchers, teacher trainers and teachers.

The researcher's contention is that teaching should recognise that each individual constructs in his mind concepts even before being exposed to any formal teaching. This means that each learner comes to classrooms with well defined ideas about concepts in that particular subject. These ideas act as frameworks for the learning of new concepts. Therefore teachers need to be aware of pre-existing ideas. This study reflects that teachers may not be aware of these ideas. It can be expected therefore that their teaching does not take this fundamental idea behind constructivism into account, and as a result does not remediate alternative conceptions.

The issue of beliefs is also an important aspect in the teaching/learning process. Some teachers in this study have reflected non-constructivist beliefs. These teachers seem to believe that some concept are easy and that students do not have any 'good' reason for not understanding them. The strategies that these teachers choose also reflect an empiricist approach to teaching. Thus their classroom practice can reasonably be assumed to be such that alternative conceptions are not addressed, but rather promoted.

The findings of this study support the view that some of the alternative conceptions originate directly from the teaching process.

Since most teachers participating in this study are trained to teach Physics, then teacher support programmes in Lesotho need to be improved in order to address possible shortcomings in teaching.

* Access to such programmes must be made easier, either by increasing their frequency, or by spreading the venues to cover all schools.
* Workshops must be organised which amongst other things address the issue of students' alternative conceptions, and their influance on the teaching/learning process.

This study also shows that teachers, as well as students, hold alternative conceptions. The design of this study does not allow for a clear picture of how deep these conceptions are. Use of a different design to ascertain these conceptions is necessary. Few studies are available which suggest possible remediation strategies. Research studying such methods will be highly appreciated by teachers and teacher educators.

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APPENDIX A

QUESTIONNAIRE 1

SECTION A

INSTRUCTIONS: Please respond to the following questions. Where there are options please tick correct response(s).

The researcher intends to use these data in his MSc research project he is undertaking. The data you give will be of importance in a number of ways. For example it will be used to contribute to the body of knowledge. The data will therefore be handled with confidentiality and maximum respect.

1. Sex: Male/Female

2. Nationality: Lesotho
RSA
India
Other

If other please specify:.....

2. Age range:
21-25 years
26-30 years
31-35 years
36-40 years
41-45 years
46-50 years
51-55 years
55 years and above

3.0 Last High school attended(as a school pupil):.....

3.1 Which subjects did you do for our school leaving certificate?
Mathematics
Biology
Physical Science
Human and Social Biology
Others

If other please specify: .....
.....
.....

3.2 Highest examination passed: COSC
GCE
GCSE
MATRIC from Republic of South Africa
OTHER

If other please specify:.....

3.3 Indicate symbol obtained in the following subjects, where applicable:
Mathematics
Biology
Physical Science
Human and Social Biology

APPENDIX A

QUESTIONNAIRE 1

SECTION A

INSTRUCTIONS: Please respond to the following questions. Where there are options please tick correct response(s).

The researcher intends to use these data in his MSc research project he is undertaking. The data you give will be of importance in a number of ways. For example it will be used to contribute to the body of knowledge. The data will therefore be handled with confidentiality and maximum respect.

1. Sex: Male/Female

2. Nationality: Lesotho
RSA
India
Other

If other please specify:.....

2. Age range: 21-25 years
26-30 years
31-35 years
36-40 years
41-45 years
46-50 years
51-55 years
55 years and above

3.0 Last High school attended(as a school pupil):.....

3.1 Which subjects did you do for our school leaving certificate?
Mathematics
Biology
Physical Science
Human and Social Biology
Others

If other please specify: ....
.....
.....

3.2 Highest examination passed: COSC
GCE
GCSE
MATRIC from Republic of South Africa
OTHER

If other please specify:.....

3.3 Indicate symbol obtained in the following subjects, where applicable:
Mathematics
Biology
Physical Science
Human and Social Biology

Other Science subject(s)

If other please specify:.....

4.0 Post-Secondary Qualification: STC
Dip. Sc.Ed.
Bsc. Ed
Other

If other please specify:.....

4.1 Institution from which you obtained your qualification:.....

.....

4.2 What were your major subjects: Physics
Mathematics
Chemistry
Biology
Other

If other please specify:.....

.....

5.0 How long have been teaching: 0-5 years
6-10 years
11-15 years
16-20 years
More than 20 years

If other please specify:.....

5.1 How long have been teaching Physics (or physics within physical science):
0-5 years
6-10 years
11-15 years
16-20 years
More than 20 years

Please specify:.....

SECTION B

Please respond to the following statements by choosing the appropriate number on the scale:

1 = strongly disagree, 2 = disagree, 3 = slightly disagree
4 = slightly agree, 5 = agree, 6 = strongly agree

1.	If there must be a choice between the understanding of concepts, and facilitating the process of self-discovery*, then the teacher should rather emphasize the concepts.(* see footnotes)	1 2 3 4 5 6
	Please explain:.....	.....
.....	.....	.....
.....	.....	.....
2.	Because students do not like experiments on the design and use of permanent magnets and electromagnets I simply do not let them do such experiments.	1 2 3 4 5 6
	Please explain:.....	.....
.....	.....	.....
.....	.....	.....
3.	A big weakness of discovery activities* in electromagnetism is the difficulty in getting the children to come up with the right answers.(* see footnotes)	1 2 3 4 5 6
	Please explain:.....	.....
.....	.....	.....
.....	.....	.....
4.	Because of the amount of specific information to be taught in electromagnetism, at least 50% of the course should be given using the lecture method.	1 2 3 4 5 6
	Please explain:.....	.....
.....	.....	.....
.....	.....	.....
5.	A big problem in teaching electromagnetism today in that it is so expensive to do meaningful laboratory experiments at all levels.	1 2 3 4 5 6
	Please explain:.....	.....
.....	.....	.....
.....	.....	.....

* refers to activities intended to help students discover a concept(s) by themselves

6. In performing experiments in electromagnetism, the best learning is likely to take place if students are able to work alone. 1 2 3 4 5 6
Please explain:.....

7. When teaching electromagnetism the teacher must first find out what ideas students already have. 1 2 3 4 5 6
Please Explain:.....

8. Students do not know any thing about electromagnetism, so the teacher needs to tell them all the basic facts. 1 2 3 4 5 6
Please Explain:.....

9. Electromagnetism is the most difficult subject in Physics, and the most difficult to teach. 1 2 3 4 5 6
Please Explain:.....

10. Experiments help students to better understand electromagnetic concepts such as 'magnetic field' and 'magnetic induction'. 1 2 3 4 5 6
Please Explain:.....

11. Students understand the difference between the 'electric' and 'magnetic' fields. 1 2 3 4 5 6
Please Explain:.....

12. It is impossible to demonstrate the factors affecting the magnitude of the emf induced in electromagnetic induction. 1 2 3 4 5 6
Please Explain:.....

13. Students understand the concept of the magnetic field. 1 2 3 4 5 6
Please Explain:.....

14. Electromagnetic induction can best be understood by students if teachers use demonstrations in their lessons. 1 2 3 4 5 6

Please Explain:.....

.....

.....

15. For students to understand the concept of the magnetic field they must understand Fleming's rules. 1 2 3 4 5 6

Please Explain:.....

.....

.....

16. Distinguishing between the magnetic properties of iron and of steel is easy for students. 1 2 3 4 5 6

Please Explain:.....

.....

.....

17. Having fun or structured play with magnets in Physics lessons is a waste of time. 1 2 3 4 5 6

Please Explain:.....

.....

.....

18. One of the things that make the concepts of 'magnetic' and 'electric' fields so difficult is the absence of formulae to explain them at Ordinary Level Physics. 1 2 3 4 5 6

Please Explain:.....

.....

.....

19. My students enjoy doing practicals on a. c. generators. 1 2 3 4 5 6

Please Explain:.....

.....

.....

20. The transformer is the most difficult topic to teach in electromagnetism. 1 2 3 4 5 6

Please Explain:.....

.....

.....

21. There is really a need for students to master all the formulae in electromagnetism because it is difficult to learn Physics without mastering such formulae. 1 2 3 4 5 6

Please Explain:.....

.....

.....

22. It is not advisable to allow students to do practicals on transformers because transformers are very dangerous to work with. 1 2 3 4 5 6

Please Explain:.....

.....

.....

23. Because it may not be possible to do experiments with transformers, the equation $V_p/V_s = N_p/N_s$ should just be given to students(where N_p is the number of turns on primary coil, N_s the number of turns on secondary coil, V_p is the voltage(pd) across the primary coil, V_s is the voltage across the secondary coil). 1 2 3 4 5 6

Please Explain:.....

.....

.....

24. Electric motors confuse students. 1 2 3 4 5 6

Please Explain:.....

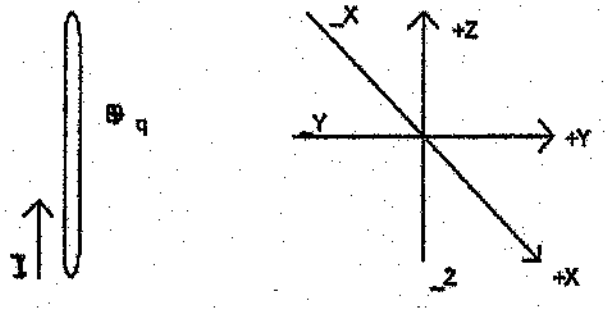
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APPENDIX B

Questionnaire 2
This is a questionnnaire, it is NOT A TEST. The information you give is going to be used for the purposes of reseach study only. PLease give as much information as possible.

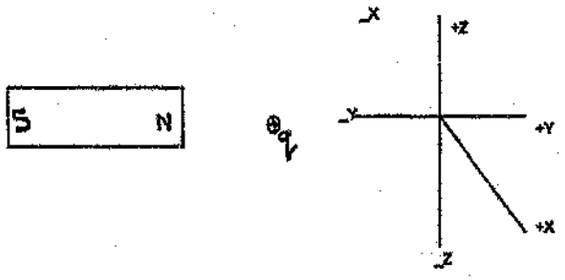
QUESTION 1.
A stationary positive charge, q, is placed near a current carrying conductor C carrying conventional current I as shown below.



In which direction is the charge q likely to move?
a. In the direction -X
b. In the direction +X
c. In the direction -Y
d. In the direction +Y
e. In the direction -Z
f. In the direction +Z
g. The charge will not move

(i) tick the correct response
(ii) Choose an option which is likely to be chosen by most students:.....
(iii) Explain why you think students will choose that response:.....
.....
.....
.....

QUESTION 2.
A small charged insulator q is placed close to a strong stationary magnet M as shown.



In which direction is the charge q likely to move?
a. In the direction -X
b. In the direction +X
c. In the direction -Y
d. In the direction +Y
e. In the direction -Z
f. In the direction +Z
g. The charge will not move

(i) tick the correct response
(ii) Choose an option which is likely to be chosen by most students:.....
(iii) Explain why you think students will choose that response:.....
.....
.....
.....

QUESTION 3.
A magnet, M, is placed next to a magnetic object W, as shown below. It is not known whether W is a magnet itself or not.



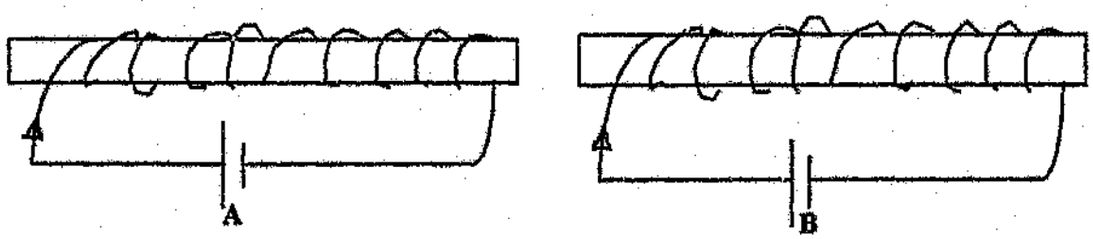
M W

An attraction is observed. This means that
(a) W is a magnet with its North pole next to the N pole of the magnet.
(b) W is a magnet with its South pole next to the N pole of the magnet.
(c) W may not be a magnet.
(d) W is a magnet but we can not know which side is the North or the South pole.

(i) tick the correct response
(ii) Choose an option which is likely to be chosen by most students:.....
(iii) Explain why you think students will choose that response:.....
.....
.....

QUESTION 4.

Somebody has two wires; wire A is insulated and wire B is not insulated. He makes an electromagnet with the wires as shown below.(The wires are wound as solenoids(coil) around soft iron cores)



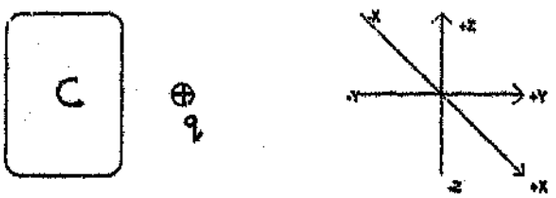
Which of the following statement is true?

(a) Both A and B will become magnets.
(b) A will become a magnet and B will not.
(c) B will become a magnet and A will not.
(d) Neither A nor B will become a magnet.

(i) tick the correct response
(ii) Choose an option which is likely to be chosen by most students:.....
(iii) Explain why you think students will choose that response:.....
.....
.....
.....

QUESTION 5.

A small charged insulator **q** is placed close to a VERY LARGE, uncharged(neutral), stationary CONDUCTOR **C** as shown below.



In which direction is the charge **q** likely to move?

(a) In the direction -X
(b) In the direction +X
(c) In the direction -Y
(d) In the direction +Y
(e) In the direction -Z
(f) In the direction +Z
(g) The charge will not move at all.

(i) tick the correct response
(ii) Choose an option which is likely to be chosen by most students:.....
(iii) Explain why you think students will choose that response:.....
.....
.....
.....

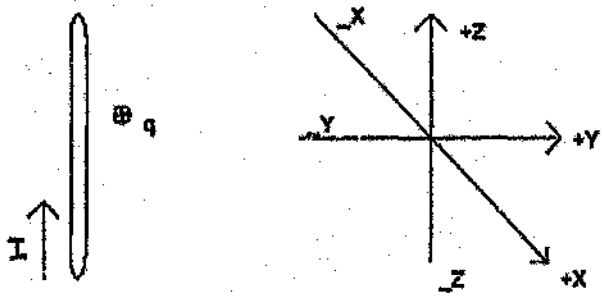
APPENDIX C

Questionnaire 3

This is a questionnnaire, it is NOT A TEST. The information you give is going to be used for the purposes of reseach study only. PLease give as much information as possible.

QUESTION 1.

A stationary positive charge. q, is placed near a current carrying conductor C carrying conventional current I as shown below.

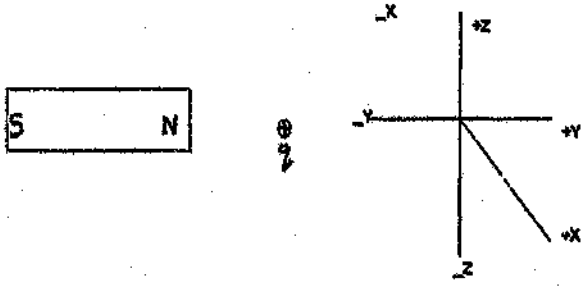


In which direction is the charge q likely to move?

a. In the direction -X
b. In the direction +X
c. In the direction -Y
d. In the direction +Y
e. In the direction -Z
f. In the direction +Z
g. The charge will not move

QUESTION 2.

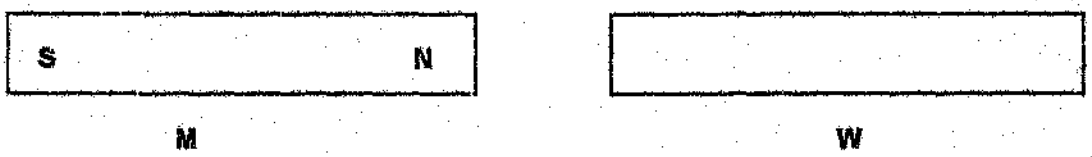
A small charged insulator q is placed close to a strong stationary magnet M as shown.



In which direction is the charge q likely to move?

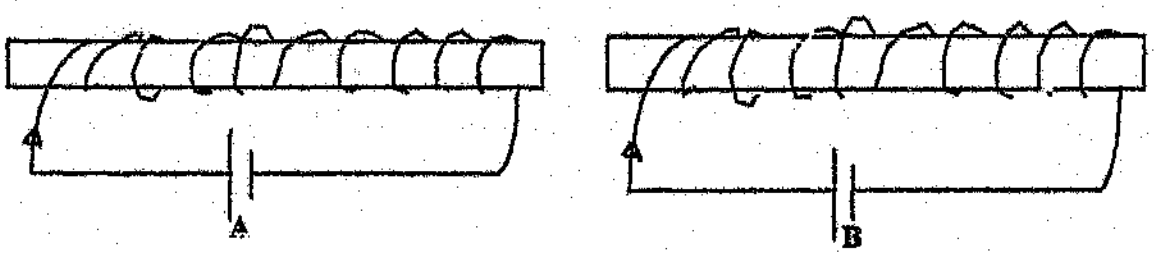
a. In the direction -X
b. In the direction +X
c. In the direction -Y
d. In the direction +Y
e. In the direction -Z
f. In the direction +Z
g. The charge will not move

QUESTION 3.
A magnet, M, is placed next to a magnetic object W, as shown below. It is not known whether W is a magnet itself or not.



An attraction is observed. This means that
(a) W is a magnet with its North pole next to the N pole of the magnet.
(b) W is a magnet with its South pole next to the N pole of the magnet.
(c) W may not be a magnet.
(d) W is a magnet but we can not know which side is the North or the South pole.

QUESTION 4.
Somebody has two wires; wire A is insulated and wire B is not insulated. He makes an electromagnet with the wires as shown below.(The wires are wound as solenoids(coil) around soft iron cores)



Which of the following statement is true?
(a) Both A and B will become magnets.
(b) A will become a magnet and B will not.
(c) B will become a magnet and A will not.
(d) Neither A nor B will become a magnet.

QUESTION 5.
A small charged insulator **q** is placed close to a VERY LARGE, uncharged(neutral), stationary CONDUCTOR **C** as shown below.



In which direction is the charge **q** likely to move?
(a) In the direction -X
(b) In the direction +X
(c) In the direction -Y
(d) In the direction +Y
(e) In the direction -Z
(f) In the direction +Z
(g) The charge will not move at all.

APPENDIX D

EXPLANATIONS OF TEACHERS ON SECTION B OF QUESTIONNAIRE 1

Statement 1: If there must be a choice between the understanding of concepts, and facilitating the process of self-discovery*, then the teacher should rather emphasize the concepts.

T2 - Concepts are well emphasised through the use of experiments
T3 - Understanding concepts is better done using experimental method
T4 -
T5 - Discovery is the best method of making students appreciate learning science.
T6 - Emphasis on concepts may at times lead pupils to memorise.
T7 - Emphasing the concepts as a means to try to open the pupils to discover them themselves actually helps them to better understand these concepts other than when they are just said out and explained to them.
T8 -
T9 - The concepts should be emphasized even in self-discovery can only be limited by equipment
T10 - This will help students to get better understanding of the subject and also build interest and confidence in them.
T11 - More understanding will follow after understanding of concepts.
T12 - Emphasizing the concepts brings rote learning while self discovery brings in concrete learning and adventure in the world of Physics.
T13 - Students believe that the teacher emphasize the most important concepts.
T14 - The concepts can only be facilitated when emphasized and understood.
T15 - A basic knowledge of the concepts will be always helpful.
T16 - This ia because the pupils will not fully understand and may soon forget.
T17 - Because it gives that teacher to do more discovery.
T18 -
T19 - The process of self-discovery promotes original thinking and makes young scientists.
T20 - There is lack of equipment for necessary activities and also discovery learning needs a lot of time.
T21 - The choice in the presence of material would best to facilitate.
T22 - When a student is allowed to discover a concept by himself the retention is evalasting, that when the concept is emphasized upon.

Catagories:

1. Disagree:
T2, T3, T5, T6, T12, T13, T16, T19, T22
2. Agree:
T7, T9, T10, T11, T14, T15, T20
3. Intention of response uncertain:
T17, T21
4. No response:
T4, T8, T18

Statement 2: Because students do not like experiments on the design and use of permanent magnets and electromagnets I simply do not let them do such experiments.

T2 - Students learn better when doing experiments
T3 - Because it is through experiments that students learn more effectively and the way the teacher introduces it.
T4 - They actually enjoy doing experiments.
T5 - Students like doing expeirments especially with magnets and electromagnets.
T6 - Youngsters like to learn by experimenting
T7 - Experiments are on their aim, the best was of making the students understand theory and the concepts involved.
T8 - Its not true that students don't like expts
T9 - The students like experiments a lot it could only be that they sometimes do not have enough time or equuipment.
T10 - The teacher should try whatever means possible within his capacity to let students know and accept the importance of these expts.
T11 - In general students seem to have great interest in experiments.
T12 - To get the concept of another metal attracting another is difficult to explain without a physical example.
T13 - Students believe and understand by doing experiments even if they do not like them.
T14 - Students learn best by doing rather than by being told
T15 - Students like best experiments on magnetism
T16 - This will not help them understand the concept, so if they do not like the experiments a teacher has to try and make them more interesting.
T17 - Because students like playing with magnets and like to do experiments.
T18 - Experiments must be performed by the students with the assistance of the teachers. It helps the students to catch up the concept easily.
T19 - Students like experiments on magnets and electromagnets.
T20 - Experiments generally form part of learning which interest pupil most and reinforce their understanding of concepts.
T21 - Students enjoying first to play about or after the experiments with materials.
T22 - This does not make the student self reliant but ties him to the ?
Strings of the teacher. The approach counts most here.

Catagories:

1. Agree:
T2, T3, T4, T5 , T6, T7, T8, T9, T10, T11, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22

Statement 3: A big weakness of discovery activities* in electromagnetism is the difficulty in getting the children to come up with the right answers.

T2 -
T3 - Though I have not done the expts with my students due to lack of equipment I don't consider the above mentioned as a weakness.
T4 - If the teacher makes sure before hand that the magnets are in good condition, then it is often not difficult for the students to come up with the right answer.
T5 - And also getting the apparatus which work
T6 - They may have not understood the concepts clearly.
T7 - If the concepts have not been properly emphasized to them, then they will of course have difficulty in getting the right answers.
T8 -
T9 - If they have had enough experimentation they certainly can come up with correct answers.
T10 - With close supervision from the teacher, students can be able to overcome such difficulties.
T11 - In discovery activities students tend to pay much attention to important points.
T12 - This because the field causing the effect cannot be seen and also the electron concept is difficult for students to stick to.
T13 - Most of the time they don't trust themselves so it's not easy for them to come up with the right answer.
T14 - Discovery activities is recommended since makes students to understand and creative.
T15 - In such cases the students will be told to repeat the experiments.
T16 - It is not always the case and even if children fail to come up with right answers, the teacher will have the task of showing them why they wrong.
T17 - Some can come up with the answer.
T18 -
T19 - Children very often make mistakes when they give answers.
T20 - Children do not necessarily need to come with right answers but they need to be given a strong idea through well designed activities.
T21 - The right answers can always be developed from the pupils vague answers.
T22 - Iterative methods could be introduced and this lead the students to surprises at his potentials e.g Production of current through HNO3 electroplates the ? Electrode.

Catagories:
1. Disagree:
T3, T4, T9, T10, T11, T14, T16, T17, T20, T21, T22
2. Agree:
T5, T6, T7, T12, T13, T15, T19
3. No response:
T2, T8, T18

Statement 4: Because of the amount of specific information to be taught in electromagnetism, at least 50% of the course should be given using the lecture method.

T2 - In the case of lack of apparatus and explanation should be done to reiforce concepts.
T3 -
T4 - I believe in making students perform experiments to discover for themselves how ordinary magnetic materials are made into magnets by passing electricity through them and also see that they behave like permanent magnets.
T5 - This topic requires practicals and even use of models to show, say, that field lines are not on a single plane.
T6 - Students will find it abstract.
T7 - It is not good rushing to finish whatever has to be offered to these pupils before their final exanimations. The lecturing method is a disadvantage since they are battling with the language with understanding the material itself.
T8 -
T9 - This could only depend on individual teacher no, that there is a lot of material to be taught.
T10 - Teachers normally use the method of expoaition in this branch of Physics because of lack of sufficient teaching aids.
T11 - Experience have proved that students are confused in learning electromagnetism. Practicals and experiments can usually bring more understanding in Physics.
T12 - The specific information in electromagnetism actually needs a practical approach at most.
T13 - Students grasp and understand things they do and those they can see happen or touch.
T14 - Electromagnetism is a practical topic hence 50% lecture method will be a waste of time since student will not make sense of the taught.
T15 - Always activities and expts. will promote their learning.
T16 - This is a purely practical topic and whenever possible lecturing should be kept minimum.
T17 - Becuase the topic might be difficult to come out of good answer.
T18 - Theoretical knowledge is essential to perform the experiments acurately.
T19 - In electromagnetism it is difficult and also time consuming for a student to discover ideas by himself.
T20 - I think practical methods should be employed whenever possible. The only reason for not doing exp. Is lack of equipment.
T21 - Pupils appreciate the facts as practical bet(?) It demonstrational is going on.
T22 - Teach a child the way to follow so that when he grows he will not depart from it. apply this when the students are optimaly developed.

Catagories:

1. Disagree:
T4, T5, T6, T7, T10, T11, T12, T13, T14, T15, T16, T20
2. Agree:
T2, T17, T18, T19
3. Intention of response uncertain:
T21, T22
4. No response:
T3, T8,

Statement 5: A big problem in teaching electromagnetism today is that it is so expensive to do meaningful laboratory experiments at all levels.

T2 -
T3 -
T4 - Improvised laboratory material can help solve this problem
T5 - I have found the problem being that the electromagnets are not usually strong enough
T6 - Difficulty in procurement of some equipment
T7 - I agree with this because these equipments/apparatus are really expensive
T8 - I agree but this does not apply to our school bioz ours has a well equipped, fully equipped lab
T9 - At COSC it is possible to do meaningfyl experiments if there is enough equipment
T10 - Experiments on electromagnetism are so expensive that schools can't afford. Authorities should try to provide the necessary equipments or apparatus for such experiments.
T11 - There is a lack of apparatus particularly at COSC level but JC level the apparatus is not that expensive.
T12 - If the teacher is creative (not just waiting to use only the models equipment) then some learning can be carried at 50 - 80% level.
T13 - At least demonstrations can do a lot to students, so using available materials experiments can be done.
T14 - The apparatus use are not available in most schools hence expensive
T15 - Not so expensive at ordinary level
T16 - There are some experiments which used expensive laboratory equipment but most of them require cheap and easily available materials.
T17 - Because many schools have no laboratory and no equipment.
T18 - To explain simple concepts of electromagnetism we need only few things - coil of copper wire, strong horse shoe magnet and a galvanometer.
T19 - Apparatus for expts on electromagnetism can be got at low prices.
T20 - This is because it seem our economy does not allow us to have well equipped laboratories hence why we cannot do such experiment.
T21 - there must always be excess materials to be present in case of accidents.
T22 - Improvisation superseeds the cost involced, if any at all. Magnets and magnetic materials are readily available hence as well as electricity low cost is involved.

Catagories:

1. Disagree:
T4, T5, T9, T12, T13, T15, T16, T18, T19, T20, T22

2. Agree:
T6, T7, T8, T10, T11, T14, T17, T21

3. No response:
T2, T3

Statement 6: In performing experiments in electromagnetism, the best learning is likely to take place if students are able to work alone.

T2 - But teacher has to be around to clarify where problems arise
T3 - Because at secondary level their knowledge is too very little regarding the topic
T4 - Working in groups helps students in that it enables them to discuss their observations and share the often difficult task of drawing conclutions from observations.
T5 - Not necessarily demonstrations and groupwork can also be effective
T6 - If they are given enough guidance
T7 - I agree with this because if they are able to work on their own those they all the opportunity to adventure into things they might have not had the chance to realise under my direct control.
T8 - They need to discuss
T9 - This is so because students should be able to discusses things on their own.
T10 - The student will get full knowledge and understanding of the experiment from his own observations and conclutions.
T11 - It better for pupils to work in groups during experimental work so that they can share ideas and knowledge there come up with possibly common strong answer.
T12 - If you the teacher is using the Inquiry approach of teaching Physics, then you the teacher must be their to encourage the learning take place.
T13 - Because they are able to discover some concepts which enable them to understand what they are doing.
T14 - Since they will see most of the things by themselves and they will come up with questions to the teacher.
T15 - with the assistance of the teachers
T16 - Students should work under close supervision of the teacher as they may sometimes try dangerous things.
T17 - They need guidance and help where necessary
T18 - Once they have the theoretical backround, it is advisable.
T19 - Most students are more active when they do groupwork. A student does not like to stay in lab alone.
T20 - Learning in most cases take place effectively in group work discussions.
T21 - Pupils will follow all the steps procedures without distructions.
T22 - Students must be sparsely supervised and guided to enable the desired results achaived. Otherwise interpretation of their findings might be impeded

Catagories:

1. Disagree:

T3, T4, T5, T8, T11, T19, T20

2. Agree:

T2, T6, T7, T9, T10, T12, T13, T14, T15, T16, T17, T18, T21, T22

Statement 7: When teaching electromagnetism the teacher must first find out what ideas students already have.

T2 -
T3 - To build on - "known to unknown"
T4 - This will give the teacher an insight as to which areas will require strong emphasis during his teaching
T5 -
T6 - This will be the baise on which they can absorb new ideas
T7 - This makes it easier to the teacher to best present the topic to the students in such a way that will help them to best understand it(when the teacher already knows their minds)
T8 -
T9 - It is of utmost importance to find how much students already know to avoid boring them.
T10 - This will draw the attention of the students to the lesson. The teacher will also know where exactly to start from.
T11 - Electromagnetism is the topic which builds up on some other concept. Therefore it is very important to know the prerequisite knowledge of the pupils.
T12 - This is expected just like you could start teaching "time" as a concept.
T13 - You will find that they already have some idea of the use of magnets especially.
T14 - Since they will be taught of the known to the unknown
T15 - Previous knowledge should be assessed as far as possible.
T16 - This will enable him to structure the work in such a way that their misconceptions can be rectified.
T17 - They may have an idea and lead them to discovery method
T18 - This helps the teacher to formulate the method for introducing the concept effectively.
T19 - This helps the students to memorise the idea which they may have forgotten. It also encourages creative thinking.
T20 - This help a teacher to know the level of the pupil and if they have the required prerequisite knowledge. The teacher can introduce the concept from the right place.
T21 - The students ideas can be a basis for modeling to the correct facts.
T22 - This will form the bases for an introducting approach. The basic knowledge of students in relation to a subject topic ? quick results.

Catagories:

1. **Agree:**

T3, T4, T6, T7, T9, T10, T11, T12, T13, T11, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22

Statement 8: Students do not know any thing about electromagnetism, so the teacher needs to tell them all the basic facts.

T2 -
T3 - Depends on the back ground and general knowledge of the student
T4 - I discovered that students had seen electromagnetism in their everyday lives but did not know that it was electromagnetism
T5 - At COSC, students already have some idea about electromagnetism
T6 - This again gives viable foundation
T7 - Telling then the basic facts actually helps in building a strong foundation of electromagnetism which will help them to best understand follow the following presentation of the topic
T8 -
T9 - This depends on the background of the students not that they do not know
T10 - Students know something about the subject but they may not be aware of that fact. Few examples and applications will help.
T11 - It is not necessarily the case that they do not anything e.g. ? students are familiar with action of magnets on other materials
T12 - Teaching electromagnetism is not unique from other topics in Physics. Students, when asked leading questions can establish their own basic facts needed.
T13 - Students become aware of the things concerning electromagnetism if they are told of the basic concepts.
T14 - The concepts should be understood so that facilitating can be easy
T15 - They know. What is needed is an introduction for recollection.
T16 - Students need not be told everything as they may find somethings for themselves if given a chance.
T17 - Because they have done this topic at lower level.
T18 -
T19 - They know many basic facts.
T20 - This fact should be reinforced by experiments where possible.
T21 - To start the students to experiment the facts.
T22 - This is indeed acceptable. By given them the basic facts they are equipped to research and enrich their knowledge further.

Catagories:

1. Disagree:
T3, T4, T5, T9, T10, T11, T12, T15, T16, T17, T19, T20

2. Agree:
T6, T7, T13, T14, T21, T22

3. No response:
T4, T8, T18

Statement 9: Electromagnetism is the most difficult subject in Physics, and the most difficult to teach.

T2 - Nuclear physics is more difficult.
T3 - Due to lack of equipment and limited syllabus - careful not to go beyond the expected.
T4 - I think its easy because it can be shown with simple materials, e.g. a torch cell, a wire and a small compass.
T5 - It is infact facinating to students.
T6 - Most teachers find it abstract
T7 - It is not necessarily the most difficult in physics, though no that easy, to relate it to pupils because of the depth with which one has to go into it to get the concepts.
T8 -
T9 - The only difficult part is the induced magnet/electricity because it is abstract.
T10 - The topic seems abstract to students at first but students tend to love it and consider it the easiest in the end.
T11 - It is not necessarily that it is difficult but the its mostly that there is inadequate teaching aids for the topic.
T12 - It becomes only difficult if the teacher is doing it without required equipment.
T13 - Because a lot of experiments which can be easily done enable the teacher to pass concepts to them.
T14 - Not really but teachers have that believe that the subject is difficult hence make them teach in a difficult manner.
T15 - There are more difficult topics viz radioactivity, electronics, etc.
T16 - With adequate equipment, electromagnetism can be fun and is not necessarily the most difficult to teach.
T17 - Because it depends on the availability of equipments.
T18 - It is not difficult to teach if you have proper lab. facilities.
T19 - A students has to think well to understand the concepts. Many students find it hart to understand the laws of e.m. induction.
T20 - This ia because there is no equipment to perform necessary experiments to make pupils see and believe what they are told.
T21 - Illustrattive experiments always simplify the teaching process.
T22 - This is absolutely not a fact. At C.O.S.C. it does not follow. If in terms of spectrometer basic natural concepts could be employed to facilitate this.

Catagories:

1. Disagree:
T2, T4, T5, T7, T9, T10, T13, T15, T16, T18, T21, T22

2. Agree:
T3, T6, T11, T12, T14, T17, T19, T20

3. No response:
T8

Statement 10: Experiments help students to better understand electromagnetic concepts such as 'magnetic field' and 'magnetic induction'.

T2 -
T3 - Through experience
T4 -
T5 - With 'magnetic field' even models are helpful
T6 - They learn from what they see.
T7 - Even though we don't perform experiments at this school because of inadequate facilities, experiments do help students understand concepts.
T8 -
T9 - They can never be understood if they have never been seen.
T10 - Experiments make students get those physical concepts which seem so abstract and imaginitive.
T11 - This are rather abstract concepts which without aid of experiment its very difficult for students grasp the concepts.
T12 - This is because its easy to visualise the two concepts on paper as well as instruments used.
T13 - Because students start to compare the magnetic field of the permanent magnets and electromagnetic field.
T14 - Since they see most of the things during their practicals.
T15 - Only through experiments they can find it themselves.
T16 - These concepts do not exist in our culture so without experiments students may not understand nor belief.
T17 - What the students have done is not easy to forget.
T18 - Cutting the magnetic lines of force will produce an emf and this process is called e.m. induction. Therefore students will get the idea about both the concepts.
T19 - Concepts such as mag. field and mag. induction are easily understood when they are demonstrated.
T20 - These are concepts that pupils cannot imagine or see around hence why an experiment can reinforce the understanding.
T21 - Vissible results with iron filings make the concepts easily understood.
T22 - Yes indeed. What the eyes see is retained in the brain for a longer time than what is heard with the ears.

Catagories:

1. Agree:
T3, T5, T6, T7, T9, T10, T11, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22

2. No response:
T2, T4, T8

Statement 11: Students understand the difference between the 'electric' and 'magnetic' fields.

T2 -
T3 -
T4 - Its very hard to explain
T5 -
T6 - Mostly they confuse the two
T7 - They slightly confuse the two and it does take them time to make a difference.
T8 -
T9 - This are not vissible so they are not very clearly demonstrable
T10 - Experimentally the effects of these fields are understood by students. Students know their existence and how differently they function.
T11 - Students tended to confuse the concepts. In fact they interchange them without reasons in most cases.
T12 - Before we normally look at Magnetic fields, the idea of electric charges having an attraction among themselves, nature are looked at. Nature of their fields discussed.
T13 - Because the properties of electric field enable the students to realise that electric field is due to current.
T14 - Not all students see the difference between the two.
T15 - Through experiments they discover.
T16 - It is not always the case.
T17 - Not all students can understand this difference.
T18 -
T19 - Most students understand mag. field. But they cannot understand electric fields.
T20 - The terms themselves are self-explanatory and if explained well students should not have problems in understanding the two. Electric implies charges in contrast with magnetic.
T21 - The causes (source) quite different except the pattens may look alike.
T22 - It indeed poses a strong confussion when these two fields are introduced but with time and through explanations as well as emphasis on direction of flows. This is over(?)

Catagories:

1. Disagree:
T6, T7, T9, T11, T13, T14, T16, T17, T19, T22

2. Agree:
T10, T12, T20, T21

3. Intention of response uncertain:
T4, T15

4. No response:
T2, T3, T5, T8, T18

Statement 12: It is impossible to demonstrate the factors affecting the magnitude of the emf induced in electromagnetic induction.

T2 -
T3 - Lack of needed equipment.
T4 - All it requires is the right apparatus and correct method(s).
T5 - It is difficult to get magnets of different strengths. Also to move the coil at different speeds in the field and detect the current.
T6 - The apparatus which can be used is simple.
T7 - It is easy to arrange such an experiment especially at High school level.
T8 -
T9 - They can even be discoved by the students themselves, not necessary that they should be demonstrated.
T10 - The effects of these factors can be proved experimentally to the full understanding and acceptance of students.
T11 - It is not that impossible as doing as required materials for demonstration are available(but inmost cases they are not enough).
T12 - By using a solinoid, Magnets, a galvanometer the factors are vividly observed by students.
T13 - Because factors affecting the magnitude cannot be seen or be demonstrated.
T14 - No impossible but something difficult, they can be demonstrated.
T15 - It is possible with the help of right instruments.
T16 - Sometimes.
T17 - There are some experiments that can be demonstrated to show this.
T18 - It is not impossible - for e.g. increase the no. of turns of coil, use a powerfull magnet, insert the magnet with more quickly will help to show the above idea.
T19 - It is easy to demonstrate the factors provided we have coils of wire and magnets and g.meter.
T20 - With well designed activities and suitable apparatus effective demonstrations could be done.
T21 - Materials and equipments are available
T22 - Since the parameters for measuring e.m.f. are there in the labs it is not difficult except for ill equipped schools.

Catagories:

1. Disagree:
T6, T7, T9, T10, T11, T12, T14, T15, T17, T18, T19, T20, T21, T22

2. Agree:
T3, T4, T5, T13, T16,

3. No response:
T2, T8,

Statement 13: Students understand the concept of the magnetic field.

T2 -
T3 - Through experiment done by them
T4 - It can easily be shown using a permanent magnet and iron filings.
T5 -
T6 - Some find it as something in heaven.
T7 - They slightly understand this concept.
T8 -
T9 - This one can be understood as the effects of its presence are clear.
T10 - Students appreciate the existence of magnetic field and how it functions.
T11 - Students seemed to understand by aid of experiment and their informal knowledge of action of magnets.
T12 - Especially when looking at magnets behaviour
T13 - Since magnet are easily found so it's easy for them to understand.
T14 - Not all will understand it at a go but they need basics.
T15 - To some extend.
T16 - With sufficient experiments students will understand the concept of magnetic field.
T17 - They have done this experiment at lower levels.
T18 - Concepts of the magnetic field is the basic idea which needs to explain e.m. induction. Besides that it is a very simple concept in magnetism.
T19 - Since mag. fields can be demonstrated.
T20 - This is because magnetic field can be defined with words clearly.
T21 - Force through invissible but its effects are very noticable eg attraction of iron fillings.
T22 - Very well, as the region within which a magnetic influence is felt.

Catagories:

1. Disagree:
T6, T14

2. Agree:
T3, T4, T7, T9, T10, T11, T12, T13, T15, T16, T17, T18, T19, T20, T21, T22

3. No. response:
T2, T5, T8

Statement 14: Electromagnetic induction can best be understood by students if teachers use demonstrations in their lessons.

T2 - Applicable in the case where apparatus are few, but students should do experiments.
T3 - experienced.
T4 - In situations where materials are hard to find, demonstrations can be used. But I believe guided experiments are the best.
T5 -
T6 - Demonstrations with equipment
T7 - Pupils can better understand the concepts if they are demontrated to them when possible.
T8 -
T9 - In addition to this the students should do some experiments on their own.
T10 - Some of the concepts are not easy to explain to the understanding of the students through more demonstrations without experiments.
T11 - Some students may not understand the underlying concepts bacause demonstrations are done in too big groups.
T12 - This bacause there are facts which cannot be just comprehended by students by belief but by seeing.
T13 - Demonstrations enable the students to figure out what is going on so teaching becomes easy.
T14 - Demonstrations in Physics put forth the best understanding of topic not only electromagnetic.
T15 - Demonstrations and activities will help.
T16 - In the case whereby the equipment is scarce demonstrations can work provided the teacher involves them as much as possible.
T17 - Experiments help students to understand better
T18 - If teachers demonstrate the expt defenetely it helps the students, but if the students perform it by themselves it helps them far better understanding.
T19 - Students are fascinated by the idea that electricity can be got without a cell or battery.
T20 - This is because demonstration is the best teaching method which gives pupils a chance to observe hence improve their understanding.
T21 - Precise to the point and no waisting of a lot time
T22 - Yes demonstrations opens way to activate the students apertite to the lesson as well as the topic in question.

Catagories:

1. Disagree:
T10, T11

2. Agree:
T2, T4, T6, T7, T9, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22

3. No response:
T3, T5, T8

Statement 15: For students to understand the concept of the magnetic field they must understand Fleming's rules.

T2 - In order to determine direction of force, field and current.
T3 - Can be shown through other relevant experiments.
T4 - I think they ought to learn about magnetic field before learning Fleming's rules.
T5 - Flemings rules deal with the motor or generator. Magnetic field is a property of magnets anytime.
T6 -
T7 -
T8 -
T9 - The magnetic field can be understood very clearly without these rules at High school level.
T10 - This will throw light on the subject but the teacher could also make them understand the concept through other ways.
T11 - In connection with electric currents Fleming's rule are very helpful as these is no formula for concluding or som[illegible]ing
T12 - Fleming's rules are s[illegible]ications of magnetic field
T13 - Fleming's hand rule i[illegible] if the concepts are known already.
T14 - If the rules are understo[illegible]ll understood.
T15 - Always the rules are very [illegible]
T16 - Not necessarily
T17 -
T18 - It helps them to understand the concept of magnetic field clearly, since it tells about the direction of mag. field.
T19 - Mag. fields can be demonstrated with the help of iron filings or compass needles.
T20 - The rules help to determine the directions in electromag.etic induction. Direction of current or field say, so it does not interact with the learning of magnetic field.
T21 - The rules are to guide to understand the concepts but not the other way round.
T22 - This is absolutely correct, demonstration with the left and right hand rules paves way for their understanding.

Catagories:

1. Disagree:
T3, T4, T5, T9, T10, T12, T13, T16, T19

2. Agree:
T2, T11, T14, T15, T18, T21, T22

3. No response:
T6, T7, T8, T17

Statement 16: Distinguishing between the magnetic properties of iron and of steel is easy for students.

T2 -
T3 - Because it can be shown through experiments
T4 - Easy to demonstrate
T5 -
T6 - Equipments used is simple for them
T7 - It is made easy by the demonstration done in distringuishing between the two
T8 -
T9 - This is very easy with experimentation or demonstration and by being told.
T10 - Through simple experiments students easily understand and appreciate the distinction between the two.
T11 - Some students tend to confuse them.
T12 - Students tend to think that Iron is the same as steel. Thus due to their prior knowledge of Iron extraction and how steel is made.
T13 - If and only if they know that iron and steel are metal of different material.
T14- Since students will be knowing the di( )ce between iron and steel.
T15 - They do the activities right from the junior level.
T16 - Sometimes it is not so easy for them to understand.
T17 - For iron because it shows better properties.
T18 - It is not quite easy - Most of the students think that there is no difference between iron and steel.
T19 - Since this can be taught with the help of iron filings.
T20 - This is under the condition that there is a use of a simple activity to reinforce the understanding.
T21 - They are materials of the same nature except for retaintion power of magnetism.
T22 - At senior levels it is not a problem because the percentage of carbon in both iron and steel gives them easy access to their differences in properties.

Catagories:

1. Disagree:
T11, T12, T16, T18

2. Agree:
T3, T4, T6, T7, T9, T10, T13, T14, T15, T17, T19, T20, T21, T22

3. No response:
T2, T5, T8,

Statement 17: Having fun or structured play with magnets in Physics lessons is a waste of time.

T2 - Because students are able to discover many concepts.
T3 - Because that would mean least exposure to the discovery of students.
T4 - Students learn more this way.
T5 -
T6 - Playing does help students to learn.
T7 - It is not a waste of time since this make students learn more about magnets.
T8 -
T9 - In most cases students understand things better if they have had time to play with such ideas.
T10 - Constructive fun or structured play will help make students understand the lessons.
T11 - This is the most important part of learning as what one does is not easy to forget.
T12 - If it is on discovery of some facts then its necessary.
T13 - Students know what they have done than what they are told of.
T14 - Students learn best when having fun with the topics.
T15 - It will create more interest in them if we have some fun to.
T16 - This will promote the students interest while they are also learning.
T17 - Because magnets are useful in our lives Physics is a good subject.
T18 - It is not a waste of time provided that if you have enough time to spend.
T19 - It is not a waste of time. It creates a deep liking for subjects.
T20 - N/A since I have never taught or carried out such activities.
T21 - Discoveries are sometimes made accidentally or while having fun.
T22 - When you organise a structured play or fun students easily adapts and understands faster as well as retain all they have learnt in the process.

Catagories:

1. **Disagree:**
T2, T3, T4, T6,T7, T9, T10, T11, T12, T13, T14, T15, T16, T17, T18, T19, T21,T22

2. **No response:**
T5, T8, T20

Statement 18: One of the things that make the concepts of 'magnetic' and 'electric' fields so difficult is the absence of formulae to explain them at Ordinary Level Physics.

T2 -
T3 - Formular is brought by/from knowledge of the theory.
T4 -
T5 - We don't need formulae to explain concepts. We use formulae to apply concepts.
T6 - Formulae may help to enhance the understanding from experiments
T7 - I agree with the fact that it is not easy to understand these concepts at ordinary level eventhough the absence of formulae is not necessarily a factor.
T8 -
T9 - The formulae do not make things clear they only help in calculations. So the problem is experimenting.
T10 - Formulae are really not available but with the help of experiments examples and applications students can understand.
T11 - The concepts tend to sound more theoretical than practically to some extend.
T12 - It is because of the confusion of the sources of magnetic and electric fields.
T13 - Students believe that dealing with physics means dealing with formulae.
T14 - Formulae are there but difficult to understand at the level stated.
T15 - Some simple formulae will be always helpful
T16 - Not necessarily
T17 - Because formulae can be discoved by using experiments.
T18 - In O-level Physics we are not going to the concepts much deeper.
T19 - They can be explained without formulae.
T20 - N/A
T21 - Stating of the facts seem to be abstract without relationship.
T22 - If one is inovative, nothing is difficult. Formulae could be invented, a thorough knowledge of the basics are necessary and it does solve the problem.

Catagories:

1. Disagree:
T3, T5, T7, T9, T12, T14, T16, T17, T19

2. Agree:
T6, T10, T11, T13, T15, T21, T22

3. No response:
T2, T4, T8, T20

Statement 19: My students enjoy doing practicals on a. c. generators.

T2 - Not sure because we don't have apparatuse
T3 - I do not know - never done - lack of equipment
T4 - I have had to do demonstartions in this topic due to lack of apparatus.
T5 - I think they would enjoy that if they had the chance - We did not have strong magnets and sensitive galvanometer.
T6 - They find them as attractive machines.
T7 - Refer to 10
T8 -
T9 - Students enjoy doing experiments on everything provided there is enough equipment.
T10 - They are excited to know that such simple experiment can lead to the production of electricity.
T11 - There was lack of equipment, and this was difficult to make students to understand.
T12 - This because they are kept on the alert by the way the e.m.f. causes the pointer of galvanometer to deflect.
T13 - Because they are supprised of how a.c. can be used to do a certain job.
T14 - Since they practice that has been lectured.
T15 - It is a difficult expt to perform at ordinary level.
T16 - N/A
T17 - Some are afraid of electricity being choked.
T18 - Not all but some.
T19 - No comment. I do not give practicals on generators.
T20 - N/A
T21 - Without oscilloscope the A.C. properties can not be seen. May be difficult to appreciate on (Motors).
T22 - They do not always enjoy it but about 70% of the students have intentions to further in science enjoy it especially the club members.

Catagories:

1. Disagree:
T2, T3, T4, T5, T6, T7, T9, T10, T11, T12, T13, T14, T18, T19, T21, T22

2. Agree:
T15, T17

3. No response:
T8, T16, T20

Statement 20: The transformer is the most difficult topic to teach in electromagnetism.

T2 -
T3 - Easy to understand even without practical
T4 - Simple hand - made transformers can solve this problem.
T5 - The problem is that a simple transformer made in our laboratory did not seem to work.
T6 - Most teachers do use it.
T7 - It is not easy for the pupils to understand the steping up and down of the transformer and this makes it not that easy to teach.
T8 -
T9 - It is difficult because this emf on the secondary coil is induced and it is hard to understand.
T10 - It is rather the easiest topic. Students easily understand the concepts and the calculations involved.
T11 - Most of my students showed enough understanding in transformers.
T12 - It is easy because there are many physical situations the transformers are used.
T13 - Students takes time to understand the difference between d.c. and a.c. so this makes transformers difficult.
T14 - If electromagnetism is understood there is no way students can fail to understand transformers.
T15 - The students understand it better.
T16 - Sometimes students find it difficult to understand especially because we never do practicals on transformers.
T17 - Because it needs a clear explanation and practicals to understand.
T18 -
T19 - The most difficult topics are A.C. and D.C. If a student has understood A.C. he can easily understand transformer.
T20 - As interesting as it is, the topic is not difficult especially if it is taught to pupils with a good background in electromagnetic induction.
T21 -
T22 - The transformer is the easiest topic to teach in Physics as a whole. The teachers capability is tested here.

Catagories:

1. Disagree:
T3, T4, T10, T11, T12, T14, T15, T19, T20, T22

2. Agree:
T7, T9, T13, T16, T17

3. Intention of response uncertain:
T5, T6

4. No response:
T2, T8, T18, T21

Statement 21: There is really a need for students to master all the formulae in electromagnetism because it is difficult to learn Physics without mastering such formulae.

T2 - Formulae display relationship between quanties very easily.
T3 - Because I do not understand how formulae is connected to mastering a subject.
T4 -
T5 - Electromagnetism formulae are not necessary for studying all Physics.
T6 - Not necessary to teach it using formulae
T7 - Formulae are basically sumaries of the concepts dealt with in a topic so understanding them actually makes it easier for one to understand the topic.
T8 -
T9 - The students should master the concepts not formulae.
T10 - Formulae or mathematical calculations throw more light on physics problems and hence should be mastered.
T11 - Formulae and theories work 'hand in' glove.
T12 - All Physics concepts are not only based on formulae of electromagnetism.
T13 - Students may master the formulae without knowing what they are doing or looking for.
T14 - There are some that can be mastered by students without formulae mastering 100%
T15 - Formulae are always required but to understand their concepts formulae is not a must.
T16 - Physics is all about formulae and using them.
T17 - Because the students like using them lasy to discover them.
T18 -
T19 - Physics can be understood without formulae.
T20 - I think understanding the physical phenomena is more important so that pupils can use the formulae meaningfully.
T21 - Equations help to remember the factors involved and how they are related.
T22 - Many formulae in physics are interrelated hence should they know the basic concepts it will be easier for them to derive the rest of it from there.

Catagories:

1. Disagree:
T3, T5, T6, T9, T12, T13, T14, T15, T17, T19, T20

2. Agree:
T2, T7, T10, T11, T16, T21, T22

3. No response:
T4, T8, T18

Statement 22: It is not advisable to allow students to do practicals on transformers because transformers are very dangerous to work with.

T2 - It is better be handled by the teacher for fear of high voltages that may result.
T3 - Because teachers wide knowledge of dangers can provide a safe surrounding.
T4 - Lab transformers are not dangerous to work with
T5 - Especially step - up transformers. Demonst ations are adequate.
T6 - They are not dangerous students should first be shown how it works.
T7 - If transformers are mishandled during the experiments they can harm the students because of their effect on the voltage of the current.
T8 -
T9 - If it is a small transformer there should be no problem. So they can make their own transformer.
T10 - With the close supervision of the teacher students can safely perform such practicals.
T11 - Demonstration should be prefered here.
T12 - Transformers which are expected to be used for experiments at this level of Physics are of low a.c input and definitely also output.
T13 - Transformers are not dangerous but the voltage which the supply is providing to the one which is dangerous.
T14 - Since students like to touch hence they may injure themselves if not cause death.
T15 - Not very dangerous as we can help them and be with them.
T16 - They can increase or lower the voltage therefore not a good idea to allow students to do these practicals.
T17 - Afraid of being choked. They can just be shown and explained to them. Voltage is very high
T18 - Simple transformers are not dangerous, even the students can design of.
T19 - Transformers are sometimes dangerous.
T20 - Especially if high voltages are involved.
T21 - Most O'level physics experiments do not need very high voltages.
T22 - When very high KVA's are in use they are not expected to carry out experiments here but for any type of transformer with very low voltages. There are no hazards.

Catagories:

1. Disagree:
T3, T4, T6, T9, T10, T12, T13, T15, T18, T21, T22

2. Agree:
T2, T5, T7, T11, T14, T16, T17, T19, T20

3. No response:
T8

Statement 23: Because it may not be possible to do experiments with transformers, the equation $V_p/V_s = N_p/N_s$ should just be given to students(where N_p is the number of turns on primary coil, N_s the number of turns on secondary coil, V_p is the voltage(pd) across the primary coil, V_s is the voltage across the secondary coil).

T2 -
T3 - It depends
T4 -
T5 - They have almost always understood it especially when they are comfortable with radios from maths lessons.
T6 - If transformers are not available
T7 - Through explanation has to proceed the giving of the equation so that they should understand all what they means.
T8 -
T9 - Just giving the equation will lead to memorizing not understanding so experimenting is still the best method.
T10 - Physics students should be able to do such calculations and they should know the formula even if they don't go through the experiment.
T11 - It is possible to do experiments using coil of different turns. That is students should not necessarily be only given formulae.
T12 - There are already build transformers of various turn ratio and even simple ones can be made to simplify the formula
T13 - At least an understanding is required for the student to accept the equation.
T14 - It is possible to some practicals if there are apparatus.
T15 - The same as above(22)
T16 -
T17 - Because it is a difficult topic in physics
T18 - Without the basic ideas about the transformers will give the students confusion.
T19 - Transformers are expensive and also they get damaged very often.
T20 - With a well prepared lecture method the concept can be learned very well.
T21 - Experimental set-ups even help to make students appreciate efficiency of it.
T22 - The formula is a basic one, for a transformer that does not waste power, what about where voltage has to be compansated for or reduced. The formula is not enough.

Catagories:

1. Disagree:
T9, T11, T12, T14, T15, T21, T22

2. Agree:
T5, T6, T7, T10, T13, T17, T18, T19, T20

3. Intention of response uncertain:
T3

4. No response:
T2, T4, T8, T16

Statement 24: Electric motors confuse students

T2 - More especially if they cannot distiguish concepts of a.c. generator well.
T3 - Not done.
T4 - It requires good explaining.
T5 - Especially if they have not understood electromagnetic induction. They confuse the two fleming rules.
T6 - Simple apparatus
T7 - The concept of electric motor under d.c. current is not that easy to grasp for these students.
T8 -
T9 - This could be because they not very available to dismentle so that students can actually see them.
T10 - Students find it a bit difficult to understand the concept of electric motors but with the help of experiment they overcome the problem.
T11 - Too many underlying concepts, lack of teaching equipment.
T12 - There is a tendency for students to a.c generators as if they are also motors.
T13 - Because it's not easy for them to accept that motors requires electric current.
T14 - Some may be confused if they did not understand electricity and its concepts.
T15 - They enjoy the expts on electric motors.
T16 - Students sometimes find it difficult to understand how the electric motor works.
T17 - This can be shown to students or demonstrate.
T18 -
T19 - The theoretical concepts of electric motor confuse students.
T20 - This is in a case where there are no apparatus to help students see what is really happening.
T21 - The make up of mators are the same as dynamo only initial energy supplied and final energy obtained may confuse the students.
T22 - With thorough basic background on A.C. and D.C.'s motors the student is at safely to watch whatever is required in uelectric motors

Catagories:

1. Disagree:
T6, T15, T17, T22

2. Agree:
T2, T4, T5, T7, T9, T10, T11, T12, T13, T14, T16, T19, T20, T21

3. No response:
T3, T8

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Name of thesis: The influence of high school physics teachers' beliefs about physics and physics education on alternative conceptions in electromagnetism: a Lesotho study.

PUBLISHER:

University of the Witwatersrand, Johannesburg
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