

**PROMOTING LEARNERS' CONCEPTUAL UNDERSTANDING  
OF ELECTROSTATICS THROUGH USE OF PRACTICAL  
ACTIVITIES IN CONJUNCTION WITH PRIOR  
KNOWLEDGE OF LIGHTNING:  
A CASE STUDY**

submitted in partial fulfillment of the requirements for the

Degree of

**MASTER OF EDUCATION**

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by

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## Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

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Signature

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Date

## Acknowledgement

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To my colleagues who are still aspiring to engage into a research journey, go for it, it is worth taking.

## Abstract

The research presented in this thesis is situated within an interpretivist paradigm. Within this paradigm, a qualitative case-study research approach was adopted. This seemed most appropriate in my research project since the main focus is on elicitation of prior knowledge and incorporation of such knowledge into 'hands-on' and 'minds-on' practical activities with a view to improving conceptual development.

For the purposes of this research project, I designed an interactive teaching and learning unit in electrostatics as an attempt to put into practice a learner-centred approach. This approach, in my view, is in line with the new curriculum in South Africa. The emerging central theme of this thesis is the notion of active participation by learners during teaching and learning.

This study was carried out over a period of two years and involved my grade 9 learners, who participated voluntarily. The research process documented in this thesis has been conceptualised into two phases. Phase one was concerned with the elicitation of learners' prior knowledge around lightning. In phase two, learners were engaged in 'hands-on' and 'minds-on' practical activities, and key concepts were identified to ensure conceptual development.

The data was collected using a variety of data collection tools, namely: focus group interviews, follow-up whole-class semi-structured interviews, worksheets, videotaped lessons and photographs. The analysis of data revealed that learners come to class with prior knowledge concerning lightning. Within this prior knowledge it was found that there were both 'scientific' and 'non-scientific' concepts. The identification of key concepts during practical activities was found to be very useful in promoting learning. However, the incorporation of prior knowledge into practical activities posed a challenge and needs further research.

This research study also highlights some insights into some of the complexities of elicitation and incorporation of learners' prior knowledge, and conceptual development in science classrooms. It also demonstrates the challenges and possibilities during teaching and learning as well as the realities of the demands of the new curriculum and OBE in South Africa, in particular, in historically disadvantaged schools.

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# **Chapter one**

## **Introduction**

### **Engagement with the study**

Learner-centred education means putting learners first, recognizing and building on knowledge, skills, abilities and experience, responding to their needs, taking into account the different ways in which they learn and demonstrating respect for their language and culture (Duggan 1996:68, cited in Ngcoza and Maselwa, 2003:9).

#### **1.1 Introduction to the chapter**

When I read this extract and related it to my everyday teaching and learning experiences, I decided to embark on an expedition to learn more about prior knowledge, its elicitation from learners and the possibility of incorporating this prior knowledge into practical activities with the aim of promoting conceptual understanding in electrostatics amongst learners. This encouraged me to engage in some research.

In this chapter, I will attempt to give a background of the research study, the rationale and purpose of the study, the context of the study, a brief overview of the chapters and the conclusion.

## 1.2 Background of the research study

The traditional methods of science teaching and learning have been widely discussed as being rigid, stereotyped and syllabus-bound. Textbook knowledge was, and to some extent is, still the focus/object of dissemination. Scientific formulae, definitions and lengthy explanations are still believed to be the acceptable method of science teaching. I believe that these aspects of science teaching do not necessarily promote conceptual understanding. Perhaps, I thought, one of the problems with these approaches is that the link between classroom instruction and learners' everyday life experiences was not taken into consideration.

Presently, in South Africa, we are faced with a transformation process in the curriculum. This curriculum is called **Curriculum 2005 (C2005)** and is underpinned by an outcomes-based-education (OBE) philosophy (Curriculum 2005 1997:16-17; Review of the Committee on Curriculum 2005 2000:8). The new curriculum is gaining momentum and demands a shift from content-based education to skills-based education, with an emphasis on the four pillars of education viz., skills, knowledge, attitude and values (Curriculum 2005 1997:19; Review of the Committee on Curriculum 2005 2000:35). Furthermore, in this new curriculum, learners' prior knowledge is regarded as important (Wilkinson and Kuiper 1999:451). However, it is not clear in the curriculum documents how learners' **prior knowledge** should be incorporated into teaching and learning.

## 1.3 Rationale and the purpose of the study

In the twenty-seven years I have been teaching general and physical science in a previously disadvantaged senior secondary school, I have always been mindful of the importance of conceptual understanding amongst learners in science. Hodson (1996:756) argues that, "in any scientific enquiry, students achieve three kinds of learning. First, enhanced conceptual understanding of whatever is being studied or investigated. Second, enhanced procedural knowledge - learning more about

experiments and correlational studies, acquiring a more sophisticated understanding of observation, experiment and theory. Third, enhanced investigative expertise" (*ibid*: 757).

In view of this kind of learning, I now believe in developing my own **learning support materials (LSMs)** from various sources rather than relying only on a textbook as a source of information. Czerniewicz, Murray and Probyn (2000:iii) “describe textbooks as learning support materials that provide a structured framework for a systematic programme of learning and that other learning support materials such as worksheets, posters, etc supplement such a programme”.

Despite this effort, I have come to realise that each year, in each grade, the teaching strategies used for a particular group of learners are not necessarily successful in other groups that follow in the same grade. This confirms that different learners learn in different ways, as pointed out by Woolnough, McLaughlin and Jackson (1999:33) and thus adaptability in teaching and learning strategies is essential.

Wilkinson and Ward (1997:49) suggest that one of the strategies of teaching and learning science is to involve learners in doing practical work. They argue that practical work helps learners to acquire skills such as making predictions, manipulating equipment, observing, recording, analysing data and drawing conclusions. Furthermore, they believe that this approach in science teaching and learning is helpful for the learners in acquiring a better understanding of science. However, Hodson (1990:33) argues that practical work, as conducted in many schools, is ill-conceived, confused and unproductive.

Hodson and Bencze (1998:685) further assert that practical work conducted in our schools is prescriptive and focusses on confirming predetermined principles and laws. Wilson and Stensvold (1991:353) argue that simply being able to do practical work does not necessarily imply comprehension. While I concur with the statements made by the various authors above, my research project was triggered by the belief that

taking into consideration learners' **everyday life experiences** could enhance conceptual understanding.

This study focuses on elicitation of learners' prior knowledge around lightning in conjunction with 'hands-on' and 'minds-on' practical activities in electrostatics in order to promote conceptual understanding. In my study, I needed to look at:

- Investigating learners' experiences and beliefs about lightning
- Incorporation of learners' prior knowledge about lightning in conjunction with 'hands-on' and 'minds-on' practical activities in electrostatics to promote conceptual understanding.

#### **1.4 Context of the study**

This research study was conducted in my school in Grahamstown in the Eastern Cape where I have been teaching for the past twenty-seven years. A teaching and learning unit on electrostatics was designed and implemented in my grade 9 class. The topic on electrostatics was chosen because I wanted to explore learners' prior knowledge around lightning and incorporate the concepts that emerged into 'hands-on' and 'minds-on' practical activities in electrostatics.

#### **1.5 An overview of the chapters**

**Chapter one** introduces the study by discussing the background to the research study, the rationale and the purpose of the study, the context of the study and an overview of the study.

**Chapter two** focuses on the literature review in which educational theories are discussed, analysed and critiqued.

**Chapter three** describes the design of the study and the methodology employed.

**Chapter four** is devoted to data collection and its challenges.

**Chapter five** looks into the analysis of results and then synchronises the emerging trends.

**Chapter six** engages in discussion, recommendations, limitations and conclusion.

**Chapter seven** presents my personal reflections on the entire research process.

## **1.6 Conclusion**

In this chapter, the following aspects of the research project have been looked into: background to the research study, the rationale and the purpose of the study, the context of the study and an overview of the study. In the next chapter, a detailed discussion of the literature review will be provided.

## **Chapter two**

### **Literature review**

Educators often focus on the ideas that they want their audience to have. But research has shown that a learner's prior knowledge often confounds an educator's best efforts to deliver ideas accurately. A large body of findings shows that learning proceeds primarily from prior knowledge, and only secondarily from the presented materials. Prior knowledge can be at odds with the presented material, and consequently, learners will distort presented material. Neglect of prior knowledge can result in the audience learning something opposed to the educator's intentions, no matter how well those intentions are executed in an exhibit, book, or lecture. (Roschelle 1997:1)

#### **2.1 Introduction to the chapter**

The focus of this chapter is directed towards specific basic aspects of education. I have attempted to put in perspective the following:

- The nature and structure of the South African educational system before the introduction of Curriculum 2005 (C2005) and its outcomes-based-education (OBE) philosophy;
- Education philosophies: behaviourism and constructivism;
- The need for a paradigm shift, introduction of C2005 and OBE;
- Practical activities, in the teaching and learning of science; and
- Prior knowledge, practical activities and conceptual understanding.

#### **2.2 The nature and structure of curricula before C2005 and OBE**

The updated edition of the *Collins English Dictionary* describes a curriculum as a course of study in one subject at a school or college, or a list of all the courses of study offered by a school or college or any programme of planned activities. According to

this description, a curriculum is the product of some authoritative planning and designing. However, from another perspective, a true curriculum may be viewed as what actually happens in practice in classrooms - what the educator does with the learners. What actually happens in a classroom may be totally different from what the curriculum planners intended.

I strongly believe that when a country designs an education curriculum, the most important decisions concerning the curriculum should be focused on the national aims or goals of education. If these goals are intelligently and realistically formulated, a plain and level platform will have been constructed for the remaining work associated with the curriculum. This work includes the implementation of the curriculum and what is to be taught. For example, is emphasis going to be put on the content of the subject, intellectual powers, conceptual understanding, practical skills, or attitudes, or all of these? This is definitely no small task, as can be imagined. The decision of what is to be learned also depends on the demands of the society and on national policies.

Social and economic forces to a large extent have influenced the traditional South African learning paradigm. The influences of behaviourism in education are similar in effect to the influences of behaviourism in the broader society. Let us consider the social order of the economy: it is divided into managers, workers and owners, who may or may not have to work. Schools, too, were made to sort people into their appropriate places in the social and economic worlds, according to their intelligence (ability to perceive and comprehend meaning).

Van Harmelen (2000:7) puts the situation of education in the country into perspective, by taking us back to 1948 when the National Party came to power and apartheid laws were formulated. "It was during this era that fundamental pedagogics (FP) was introduced. FP took as its starting point the fact that education has two functions:

- To ensure that the learning environment of the child should be guided and shaped by the value systems of the community it serves rather than by a *common* set of values that the nation should share; and
- The second function of education adopted by FP, is that education as an activity ought not to be concerned with values, but should instead be based on the principles of science. FP was therefore developed as a 'scientific' theory for educational practice. Because the modern positivist approach to science is that knowledge is 'neutral' - that is, value-free - then it followed that teaching and learning based in science would also be value-free. FP could therefore be introduced to all schools" (*ibid*).

The traditional schooling system was mainly concerned with the transmission of knowledge and the acceptance of this knowledge without question by learners. Teachers imparted new knowledge, which was prescribed in a state-structured curriculum according to government guidelines, state-authorised textbooks and standardised tests. Learners were categorised and sorted according to their ability. I believe that this classification process still divides learners, not only by intelligence but by socio-economic class, race, language competence and ethnic background. Ozman and Craver (1986:178, cited in Shepard 2000:5) summarise the procedure for behaviour in the traditional classroom as follows:

- Learning occurs by accumulating atomised bits of knowledge;
- Learning is tightly sequenced and hierarchical;
- Transfer is limited, so each objective must be explicitly taught;
- Tests should be used frequently to ensure mastery before proceeding to the next objective;
- Tests are isomorphic with learning (tests = learning); and
- Motivation is external and based on positive reinforcement of many small steps.

The criticisms levelled by Stenhouse (1975:72-75) against behavioural teaching still hold some truth, even now. Selected criticisms follow:

- Trivial learning behaviours are the easiest to operationalise, hence the real important outcomes of education will be under emphasised;
- Pre-specification of explicit goals prevents the teacher from taking advantage of instructional opportunities unexpectedly occurring in the classroom;
- Besides pupil behaviour changes, there are other types of educational outcomes which are important, such as changes in parental attitudes, professional staff, community values, and so on;
- It is somehow undemocratic to plan in advance precisely how the learner should behave after instruction;
- Teachers might actually be judged on their ability to bring about desirable changes in learners; and
- In evaluating the worth of instructional schemes it is often the anticipated results that are really important, but pre-specified goals may make the evaluator inattentive to the unforeseen.

### **2.3 Education theories: behaviourism and constructivism**

In the preceding paragraphs of this chapter, an attempt has been made to build a picture and develop an understanding of the context in which teaching and learning occurred, by exploring the nature of the schooling system in South Africa. The roles and characteristics that teachers needed to demonstrate, the challenges and frustrations the teachers encountered, the type of learner resulting from the system, were also examined. An attempt will now be made to examine traditional views of learning and explore some factors that influence learning. These influences will also provide an overview of the various learning theories and the general learning principles associated with them.

The first learning theory I will discuss is **behaviourism**. The principles of behaviourism and the techniques of behavioural engineering go back to Ivan Pavlov and J.B. Watson (Ozman and Craver, 1986:167). However, B.F. Skinner pioneered their implementation in many fields of contemporary life (*ibid*). Ivan Pavlov found

that when a bell is rung each time a dog is fed, the dog is conditioned to associate the sound of the bell with food. J.B. Watson believed that the fears people have are conditioned responses to the environment (Ozman and Craver, 1986:167, van Harmelen, 2000:5).

Watson (cited in Ozman and Craver 1986:167) thought of the environment as a primary shaper of behaviour and maintained that if he could control a child's environment he could engineer that child into any kind of person desired. According to Skinner (cited in Ozman and Craver 1986:170-171), the important thing is social environment. If you make the environment favourable to the desired behaviour, you can influence any organism to the desired behaviour. In this instance, I would agree with Skinner that this environment contains the significant contingencies of reinforcement. Ozman and Craver (1986:172), suggest, "contingencies are conditions in which behaviour occurs; they reinforce it and influence the future direction and quality of behaviour." During the primary and secondary education phases, conditioning became almost part of my life. I was conditioned to believe that punctuality, good manners, obedience to your teachers, respect for your teacher, would create a good scholar who will achieve greater heights in society and lead a better life style.

The main components of behaviourism are **stimuli** and **responses**. Behavioural theorists focus on two things that can be observed or seen: people's behaviour (**response**) and environmental events (**stimuli**). Is it not true that when educators enter their classrooms, learners respond to those educators and what they have planned for their learners? Learners will respond to the lesson presented, the tests that are administered, the rules established, the questions posed, or instructions that are provided.

The integrity or capabilities of the child are measured by how retentive the child's mind is and how the child can reproduce knowledge in exchange for a variety of rewards (the main one being to pass your exam). The reinforcement contingency in

this case is punishment and praise. In this respect, the only person who has knowledge is the teacher and only he/she can transfer it into the mind of the child. In implementing some more recent teaching and learning strategies, it is suggested or even recommended that some of the behavioural approaches be retained. Some behavioural approaches provide useful classroom management strategies in learning and can be helpful in resolving and preventing discipline problems. Educational theorists and psychologists have for a long time put forward the theory that the learning process cannot be fully known if the thought processes behind it are not understood. This has resulted in learning theories changing in response to emerging theories of cognitive development. It became clear that we could not rely only on behaviourism to provide us with an understanding of learning.

The cognitive theory as explained by Vygotsky, cited in Shepard (2000:7), focuses on the nature of thought processes that occur as people learn new knowledge skills and attempts to explain how people process the information. One of the features of the cognitive learning theories is that the learning process involves the *constructing* of knowledge. 'Constructing' describes a learning process of building one's own meaning and understanding from one's experience. This learning theory is referred to as **constructivism**. This will be the second theory I discuss. Dougiamas (1998:3) describes constructivism as "building on knowledge by the student. Education is student-centred, students have to construct knowledge themselves. Constructivism is a theory, a tool, a lens for examining educational practices."

Confrey, Piaget and Inhelder, and von Glasserfeld (cited in Etchberger and Shaw 1992:411), contend that the basic principle of constructivism is that "knowledge does not exist outside of a person. True knowledge can only exist when constructed within the mind of a cognizing being." Furthermore, "understanding of any event, situation, or problem occurs when relationships are made to existing understanding in the learner's mind" (Etchberger and Shaw, referring to Cobb and Steffe) (*ibid*). This implies that during any teaching and learning process, teachers should always be

aware of the type of knowledge learners possess and use this knowledge in structuring, planning and implementing any lesson.

From a constructivist perspective, learners are viewed as being actively involved in making sense and meaning. If teaching could be approached as such, then learners could be produced who can analyse, investigate, collaborate, share ideas, generate on their prior knowledge, rather than learners who regurgitate facts. For that to be done effectively, teachers need to be learners and researchers, who at all times strive to be aware of the environments and their learners in any teaching and learning situation.

The process of knowledge construction in terms of teaching and learning is outlined by Tobin (cited in Etchberger and Shaw 1992:411) as follows:

- Sense perception: information comes into the mind through the five senses. Constructivists believe that the data-gathering stage is only the beginning of knowledge construction;
- Reflection: this is making sense of the gathered information;
- Collaboration: this is where another person or group discusses the problem looking for possible solutions and alternatives;
- Consensus: the group comes to some agreement as to why and how the problem was solved; and
- Sharing: as each group shares their findings and reasoning, other groups can learn from it as well. Etchberger and Shaw (1992:412) also echo the suggestions of many educators and researchers that "cooperative learning is an ideal method that will assist students to construct knowledge and is a powerful tool to enrich learning."

Constructivism has been given many faces by Dougiamas (1998:1-10).

Selected faces follow:

- Radical constructivism;
- Social constructivism; and
- Critical constructivism.

These three forms of constructivism are fascinating and, to me, fit well into OBE.

**Radical constructivism** is concerned with the principle that: "Coming to know is a process of dynamic adaptation towards viable interpretations of experience. The knower does not necessarily construct knowledge of a 'real' world" (Von Glaserfeld, cited in Dougiamas 1998:6). In support of this argument, Dougiamas suggests that constructivism does not deny any objective reality, but simply states that we have no way of knowing what that reality might be. Mental constructs from past experiences help to impose order in one's flow of continuing experience.

The fact that there are many theories of how it is possible to obtain knowledge is an indication of the diversity of opinions in our present society. Radical constructivism perceives the individual learner as a constructor. The issues that are overlooked by radical constructivism are brought to the fore by social and critical constructivism.

**Social constructivism** addresses the concept that: "Individual learning can be more or less socially-mediated learning, individuals can participate in the learning of a collective, sometimes with what is learned distributed throughout the collective more than in the mind of any one individual, individuals and social aspects of learning in both of these senses, can interact over time to strengthen one another in a reciprocal spiral relationship" (Vygotsky, cited in Dougiamas 1998:8). The social world of a learner includes all the people that directly affect that person, including teachers, friends, learners, administrators and participants in all forms of activity. This takes into account the social nature of processes, in collaborative learning and in the discussion of a wider social collaboration in a wider subject.

**Critical constructivism** "looks at constructivism within a social and cultural environment, but adds a critical dimension aimed at reforming these environments in order to improve the success of constructivism applied as referent" (Dougiamas 1998:10). According to Taylor (cited in Dougiamas 1998:10), critical constructivism is a social epistemology that addresses the social context of knowledge construction.

Furthermore, critical constructivism adds a greater emphasis on the actions of a learning teacher.

Dougiamas (1998:13) supplies a list of some of the tenets of constructivism in pedagogical terms:

- Students come to class with an established world-view, formed by years of prior experience and learning;
- Even as it evolves, a student's world-view filters all experiences and affects their interpretation of observations;
- For students to change their world-view requires work;
- Students learn from each other as well as the teacher;
- Students learn better by doing; and
- Allowing and creating opportunities for all to have a voice promotes the construction of new ideas.

Marti (1997:1) suggests that a gradual general acceptance of **constructivism** and a gradual general disapproval of **behaviourism** (especially as championed by Skinner) seem to be under way. However, he is quick to point out that constructivism is not universally accepted. There are many critics who raise some arguments around it. One critic has this to say: "There seems to be a readiness to polarize one theory of learning (behaviourism) with a metatheory (constructivism), and, further, to present the former as grossly deficient and the latter as the only credible explanation of student learning" (*ibid*). This implies that people tend to 'swing with the pendulum' (van Harmelen, pers. comm. 2002).

Throughout this chapter I have attempted to give an overview of the two learning theories **behaviourism** and **constructivism**. I became fascinated by the way various writers outlined their perspectives on the theories, and I have also tried to give my personal interpretations of the meaning of the theories. It became clear that the behavioural-learning approach is based on conditioning using **response** and **stimuli**, and from my perspective, I believe that South Africa has been following this approach in her schooling system. On the other hand, the constructivist approach is based on

the fact that learners *construct* understanding of knowledge based on what they *already know*. Having said all this, I believe that ideas from each camp can be applied in different teaching and learning situations when the appropriate time presents itself. Thus, behaviourism and constructivism are hard to separate, since what is to be constructed is usually designed in a behavioural way. From my teaching experience, I have come to realise that the curriculum, the syllabus, my own lesson preparations, and practical activities have predetermined goals. All that the learners have to do is to follow the instructions when working in their groups.

## **2.4 Curriculum 2005 and OBE**

In 1994 South Africa experienced the first democratic national elections, and a post-apartheid government came into power. The new government felt the need for educational reform. Its view was widely recognised and applauded (Rogan and Grayson 2002:3): "Curriculum 2005 was introduced by the new government as a way of overcoming the educational inequalities of the past and preparing citizens for a full participation in a democracy" (*ibid*). Sanders (1999:382) suggested that in this new curriculum "teaching would become more pupil-focused, using *constructivist methods* and based on work which was relevant to the pupils' lives. The curriculum would focus strongly on the development of relevant skills."

C2005 is underpinned by the OBE philosophy (Curriculum 2005 1997:16-17; Review of the Committee on Curriculum 2005 2000:8). It demands a shift from content-based education to skills-based education, with an emphasis on the four pillars of education, namely, skills, knowledge, attitude and values (Curriculum 2005 1997:19; Review Committee on Curriculum 2005 2000:35). Furthermore, "assessment as we knew it was to disappear, replaced by a system in which students' achievement of outcomes, at their own pace, would be recognized" (Sanders 1999:382). The outcomes referred to by Sanders are that the learners will:

- Identify and solve problems in which responses display that responsible decisions using critical and creative thinking have been made;
- Work effectively with others as members of a team, group, organisation, and community;
- Organize and manage themselves and their activities responsibly and effectively;
- Collect, analyze, organize, and critically evaluate information;
- Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation;
- Use science and technology effectively and critically showing responsibility towards the environment and the health of others; and
- Demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.

The outcomes listed above, as constructivists suggest, may be obtained through use of cooperative learning. If teachers are to be engaged in cooperative learning, then their present teaching methods and strategies will have to change, and this may require a change in the manner in which they believe learners learn. Shaw, Davis, Sidani-Tabbaa and McCarty (cited in Etchberger and Shaw 1992:412) suggested six requisites necessary for this change in teachers to occur. These are:

- Perturbation: this is when there is a dissatisfaction or uneasiness with the way things are. Teachers may not be happy with their present teaching methods or satisfied with their students' understanding;
- Awareness of a need to change: this happens when the teachers realise that for things to improve there will have to be a change;
- Commitment to change: when a teacher commits to change, he or she has made a firm decision to move beyond awareness and into action;
- Vision: with the decision to change, the teacher envisions what the change will involve, for example, arranging desks from rows of two students to groups of six students;
- Projection into that vision: this occurs when the teacher visualises self and class becoming participants in the change; and

- Reflection: reflection throughout the change process is vital for continued teacher change. Schon (cited in Etchberger and Shaw 1992:412) contends, "When teachers become reflective on their actions in the classroom, they begin to challenge the customs of the educational system on a broad scale and challenge their own traditions of teaching on an individual basis."

In view of these suggestions, one may wonder what challenges the implementation of C2005 will encounter. Rogan and Grayson (2002:6) refer us to a note made by De Feiter *et al.*: "Considering the complexity of the intended changes, and taking into account current classroom practices, we may wonder whether the innovation gap is not too big to bridge." In support of this, Rogan and Grayson (*ibid*), assert that most experienced educators all over South Africa have a feeling that the implementation of C2005 cannot take place in one big step in a short space of time, as laid down by the policy documents.

Another aspect of C2005 is the question of assessment. Indeed, it can be argued that changes at the policy level of education can be effective only if there are major changes in classroom practices. Classroom practices, however, are unlikely to change unless there are also major changes in the way learners are assessed. Shepard (2000:7) suggests, "To be compatible with and support this social-constructivist model of teaching and learning, classroom assessment must change in two fundamentally important ways. First, its form and content must be changed to better represent thinking and problem solving skills in each of the disciplines. Second, the way assessment is used in the classrooms and how it is regarded by teachers and students must change". However, teachers are still grappling with assessment, although the official Department of Education documents explicitly say how assessment should be conducted. This means that professional development is important.

Despite this, it is envisaged that the new ways of teaching and learning in C2005 would bring many changes in the way teachers assess. C2005 would encourage:

- Application and use of knowledge;

- Use of skills in context;
- A wide range of knowledge skills, values and attitudes to develop the learner holistically;
- Transparency, with outcomes and ways to demonstrate them made clear beforehand;
- Flexibility, with learners being encouraged to demonstrate skills and knowledge in various ways;
- A focus on learners' strengths - what they can do; and
- Demonstration of knowledge and skills in real life contexts together with ongoing use of a wide range of assessment strategies.

Seemingly, South Africa has adopted the social constructivist theory of teaching and learning in its OBE philosophy. Marti (1997:2) suggests that constructivism and behaviourism are not mutually exclusive. Ideas from each camp can be applied in various teaching and learning situations when the appropriate time presents itself. "What is important is that whatever theories or ideas we apply they do the most to enhance the learning possibilities in the given environment and particular domain" (*ibid*). Also, people cannot be likened to machines: they live in an environment that has other social components. Learners cannot be left alone to find out what is important for them to learn. They still need guidance.

## **2.5 Practical activities in the teaching and learning of science**

Bodner (1990:2) posits that: "teaching and learning are not synonymous, we can teach and teach well, without having the students learn." One possible reason for some students not learning during teaching and learning is that, in the traditional science teaching approaches, emphasis was put mainly on the transfer of knowledge from the teacher to the learner (*ibid*). The science subject became fragmented and did not make sense to the learners. Furthermore, the nature of practical work had a 'cookbook' approach, based on the verification and confirmation of predetermined scientific principles (Hodson and Bencze, 1998:685).

In most of my science lessons, I decide on the topic (following the syllabus programme) and dictate the pace, structure, pattern and meaning of learners' contributions. Further, I determine who speaks and for how long. Learners are, from time to time, required to recall and regurgitate information that has been pre-designated as important. The only time learners are allowed to talk and ask questions is when instruction is over and the lesson instruction is being evaluated. Todd and Barnes *et al.* (cited in Rodrigues and Bell 1995:797), describe "this pattern of talk with the teacher in the initiating and evaluating role as 'Initiate-respond-evaluate' (IRE)."

Earlier in this chapter, OBE has been described as forming the foundation for the curriculum in South Africa. This implies that if the outcomes to be achieved at the end of the instruction process are set, then OBE strives to enable all learners to reach their maximum learning potential. The above statement is simplified by Woolnough, McLaughlin and Jackson (1999:27) when they write: "One of the main objectives of science teachers is to find ways of helping their pupils gain a better knowledge and understanding of the facts and principles of science". However, they are quick to point out that "this is not an easy task as we still know so little about how learners learn; indeed it is evident that different pupils learn in different ways."

Throughout my teaching career, it has been my belief that practical work is an important aspect of science teaching and learning. Yet I have never had an opportunity to research my own practice. Wilkinson and Ward (1997:49), too, suggest that one of the accepted ways of science teaching and learning is to involve learners in doing practical work. They argue that practical work helps learners to acquire skills such as manipulating equipment, making predictions, observing, recording, analysing data, drawing conclusions, and preparing learners for examinations.

Furthermore, they believe that this approach in science teaching and learning help the learners to acquire a better understanding of science (*ibid*). However, Hodson (1990:33) argues that "practical work as conducted in many schools, is ill-conceived, confused and unproductive." Wilson and Stensfold (1991:353) argue that simply

being able to do practical work does not necessarily imply comprehension. Hodson (1990:34) gives his opinions about the role of practical work in the teaching and learning of science, listing the points thus:

- To motivate, by stimulating interest and enjoyment;
- To teach laboratory skills;
- To enhance the learning of scientific knowledge;
- To give insight into scientific method and develop expertise in using it; and
- To develop certain 'scientific attitudes' such as open-mindedness, objectivity and willingness to suspend judgement.

Having listed these claims about the role of practical work, Hodson makes a critical comment "Not only may it be the case that some goals are better approached by other means, it may be that none of these goals of science education is best approached by practical work". Hodson then asks a number of questions in relation to practical work:

- Does practical work motivate children? Are there alternative or better ways of motivating them?;
- Do children acquire laboratory skills from school practical work? Is the acquisition of these skills educationally worthwhile?;
- Does practical work assist children to develop an understanding of scientific concepts? Are there better ways of assisting this development?;
- What view/image of science and scientific activity do children acquire from engaging in practical work? Is that image a faithful representation of actual scientific practice?; and
- Are the so-called 'scientific attitudes' necessary for the successful practice of science? Are they likely to be fostered by the kinds of practical work children engage in?

These questions are, to me, genuine and difficult to answer. From my experience in the teaching and learning of science, some children do enjoy the kinds of practical activities that are provided in class, but some do not. Hodson views this as contradicting teachers' expectations that the interest and satisfaction of learners

increase when the amount of practical work is increased. Despite all the arguments and debates put forward by various science educationists, I strongly believe that conceptual understanding of scientific principles can be greatly enhanced by engaging learners in practical activities related to the science topic being dealt with. However, what needs to be researched is: what type of information should be gathered, how that information is incorporated into a practical activity, how a practical activity should be designed, and what type of questions should be asked to enhance the intended concept(s) or principle(s) in the topic.

## **2.6 Prior knowledge, practical activities and conceptual understanding**

Section 2.3 of this document gives Dougiamas's tenets of constructivism in pedagogical terms. These tenets will now form the basis of my discussion. To start my discussion, I introduce a statement written by Taber (2001:159):

There are many reasons why a teacher may fail to bring about desired learning. A pupil may be unable to see the board or hear the teacher clearly. The 'learner' may not be motivated to learn for various reasons. Perhaps, occasionally at least, a teacher may not be sufficiently prepared for the class. The literature on learning (for example, in science education) also makes it clear that motivated, able pupils, in appropriate learning environments, may often fail to learn effectively from keen, able, well-organized teachers.

Taber (2001:160) suggests that there is a general view among science teachers that learners do not learn much of the material presented to them. This seems to be prevalent even in situations and contexts where environments are well resourced and learners are well motivated. Many questions may be asked: Why do attentive learners not do well, when seemingly competent teachers, in terms of knowledge, present accurate content? What needs to be addressed to achieve the intended 'transfer' of knowledge? What should be done to improve the effectiveness of teaching and learning?

Ausubel, (cited in Taber 2001:160) points out that "although it is possible to memorise random strings of letters and numbers, education is intended to produce meaningful learning where new information is understood and can be applied." Ausubel goes on to suggest that meaningful learning occurs when the learner is able to make sense of the materials presented and that what is being taught has some link with existing knowledge. Furthermore, the prior knowledge of the learner does not have to be accurate. A supporting statement is: "If a learner holds frameworks of understanding that are at odds with the accepted knowledge, these alternative frameworks may act as suitable anchors for new knowledge" (*ibid*).

When the learner makes sense of the presented material in terms of an alternative framework, it might be a different sense from the intended. Driver *et al.*, (cited in Taber 2001:160-162), suggest that many research programmes have been conducted about learners' prior knowledge. These programmes have revealed that, most learners who enter science classrooms already hold ideas that are relevant to the topic being taught. It is often found that this prior knowledge is at odds with the accepted knowledge in the curriculum. Also, it has been found that learners interpret new information quite easily to fit their existing ideas and that, during practical work they often see different phenomena to their teachers.

Roschelle (1997:1) draws our attention to the fact that it is common practice for teachers to focus on the ideas they want to put across to their learners. Sometimes this approach confounds the teacher's best effort to put ideas across correctly and accurately, when learners bring up their prior knowledge. Quite a number of findings have shown that learning happens primarily from prior knowledge and only secondarily from the presented materials. Roschelle (*ibid*) suggests that "prior knowledge can be at odds with the presented material, and consequently, learners will distort presented material. Neglect of prior knowledge can result in the audience learning something opposed to the educator's intentions, no matter how well those intentions are executed". Roschelle (1997:3), referring to Dewey, suggests that

"designers discover that which is problematic for the learners, and establish conditions that support the process of inquiry: time, talk and tools."

Roschelle (1997:3) explains: "Vygotsky emphasizes the role of social process in learning, suggesting that new concepts appear first socially, and only gradually become psychological. He suggests that designers provide social models of appropriate activity, enable groups of learners to do more complex activities that they could handle individually, and use signs to enable people to negotiate the different meanings they find in social activity". A summary on prior knowledge given by Roschelle (*ibid*:5) produces three points:

- Designers should seek to refine prior knowledge, and not attempt to replace learners' understanding with their own;
- Designers must anticipate a long-term learning process, of which the short-term experience will form an incremental part; and
- Designers must remember that learning depends on social interaction; conversations shape the form and content of the concepts that learners construct. Only part of specialised knowledge can exist explicitly as information; the rest must come from engagement in the practice of discourse of the community.

The discussions that were brought up in this writing are also reiterated by Davis and Linn (2000:820). They contend that the reasoning by teachers and learners about scientific phenomena should be guided so that it reveals their own thinking. Secondly, the teaching and learning of science should make science accessible, and models that make sense to learners should be identified so that new information could be connected to prior knowledge. Thirdly, teaching should lend support to all learners so that new links and connections can be made from their own ideas and discussions. Finally, learners should be encouraged to be responsible for their learning and also reflect on their ideas and knowledge integration.

The concept of prior knowledge seems to fit well into the constructivist approach to teaching and learning as (outlined in 2.3) and, indeed, into the OBE philosophy. Prior knowledge may or may not be accurate, and may come in different forms for different fields of study. The contributions made by various authors are greatly appreciated. I agree that prior knowledge is essential and active at all levels ranging from children to adults. But Roschelle (1997:2) points out that there is much discussion and debate on how to incorporate prior knowledge into lessons in order to improve learning. I may also add that little or nothing is said about its elicitation from learners during teaching and learning.

## **2.7 Conclusion**

In this chapter, I discussed at length about education theories. An attempt was made to show how each theory impacts on teaching and learning. I have tried to highlight how these theories can be jointly used in a teaching and learning situation. Prior knowledge, its elicitation and incorporation into practical activities were also explored. In the following chapter I will focus on the methodology of my research study.

## Chapter three

### Research methodology

Qualitative research is multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Denzin and Lincoln 1994b, cited in Dupuis, 1999:45).

#### 3.1 Introduction to the chapter

To be engaged in a research project, I believe is like undertaking a journey into the dark wilderness. Before undertaking the journey, you need to prepare provision to sustain yourself along the journey. Most important is to stay focused and look for some light ahead. During the journey, you need to be prepared for the unexpected.

In this chapter, I will discuss the paradigm informing my study, goals of my research, research site and participants, data collection techniques and ethical issues.

#### 3.2 Philosophy underlying the research methodology

My research project is situated within an interpretivist paradigm, as this approach is able to provide “the meanings and purposes attached to human actors to their activities” (Guba and Lincoln 1994:106 cited in McRobie and Tobin 1997:194). Within this interpretive framework, a qualitative case-study research approach was adopted (Stake 2000:242; Merriam 2001:26). This seems most appropriate to my case study as, according to Hitchcock and Hughes (1995 cited in Cohen, Manion and Morrison 2000:182), a case study “focuses on practice, intervention and interpretation with the aim of improving the situation.” In my case I would like to improve conceptual change and development in **electrostatics**, an area basic to the understanding of electricity, according to Park, Kim, Kim and Lee (2001:1223).

In choosing this topic, I hoped that learners would be encouraged to share their experiences and beliefs about lightning, discuss some of their findings with their parents, and discuss lightning-related issues from a scientific perspective. Boud and Miller (1996:68) suggest that "interpretivists are intrigued by the shared practices, beliefs and spoken and unspoken agreements among different groups and individuals which guide that society." However, learners who may not see the link between lightning and electrostatics may not easily understand the phenomenon of lightning. Both lightning and electrostatics are sparks of electricity created through the attraction of unlike charges. As Weathereye (2003:2) says: "lightning is simply electrostatics on a large scale."

In view of this, learners' prior knowledge on lightning was elicited. Learners were allowed to brainstorm and discuss lightning-related issues. Furthermore, they were required to research and record their findings on lightning. Clark and Ramahlape (1999:112) believe that by introducing learners to the provisional nature of scientific knowledge in this way, we can begin to counter the stereotypical image of science projected in conventional South African textbooks. In my teaching and learning unit an attempt was to incorporate learners' prior knowledge. It comprised 'hands-on' and 'minds-on' practical activities using easily accessible learning support materials.

I conducted this research at a school in the Eastern Cape where I have been teaching for the past twenty-six years. In this chapter I will attempt to portray the complex pattern of eliciting prior knowledge, identifying prior knowledge and incorporating this knowledge into 'hands-on' and 'minds-on' practical activities during a science lesson in electrostatics. In this research project, a teaching and learning unit in electrostatics was designed and utilised as a vehicle to promote conceptual change in my Grade 9 class.

### **3.3. Research goals**

The goals of this research were to:

- **Investigate learners' experiences and beliefs about lightning;** and
- **Incorporate learners' prior knowledge during 'hands-on' and 'minds-on' practical activities in electrostatics to promote conceptual understanding.**

To realize these goals, I needed to:

1. Elicit learners' prior knowledge in order to facilitate conceptual development in electrostatics; and
2. Identify key concepts during 'hands-on' and 'minds-on' practical activities in electrostatics to enhance conceptual understanding.

### **3.4 Research site and participants**

My research study comprised my Grade 9 class consisting of thirty learners in my school in Grahamstown in the Eastern Cape, who were requested to participate voluntarily. One of the conveniences of using my own class was that the research process would not deviate from my normal teaching programme (Woolnough *et al.* 1999:28) and no resistance was expected from my learners. The teaching and learning unit (see appendix A) was used to teach my Grade 9 class in my school. The potential value of my research project enables me to design my own LSMs (Czerniewicz, Murray and Probyn 2000:iii), implement them and evaluate whether they enhance conceptual development. Also, in doing this research project, I have begun to learn to research my own teaching strategies.

### **3.5 Data collection techniques**

The data-collecting techniques were focus group interviews, informal whole-class semi-structured interviews, worksheets and videotaped recordings. By using a variety of data-collection tools, it was hoped that the weakness of one method would be complemented by the strength of another.

### 3.5.1 Focus group interviews

Focus groups have a predetermined agenda and are designed for interviewing groups of participants in a natural setting where all participants are made to feel comfortable (Schurink, Schurink and Pogenpoel 1998:1; Jones 2003:126). Sanders (1999:383) argues that “semi-structured interviews ensure that specific questions will not be omitted; yet they allow the flexibility to probe the unexpected.” In support of this, Loughran and Derry (1997:928) argue that data obtained from interviews is qualitative. In addition, Wilkinson (2000:44) asserts that “open questions allow the respondent to insert his or her own view, ideas or suggestions about the question posed, whereas closed questions require that the respondent choose one or more from a predefined category of answers.”

During the interview session, the learners were seated in six groups of five and these constituted focus groups (Berg 1998:104). According to Berg (*ibid*), “meanings and answers arising during focus group interviews are socially constructed rather than individually created.” Semi-structured interviews were conducted with each of the focus groups to determine the extent of the learners' prior knowledge of lightning. Interviewing learners as a group, I hoped that a relaxed environment in which learners could express and support each other's views would be created (Wilkinson 2000:49). All interviews were tape-recorded (with the permission of the participants) and transcribed verbatim for accurate record-keeping and review.

### 3.5.2 Informal whole-class semi-structured interviews

In addition to the focus group interviews, **an informal interview** was conducted with the whole class. The purpose of this exercise was to follow up and probe some of the responses emanating from the focus group interviews. The follow-up exercise was not done during the **focus group interview** because I had noticed that in almost every focus group, the same participant supplied responses and some participants were reluctant to talk into the recording machine. This is because in the normal teaching and learning situation, responses to questions by the teacher are not usually recorded. Further, there

was no relaxed atmosphere (perhaps because of the perceptions held by their parents about lightning or perhaps my approach and body language). The follow-up informal whole-class interviews were also tape-recorded and transcribed verbatim.

### **3.5.3 Worksheets, photographs and videotaped recordings**

Worksheets were designed in which learners were encouraged to **predict, explain, explore, observe**, and **explain** again, as suggested by Gunstone (1990:12). It was hoped that this approach would enhance conceptual development in electrostatics. Furthermore, emphasis was placed on identifying key concepts and forming links between what learners observed during the practical activities and their responses during the interview. During the implementation of the practical activities and worksheets, a video recording of the proceedings was conducted and photographs of each group were taken for in-depth analysis. During the 'hands-on' and 'minds-on' practical activity session two of my colleagues assisted me by videotaping and taking photographs of the proceedings for close observation of the interaction between members in the groups and of course to help me to record my involvement in the activities and my body language reaction to the whole exercise.

### **3.6 Ethical considerations**

Merriam (2001: 213) argues that, “in qualitative studies, ethical dilemmas are likely to emerge with regard to the collection of data and in the dissemination of findings.” In view of this, prior to doing the research, permission was sought from the learners, parents and the Headmaster of the school. Using pseudonyms concealed the identity of the participants. Respect and confidentiality was upheld throughout the duration of this case study.

### 3.7 Conclusion

The informal whole-class semi-structured interviews and the worksheet data-collecting techniques enabled me to compare and contrast information, which in turn helped to make data more reliable and trustworthy. The focus group interviews, informal whole-class interviews, the worksheets and the 'hands-on' and 'minds-on' practical activities were designed, discussed and criticised by the supervisors, then pilot-tested and modified before being implemented.

However, I must point out that collecting data using **focus group interviews** and **informal whole-class interviews** strategy was challenging. Information may be difficult to obtain if the interview sessions are not carefully guided. A **worksheet** during a 'hands-on' and 'minds-on' practical activity in teaching and learning may be used as a means of engaging learners in reflecting their understanding of a particular topic, but the worksheet needs to be well structured.

The next chapter will be devoted to how data was collected using the focus group interviews, informal whole-class semi-structured interviews, worksheets and video recordings.

## **Chapter four**

### **Data collection**

In qualitative studies, researchers gradually make sense of what they are studying by combining insight and intuition with an intimate familiarity with the data . . . this is often a difficult process. Most people inexperienced in qualitative research have difficulty in recognizing patterns in their data . . . There is no simple formula for identifying themes and developing concepts . . . (Taylor and Bogdan 1998:142)

#### **4.1 Introduction to the chapter**

In the previous chapter I outlined the research methodology of my case study. Various aspects of the methodology were discussed. I looked into my research goal, research site and participants. Four data collecting techniques, namely, focus group interviews, whole-class semi-structured interviews, worksheets and video recordings were mentioned. The purpose of these techniques was also discussed. The focus of this chapter is on discussing and elaborating on how these techniques were implemented during the data-collection sessions and the challenges that went with the exercise.

#### **4.2 Data collection using focus group interviews**

During the normal course of my science lessons, learners are seated in six groups of five. Since the learners in each group are familiar with one another in terms of behaviour, attitudes and opinions, I decided not to change or re-arrange the group structure during the interviews, as the familiar structure would encourage smooth interaction between the members in each group. These groups constituted the focus groups. Literature says that one of the advantages of focus group interviews is that they are easier to conduct than individual interviews, but from my experience they turned out not to be so. Furthermore,

according to Berg (1998:105), focus group interviews need less time than individual interviews do, but I found them to be time-consuming.

Schurink *et al.* (1998:6) suggests that, when planning an interview session, it is important to consider the information the interviewee could possibly know. I agree with Schurink *et al.* as this would help in designing the interview schedule. Furthermore, before doing the interview, the participants will have been informed about the area of research and that "if the interview is to be tape-recorded, then consent should be sought." So, before conducting the interview I had to design an interview schedule, taking into account Schurink *et al.*'s suggestions. During the schedule-designing process, I needed to define the concepts to be investigated clearly and inform my learners about the topic they would be interviewed on. Critical questions that captured the intent of the case study had to be identified, and so five questions for the focus group interview schedule were designed. Attention was also given to the sequence of the questions.

The interviewing process was conducted at school towards the end of the school day. This was done so that the interview process should be free from distractions that would make the tape-recording of proceedings nearly impossible. An empty classroom was prepared away from the learners' usual classroom so that the interview would be conducted away from open doors where traffic might interrupt the interview and tape-recording. In this interview room, tables and chairs were arranged so that the participants could face each other during the discussions and interviews. During interviewing, one group at a time visited the interview room, all other groups remained in their usual classroom and visited the interview room in turns when requested to do so.

The focus group interviews were divided into two phases. In the first phase, interviews dealt with my learners' experiences and what they had gathered from their parents. In the second phase the interviews had to do with my learners' research findings on lightning and electrostatics. In the interviews it became apparent that focus group or group interviews do not necessarily create a relaxed atmosphere, as anticipated, in which learners are free to talk. During the discussions and interviews, some learners were

passive, whereas others dominated. After the interview I heard one of the learners saying: "Hey sonny (talking to another classmate), I understand the questions but the problem is how to answer" (Journal 22/05/03). This shows that some learners could be reluctant to give their views because of lack of proficiency in English, which is the recommended medium of instruction.

The passive stance adopted by some learners could have been due to my expectations from certain learners in the group, fear of giving undesired responses, lack of language proficiency, lack of confidence, or relying on learners who are extroverts. For example, regarding language proficiency, in one of the groups I had to repeat the question in Xhosa before my learners could respond.

Despite these challenges, the first-phase interview provided some revealing insights into the process of eliciting prior knowledge. The responses showed that the learners possessed diverse conceptions or perceptions of lightning-related issues. Nevertheless, there were some commonalities in the responses. These commonalities will be discussed in the next chapter.

#### **4.3 Data collection using informal whole-class semi-structured interviews (follow-up)**

That the informal whole-class or active interviews, as Dupuis (1999:57) calls them, became my second data-collecting tool, was made necessary by the manner in which the focus group interview session took place. Dupuis suggests that "active interviews recognise that the interview is very much shaped by the interviewer and his research agenda and the topic areas of interest to the researcher as well as the position of the researcher are made explicit to the participants. The active interview is much more conversational in style and capitalizes on the dynamic interplay between researcher and respondents."

Another day was arranged with my learners to make a conversational follow-up interview session on some of the responses provided by each group during the first-phase interview. The main focus of this follow-up interview was to establish reasons behind some of the responses of the learners. The informal whole-class interview was also tape-recorded to ensure accurate data-capturing for later analysis and safekeeping.

At the beginning of the whole-class interview, I thanked all participants for the wonderful responses they supplied and told them that some of the responses really made one wonder what lightning is all about. I also indicated that I wanted to probe further on the same questions they responded to during the interview session. To me the whole class interview was better conducted and directed than the focus group interviews. The learners spoke freely and with confidence. They all seemed eager to speak into the tape recorder microphone.

This could have been because learners were not being asked unfamiliar questions and they were acquainted with being asked questions as a class rather than as small isolated groups, and it was their second exposure to tape-recorded interviews. Secondly, the learners who did not get an opportunity to express their views during the first interview felt their chance had arrived. Thirdly, there would be no domination by some of the group members. Sensing the relaxed atmosphere in the classroom, I then requested them to introduce themselves before responding to a question. This strategy was adopted so that I could note the contributions from the various groups. All learners in the various groups gave consent.

#### **4.4 Data collection using worksheets and videotape during practical activities**

In section 3.2 I gave a description of the main goals of my research project as investigating the learners' experiences and beliefs about lightning and incorporating learners' prior knowledge during 'hands-on' and 'minds-on' practical activities in electrostatics to promote conceptual understanding. To realise these goals, I needed to elicit learners' prior knowledge in order to facilitate conceptual development in

electrostatics and identify key concepts during 'hands-on' and 'minds-on' practical activities to enhance conceptual understanding.

In this research project, a teaching and learning unit was designed. The unit comprised 'hands-on' and 'minds-on' practical activities, using easily accessible resources. Worksheets were designed in which learners were encouraged to Predict-Explain-Explore-Observe-Explain (PEEOE approach) (Ngcoza and Maselwa, 2003:10) and write scientific concepts in their own words in order to enhance conceptual understanding of electrostatics. The PEEOE approach was adopted and modified from Gunstone's (1990:12) Predict-Observe-Explain (POE) approach. Gunstone used the POE approach usually incorporating small and whole-class discussions. In my PEEOE approach, I included two extra 'Es' to highlight a special emphasis I gave to learners' explanations for their predictions prior to their observations as well their explanations later on. Furthermore, an emphasis was placed on identification of key concepts, which the learners wrote on their worksheets.

During the practical activity session, each group was supplied with a used transparency, a pair of scissors, and a ruler. All learners in each group were required to read the instructions and follow them to the letter. The practical activity required the learners to interact and help one another in taking the required measurements, making predictions, forming explanations, cutting strips from the transparency as shown in the worksheet, rubbing the strips with their jackets, ties and jerseys and observing what happened, and explaining their observations.

The basic component of the practical activity was that the learners were to:

- Observe the charged strips;
- Attempt to identify the type of charge;
- Explain the production of the charge;
- Explain the attractive force between the strips or between strip and rubbing object;
- Explain the repulsive force between the strips or between strip and rubbing object;

- Find out what happens to the size of the force when we change the distance between charged objects and the strips; and
- Find out what happens to the size of the force when we increase the amount of charge on the charged strips.

During the completion of the worksheets, learners were not expected to give accurate answers. The main intention was to find out whether learners could associate the charges on the strips with their responses about lightning and electrostatics. Secondly, the worksheets were meant to help learners learn new concepts related to charges. In the groups there was more interaction between the members than any other instance of my teaching in the class.

The approach that I used is a form of co-operative learning. Co-operative learning is a technique that requires students to work together in small fixed groups to accomplish some task. I felt that I had created an atmosphere in the class that fostered that kind of student learning (Magel 1996:52 and 55). Herder, Subrahmanian, Talukdar, Turk and Westerberg (2002:39) suggest that, in teaching, the use of various forms of collecting, storing and retrieving information is of vital importance. In view of this, during the 'hands-on' and 'minds-on' practical activity session, I requested two of my colleagues to assist me by videotaping and taking photographs of the proceedings for close observation of the interaction between members in the groups and of course to help me to record my involvement in the activities and my body language reaction to the whole exercise. Furthermore, the information on the tape and photographs could be stored, reviewed and later used as a starting point should one exploit the possibility of improving classroom management during other 'hands-on' and 'minds-on' practical activities.

Using this approach required a great deal of work and organization. The designing of the 'hands-on', 'minds-on' practical activities, and construction of the questions was challenging. I probably had the most wonderful time during my involvement with this class. After hearing what they had to say about their participation during the activity, I asked myself; why did I take so long to realise the importance of co-operative learning?

Having said that, it would be difficult to assess whether learning in my classes would always be successful using this approach.

#### **4.5 Conclusion**

In this chapter, I looked into data-collecting techniques. Although literature suggests that focus group interviews are easier to work with, the reality in my case was that it was difficult to probe due to time constraints. But the whole-class semi-structured interviews were productive. Having a video camera during the practical activities proved worthwhile. In the next chapter, I will describe how the data collected was analysed.

## Chapter five

### Data analysis

Data analysis is probably the most difficult aspect of qualitative research to communicate to others. Many people who are new to the methodology are capable of establishing rapport in the field, asking questions, and recording data, but get stuck when it comes to analyzing their data (Taylor & Bogdan 1998:140).

#### 5.1 Introduction to the chapter

In the chapter on data collection I have attempted to discuss a variety of ways that I have used to collect data. I have conducted **focus groups** interviews to elicit prior knowledge from my learners on lightning and used follow-up **whole-class informal semi-structured interviews** on some of the responses learners provided. Also, **worksheets** were used during the 'hands-on' and 'minds-on' practical activities to help learners see links between lightning and electrostatics. In this chapter the focus will be on analysing the data obtained from these data-collecting techniques. The purpose of the analysis was to look for trends in the learners' prior knowledge and for a sense of their conceptual understanding of lightning with the intention of incorporating the prior-knowledge concepts into the 'hands-on' and 'minds-on' practical activities in the teaching and learning of electrostatics.

## 5.2 Results from focus groups interviews

My focus group interview schedule consisted of five questions (see appendix B). The following responses for each of the following questions were received.

### 5.2.1 *Can you tell me about your own experiences or what you have heard from your parents about lightning?*

The responses received from the learners varied from group to group depending on the background of the learners. Nevertheless, all learners in the various groups had a common understanding about lightning. They said their parents told them to respect lightning because it was dangerous and that there were some precautionary measures to be taken during a lightning storm. After analysing all the responses for this question, four categories of data were formulated.

The first category had to do with electrical appliances. During a lightning storm their parents said that the learners should not:

- Watch Television;
- Play radios;
- Touch electricity wires; and
- Use telephones.

The second category had to do with consumption. Regarding drinking and eating, they said that they were not allowed to:

- Drink water;
- Drink milk;
- Eat eggs;
- Eat meat; and
- Eat *umphokoqo* (African salad, that is, cooked maize meal with sour milk)

The third category had to do with social issues. Learners had the following to say:

- Do not play in the field;
- Do not wear red clothes;
- Do not sit close to one another;
- Do not sleep while others are not sleeping; and
- Do not stand on the threshold of a building.

The fourth category had to do with general issues. Here the learners that said that their parents warned them:

- To cover mirrors;
- Not to handle metals or shiny objects;
- Not to handle or carry water;
- Not to throw soapy water through the door;
- Not to stand under a tree; and
- To put a motor car tyre on the roof of the house.

Analysis of data revealed learners came to class with some prior knowledge. This prior knowledge contained scientific and non-scientific concepts. In this question, the following concepts related to lightning emerged: metals, distance, electricity, electric current, charge, conductors and insulators. One of the misconceptions, or alternative conceptions, that emerged was that a mirror has to be covered during a lightning storm because it is a conductor of lightning.

### ***5.2.2 During a lightning storm, what do you think is happening in the sky? How do you think lightning is formed?***

Generally all the groups had an idea of what is happening during a lightning storm. They also mentioned that they learnt that clouds could become oppositely charged through friction. Furthermore, when the opposite charges attract each other in the clouds, lightning is formed. Interestingly, the learners did not mention any lightning between the clouds and earth. In this question the concepts that emerged were:

oppositely charged, friction, positive charge, negative charge, and movement of negative charges.

Here is a response from one learner: "I think during a lightning storm, the cloud . . . the cloud usually gets eh . . . the bottom of the clouds gets a negative charge and the top of the cloud usually gets a positive and the ground gets a positive charge and when the lightning is formed the negative charges at the bottom of the cloud try to jump over to the positive charge on the ground".

### **5.2.3 Can you briefly explain what is meant by electrostatics?**

Learners seemed to have some basic knowledge about the concept of electrostatics. Rubbing of hair, plastic combs, nylon, wool, balloon, transference of electrons, and causing objects to be charged are some of the aspects they mentioned. During an interview with one group, there was an almost 'one-to-one' interview within the group with one learner who described how he saw sparks when he rubbed his brother's cat at night (see excerpt 1 below).

#### **Excerpt 1**

- T. The next question will be . . . You were required to find information on electrostatics. **Can you briefly explain what is meant by electrostatics?** Any body? Yes.
- L. In electrostatics is like when you rub . . . comb your hair with a plastic comb, some electrons are rubbed off your hair onto the comb.
- T. How do you know that? That some electrons are rubbed off the comb or your hair? All right. Any other response on electrostatics . . . or do you want to continue?
- L. Its like when you have a plastic like polythene and a wool or a nylon rub, it with a polythene, the nylon . . . the polythene will try to connect the other charge.

- T. Okay, . . . another one?
- L. When you take a balloon and rub it . . . rub the balloon in your hair . . . you are making a charge.
- T. Okay . . . Yes!
- L. At night sir when you brush a cat there is there's lightning there.
- T. Have seen that?
- L. Yes . . .
- T. Have you done that?
- L. Yes.
- T. And you saw some sparks?
- L. Yes.
- T. Are you sure?
- L. Yes.
- T. Do you have a cat at home?
- L. My brother has one.
- T. Okay. You rubbed the cat and you saw something . . . you know you saw some sparks?
- L. Yes.
- T. That's lovely. Okay.

#### **5.2.4 *What do you think is the link between lightning and electrostatics?***

As predicted, most learners did not see the link between lightning and electrostatics. They perceived the discussions and interviews around lightning as routine teaching where the teacher wanted to impart knowledge on how lightning is formed. This could possibly be due to the fact that lightning is a natural phenomenon occurring far away from the classroom environment. I began to feel that my attempt at bridging the gap between learners' prior knowledge on lightning and classroom activities on electrostatics was going to be unsuccessful.

The fact that the learners did not realise that the discussions and interviews on lightning were an introduction to electrostatics indicates that there is a need for clear guidelines on how to elicit, link and incorporate learners' prior knowledge into teaching and learning. However, one group did see the link between lightning and electrostatics. One learner in the group responded by saying: "Yes I see the link between lightning and electrostatics. Electrostatics has small sparks but lightning has larger sparks than the electrostatics. In the lightning you can see those sparks but in electrostatics you cannot see if you don't know about it" (see excerpt 2 below).

### **Excerpt 2**

**T. What do you think is the link between lightning and electrostatics?**

Remember you studied or you learnt about lightning or you gave me your perception or knowledge about lightning knowledge about lightning and you went out to read about electrostatics. Do you see or have you seen any connection or link between the two, lightning and electrostatics? Anybody?

L. Yes I see the link between lightning and electrostatics. Electrostatics has small sparks but lightning has larger sparks than the electrostatics. In the lightning you can see those sparks but in the in electrostatics you cannot see it if you don't know about it.

T. But our friend here saw some sparks with his . . . brothers' cat.

L. . . . we learn about lightning, and he knew that there's some electro, there's some sparks in cat when you rub it, but if we did not know . . . (Interruption by teacher)

T. Know but he saw the sparks. . . . why was he able to see the sparks? Why do you think he was able to see some sparks?.

L. Because the weather was dry.

T. The weather was dry? . . . Why were we able to see the sparks when we rubbed your cat?

L. Yes, sir, it was at night, sir.

- T. (Satisfied) It was at night yes good. So you can see sparks at night but during a lightning storm you can see the sparks even if it is daylight. Okay, any other link you see between lightning and electrostatics? any other link?
- L. I think, sir, there are charges positive and negative between electrostatics and lightning.
- L. I was saying they both have charges.
- T. What charges now?
- L. There were like when you rub matter by a matter and you can see negative charges and positive charges and in the lightning there's some charges.

### ***5.2.5 Was the teaching of electrostatics made easier by starting with lightning-related things?***

Again some groups did not relate to the question because some learners did not see the link between lightning and electrostatics and would therefore not be in a position of knowing whether it was made easier or not. A few learners in three groups did see that it was easier to understand electrostatics after discussing lightning. One learner had this to say: "We all see lightning and we do not see electrostatics so our teacher helped us to know electrostatics by teaching us about how lightning is happening and lightning is common to electrostatics." Another learner had this to say: "And I think it was a good idea to study about lightning because we see lightning every day but electrostatics we can't see it."

### **5.3 Results from whole-class semi-structured interviews**

As indicated earlier, the focus group interviews did not take place in a comfortable and relaxed environment. Some learners were passive and did not seem interested in the interview because of reasons I have highlighted earlier. I thought that a whole-class conversational type of interview was necessary to probe into some of the responses that were provided by the learners during the focus group interviews.

The whole-class interview looked into the following: Why, during a lightning storm

- Should you not watch television?
- Should you not use a telephone?
- Should you not touch electric wires?
- Should you not drink water?
- Should you not eat eggs or red meat?
- Should you not play in the field?
- Should you not wear red clothes?
- Should you not sleep while others are awake?
- Should you cover mirrors?
- Should you put a motorcar-tyre on the roof of the house?
- Should you not eat *umphokoqo*?

On the first three responses on television, telephone and electric wires learners gave an impression that they understood that lightning could easily travel in wires. Learners provided scientific answers to the questions. Responses such as the following were received: "Television works with . . . an electricity so . . . lightning, does it conduct with an electricity." Another response was: "Because the phone has a line that's why do not touch them." Others were: "Because electricity move through the wires" and "Because a wire is good conductor of electricity, so you may be shocked when lightning strikes." (see excerpt 3 below).

### **Excerpt 3**

- T. Why did you say **Do not use telephones**. Is there any reason why we should not use telephones? Any person? . . . Any person? Why can't we use a telephone when there is a lightning storm? . . . Why can you not use a telephone? . . . Say anything, say anything that you think is the reason why we cannot make telephone calls when there is a lightning storm . . . Any response now? Why? . . . Why can't we make telephone calls . . . Any person . . . Who would like to try? .

- . . Who would like to try and explain why we cannot make telephone calls . . .  
 Yes S.
- S. Because the . . . the phone has a *li* . . . the wires that's why do not touch them.
- T. Alright. Any other response? Any other response? Yes S.
- S. I think because lightning like tall things then it may attract the pole, then it may damage phone *ke ngoku*
- T. Alright. Good. Any other one? Any other response about telephones? . . . Any other response? . . . Okay. B yes.
- B. Lightning don't like sounds and when you talk through the phone we making a sound and that sounds go through with the line, and that can be damaged by lightning.
- T. Alright. The other response you gave me was: **Don't touch electric wires.** Why do you think we should not touch electric wires when there is a lightning storm? . . . Yes M.
- M. Because electricity move through the wires.
- T. Right. Any other person? . . . Ja Z . . . Z yes yes
- Z. Because lightning is a conductor of electricity.
- T. Lightning is a conductor of electricity . . . what do you mean by that?...lightning lightning is a conductor? Lightning is a conductor of electricity.  
 Can somebody help - help him? Yes B.
- B. Because lightning likes to attract electricity things.
- T. Okay. Ja K.
- K. I think the reason is that the electric wires are good conductors of electricity so electricity can flow easy.
- T. Okay. Eh M yes.
- M. Because the minute you touch the electricity wires lightning will go straight by the wires and through you and you will be killed.
- T. Okay. Thank you. Any other response? X.
- X. Because wire is a good conductor of electricity, so you may be shocked when Lightning strikes.
- T. Okay. Another one. N.

N. Because the electricity wires sure, and when you touch them you can die.

Despite these positive responses there were some learners who said: “Lightning don't like sound and when you talk through the phone we are making sound and that sound go through with the line, and that can be damaged by lightning.” This confirmed the belief that there should be no talking during a lightning storm.

On the question about not drinking water, all learners considered water to be a bad conductor. They maintained that a bad conductor is something that does not allow electricity to pass. At this stage I realised that learners associate conductivity with metals only. So, since water is a liquid it cannot be associated with lightning conductivity. After being asked what a bad conductor is, one learner said that a bad conductor of electricity is something that does not allow electricity to pass. Almost all the learners perceived a mirror (a solid) to be a good conductor and that it should be covered during a lightning storm to avoid the movement of electricity through it.

The responses received about not eating red meat or not wearing red clothes emanated from the idea that a cow is a good conductor of electricity because it has red flesh. So, anything that is red will attract lightning and be a good conductor of electricity. But one learner said that people should not wear red clothes because some players that were wearing red shirts were struck by lightning during a soccer game. They also said that if people are seated close to one another during a lightning storm, no room is given to lightning to pass, so people could be struck. The same reason was given about a person standing on the doorsill: lightning must be given the right of way. To me this was not a scientific explanation.

Responding to why we should put a motor car tyre on the roofs of our houses, learners seemed to possess better scientific reasoning. The meanings of 'good conductor' and 'bad conductor' emerged. The learners listed zinc as a good conductor and rubber as a bad conductor. All learners agreed that the reason why a tyre is put on the roof of a house is to insulate the house from lightning.

These are some of the responses learners provided: "Because a motor-car tyre stop the lightning not to come inside the house"; "Because tyre is a bad conductor of electricity. Electricity cannot pass through the tyre"; "Because tyre is bad conductor of electricity and roof is made up of zinc and zinc is a good conductor of electricity"; and "Because motor tyre is a rubber, electricity cannot move through the tyre rubber". (see excerpt 4 below).

#### **Excerpt 4**

- T. The other response you gave me was: **You should put a motor-car tyre on the roof of a house.** Why should we put a motor-car tyre on the roof of a house during a lightning storm? . . . Eh? . . . Na, yes let's hear from you.
- Na. Because a motor tyre stop the lightning not to come inside the house.
- T. Okay, any other person, any other response? Any other response . . . any other Response . . . any other response? K.
- K. Because lightning can be stopped by that car tyre to be passed through the house.
- T. Okay. Who is this one? Yes . . . Mp . . . Why?
- Mp. Because tyre is a bad conductor of electricity. Electricity cannot pass through the tyre.
- T. Okay, okay, okay, any other person, any other response?, any other response? Any other response? . . . R girl, yes.
- R. Because tyre is bad conductor of electricity, and roof is made up of zinc and zinc is a good conductor of electricity.
- T. Okay, okay, any other one, any other response, any other response, any other response any other response? Are you going to say something different from the other people? Yes . . . let's hear BM.
- BM. Is to avoid lightning not to pass through the shinny roofs.

T. Okay. Mj do you have another response different from the other people? Let's hear it Mj.

Mj. Because motor tyre is a rubber, electricity cannot move through the tyre is a rubber.

T. Alright. Good. Thank you

After the session, learners were asked whether they thought their parents knew more scientific principles about lightning than they did and there was no response.

#### **5.4 Results from the worksheets and video tape**

The results from the two interviews revealed that learners come to class with prior knowledge. In this case the prior knowledge my learners brought to class contained some scientific and non-scientific knowledge. From the prior knowledge I picked up some key concepts that would be essential during the 'hands-on' and 'minds-on' practical activities. Key concepts that emerged were: metals, distance, electric charge, conductors insulators, electric current, friction, oppositely charged, positive charge, negative charge, transfer of electrons, nylon, hair, plastic and wool.

The 'hands-on' and 'minds-on' practical activity session was a wonderful experience for both the learners and myself. All the groups were able to come up with the basic properties of charges. Learners were able to explain that objects can be charged by friction and that during friction negative charges are transferred. If one object acquires a negative charge, the other object acquires a positive charge.

The first 'hands-on' and 'minds-on' practical activity on the worksheets investigated the effects of charged objects on one another. This activity involved the rubbing of plastic strips and observing the behaviour of the strips when neutral objects are brought close to the strips and when the strips are brought close to the rubbing object. Learners could not be sure of the type of charge acquired by each of the rubbing objects, but could reason that after rubbing, the objects have opposite charges. They said that

negative charges moved from one object to another during the rubbing. The object that loses electrons acquires a positive charge and the other object gains those electrons.

After completion of the activity, I found out that learners had written the following about charges: “Charges of the same type repel”; “Charges of different types attract”; and “Charged objects attract neutral object”. When I asked them to explain how a charged object attracts a neutral object, only two groups could explain that a charged object causes polarity on the neutral object because of induction.

The next 'hands-on' and 'minds-on' practical activity was intended to investigate the force each charge exerts on the other charge. The first part of this activity required learners to rub the strips several times. By so doing they would be increasing the amount of charge accumulating on the strips. The learners were then expected to associate the number of rubbings with the amount of repulsion between the strips.

The second part of the activity required learners to give the strips a charge by rubbing them several times. Afterwards, the learners had to hold the other object used in the rubbing at varying distances from the strips and describe how the force between the strips and the object was affected. Both of these activities provided learners with a lot of challenges. In some cases the strips would not get charged because of the manner in which the learners handled the strips. In these instances my two colleagues and I intervened to give assistance.

Despite these challenges, four of the groups came up with information that is embodied in Coulomb's law of electrostatics. One group wrote the following: "When the amount of charge is bigger the force become stronger, but when the distance is bigger the force became small."

The video recording showed that during the practical activities I sometimes forgot that I was doing research and handled myself as a teacher in a normal teaching period. In one instance almost all the groups could not get a charge on their strips; this made me visibly frustrated. As I moved from group to group I strongly urged that learners should read instructions carefully and should rub hard on the plastic strips to get them charged.

Although I tried hard to let learners enjoy themselves during the practical activity, I soon realised that some learners in the groups had reading problems and could therefore not understand clearly some of the information required by the worksheets. This was evident from some of the responses they provided and the time taken to agree on those responses. During these activities, participation and co-operation by group members was noticeable.

As I moved around the groups to monitor the activities I also asked the learners how they felt about the activities. All learners said that they enjoyed the way the activities were progressing. Also, they found that doing 'hands-on' and 'minds-on' practical activities in groups was helpful in that they were given an opportunity to share ideas. Learners said that they became exposed to manipulating apparatus and thus acquire manipulative and observation skills. This, they believed, stimulated their interest and understanding of scientific concepts.

Below are pictures showing learner minds-on and hands-on interactions.



Teacher scaffolding showing learners how to rub strips to get them charged.



Learners actively involved in hands-on and minds-on practical activities.



Strips are charged, learners look fascinated.



Learners discuss to make sense of concepts.

## **5.5 Conclusion**

I have found this chapter on data analysis demanding. It was like doing a jigsaw puzzle where each piece of the puzzle must fall into the right place. Looking for trends that emerged from data-collecting techniques required undivided attention. It is my hope that such attention was demonstrated in this chapter. The next chapter will be dedicated to the discussion, recommendations and limitations of my research study.

## Chapter six

### Discussion, recommendations and conclusion

First, designers should seek to **refine prior knowledge**, and not attempt to replace learners' understanding with their own. Second, designers must anticipate a **long-term learning process**, of which the short-term experience will form an incremental part. Third, designers must remember that **learning depends on social interaction**; conversations shape the form and content of the concepts that learners construct. (Roschelle 1997:5)

#### 6.1 Introduction to the chapter

In the previous chapter I have attempted to analyse and report on the aspects and concepts that emanated from the data I had collected from the focus groups interviews, whole-class informal semi-structured interviews, and shown how the 'hands-on and 'minds-on' practical activities were conducted using worksheets to incorporate learners' prior knowledge. This chapter will be devoted to a brief discussion about my experiences followed by my data collection and its analysis, research limitations, recommendations and conclusion.

#### 6.2 Discussion, research limitations, recommendations and conclusion

In this case study, I attempted to elicit learners' experiences and beliefs around lightning with the intention of incorporating these experiences into 'hands-on and 'minds-on' practical activities in electrostatics to promote conceptual understanding. It emerged that talking about elicitation of learners' prior knowledge is one aspect; on the other hand the actual process of eliciting learners' prior knowledge is another. My experience is that the process of eliciting learners' prior knowledge is challenging, time-consuming and needs thorough preparation. This suggests that the eliciting of learners' prior knowledge is easier said than done. But Roschelle (1997:1) suggests that if learners' prior knowledge is neglected, the learners can miss the educator's

intentions or the educator misses what to add to what the learners already know. Furthermore, he suggests that in many instances teachers tend to focus on the aspects that they want their learners to learn. In view of this, I recommend that programmes that deal with teachers' professional development should recognise the importance of prior knowledge and its incorporation into teaching and learning. Furthermore, these programmes should encourage teachers to be researchers so that in the process they acquire research skills.

For instance, during the focus group interviews, I found myself in a teaching mode rather than in a research mode. Learners were scaffolded, praised for satisfactory responses and censured for certain responses. Woolnough, MacLaughlin and Jackson (1999: 28) suggest that "the beauty of teachers doing research with their own pupils is that they control the teaching, and vary it according to what they want to investigate in such a way that it is always in line with the objectives of the teaching programme"; but this was different from my interview experience, as highlighted above. Perhaps my bias during the interview session turned out this way because the case study involved my own class and some responses would not fit well with my research goals. This proved to be one of the limitations of my research.

Further, it became apparent that focus group or group interviews do not necessarily create a relaxed atmosphere, as anticipated, in which learners are free to talk. During the interviews, some learners were passive, whereas some dominated. This could be due to my expectations from certain learners in the group. As a result of this expectation, some learners seemed to fear giving responses that they possibly thought would be regarded as undesirable by their teacher. This I believe were other limitations of my case study. Perhaps, another prohibiting factor for learners being passive was language proficiency, lack of confidence, or relying on learners who are extroverts. For example, regarding language proficiency, in one of the groups I had to repeat the question in Xhosa before my learners could respond.

Despite all these challenges, most concepts related to electrostatics emerged, but in-depth explanations of the concepts surfaced during the informal whole-class interview. The informal whole-class active interviews brought back comfort and relaxation to the learners. Firstly, they could hear one another respond to questions in the class as usual. Secondly, they could verify what their parents might have told them about lightning. Thirdly, the positive comments I made about their responses during the focus group interviews and how I had learnt from them, gave my learners confidence. So, the elicitation of learners' experiences, using informal whole-class active interviews needs further research, in particular the asking of questions by the learners.

The use of worksheets in my teaching and learning unit was successful in promoting group discussion and active participation by group members. Also, learners were able to identify key concepts and thus, to some extent, conceptual understanding in electrostatics was promoted. Although no formal assessment was conducted, I believe that the worksheets helped incorporate learners' prior knowledge into 'hands-on' and 'minds-on' practical activities. However, although the worksheets encouraged learners to make predictions during the practical activities, I found the worksheets prescriptive. For future research, the design of my teaching and learning unit will need improvement to promote enquiry and investigative skills. Also, I recommend the use of concept maps in which the learners show the links between concepts.

Given the findings of my study and the challenges I encountered in eliciting prior knowledge from my learners, the process and execution was exciting, an eye-opener and worthwhile. The study revealed that researchers engaged in eliciting learners' prior knowledge need to be equipped with a variety of skills, such as questioning, probing and scaffolding. Without these skills, superficial data may be obtained. This also suggests that teachers need to be knowledgeable about the subject content and mindful of the elicitation and incorporation of learners' experiences into their teaching and learning practices.

### **6.3 Conclusion**

In this chapter, a discussion, research limitations, areas for future research and recommendations were provided. Monitoring the 'hands-on' and 'minds-on' practical activities using worksheets was enlightening. I feel I have a better understanding of the importance of engaging learners in various teaching and learning strategies and types of practical activities in order to promote conceptual understanding. I am now planning to use the same method of incorporating learners' experiences into 'hands-on' and 'minds-on' practical activities to enhance conceptual understanding with other topics in my teaching and learning practice. The method of using carefully prepared worksheets in groups promises to be exciting and creates a learning environment in which learners are able to brainstorm, share ideas, argue vigorously and eventually come up with solutions.

In the following chapter, I will provide some reflections on my experiences in this research journey.

## **Chapter Seven**

### **Reflections**

Travellers normally prepare for the adventures they hope to have, but itineraries, maps and plans in themselves do not create their journeys. A journey is an experience lived just as it turns out to be: moment by moment, day by day, month by month, event by event. Preparing for each part of the journey involves making decisions, making plans, and outlining key strategies to help set directions for the coming adventure. (Lotz 1996:2)

#### **7.1 Introduction to the chapter**

Was it being complacent that it took me such a long time to be engaged in such an adventure or was it destiny? Was I waiting for experience to give me a few lessons or was it that I missed opportunities? The English proverb puts it this way: Procrastination is the thief of time. In response to these questions, I believe it is never too late to mend. In this chapter, I will share some of my experiences in my teaching profession and the Masters course at Rhodes University.

#### **7.2 My learning and teaching journey**

Like many other young fellows, after I left high school I continued with tertiary education. I registered as a student teacher at teacher training college. After I graduated I ended up as a physical science teacher. I started teaching at my present secondary school in 1976. As a young and inexperienced teacher, the greatest challenge for me was to be given Standard 8, 9 and 10 classes to teach. I had to prepare carefully and cautiously, read extensively and do practical activities that I had never seen before (except in a textbook) to meet the demands of my learners.

While battling to do a reasonable job, I saw others do a totally unsatisfactory job of teaching and I recalled the high-class methods of teaching that I had seen being used at the college when I was a student teacher. If we are to be good teachers, then we must 'do it right'. There is little purpose in standing before a class of 25, 45 or 50 learners, pontificating, if no one in the class can see or hear or understand what is being said. Such a person cannot be called a teacher although he/she may call himself/herself one. It was during those difficult and challenging times that my relationship with Rhodes University began.

In 1983, Rhodes University Education Department put me through a rigorous training in science practical activities. This helped me to improve my science-content knowledge as well my teaching strategies. However, I was not exposed to doing research on my own teaching practices. Since the inception of the Science Education Project (SEP) in the Grahamstown District in 1993, I believe I have made valuable contributions in science workshops conducted by my current supervisor, who was coincidentally my former pupil. During that period I also played a key role in the development of LSMs.

To improve my content knowledge, I often sought help from lecturers at both the Physics and Chemistry Departments at Rhodes University to enhance my teaching and learning practice at school. As a result, I felt empowered and comfortable with most of the textbook content. In addition, my science results were satisfactory for the state Education Department. This, however, made me complacent, I did not think of improving my studies on teaching and learning.

Somehow the need for change and improvement crept over me. I no longer felt happy with the way things were going on in my classes. So I started reading more about my science content. In 1999, excited by having done well in Physics and Chemistry courses offered by the University of Port Elizabeth (UPE) I went to the Rhodes Education Department to tell the news to my current supervisor and my other

supervisor, the long-time lecturer at the university who was instrumental in my 'training' for the SEP programme.

After the long-time lecturer had congratulated me, she said: "Well, Reuben, go to your diary, journal or something and write down that in 2002 you will be engaged in a masters course in science education." My supervisor confirmed the statement and encouraged me to keep focused. I did not believe my ears. I remembered a comment made by a laboratory assistant at UPE who said that I will get my PhD at an age of ninety years. Anyway, I will cross at the bridge when I reach it, was my silent response.

Eventually in 2002 I was registered for the MEd class. During the same year, I had also registered for a National Professional Diploma in Education (NPDE) with the Port Elizabeth Technikon. The Department of Education had requested all teachers who held teaching certificates from the old department to do so, otherwise they would be deemed unqualified. The duration of the diploma course coincided with the duration of the M.Ed course. So, I had both hands full.

I would like to think of myself as a teacher who at all times tries to do best. At first, I thought being involved in the Master's course would have an effect on my performance at work. Rumours moved around in my school that it would take me five years to complete the course. However, the way the course has been structured takes into account that we are part-time students. The design of the core programme by Ursula and Wayne was an eye-opener. The support I received from all the people in the department was amazing. The assistance from Sean and Judy cannot be over-emphasised. Nobody was too busy to listen to the smallest detail of my questions. Thus, I later, changed the challenges to motivations, and I was determined to prove my critics wrong.

I will have not done justice to myself if I cannot comment on my experiences of designing my research proposal. During the elementary interviews about what I wanted to research, both my supervisors seemed pleased with how I had articulated my proposal, and assured me that the topic was researchable. To my surprise, the actual designing of the research proposal took me ages to get up to standard. I had to rewrite it thirteen times to meet the requirements and satisfy the university. Where was the plain sailing? The task was daunting, and I hope I will never have to design another proposal again.

At the time of writing the proposal, my supervisor had engaged me in another venture: presenting papers at conferences. This was an eye-opener and a wonderful experience for me. I felt elated when I was afforded the opportunity of sharing some ideas pertaining to teaching and learning with university academics. Also, I was given the chance to pilot-test my teaching and learning with teachers from other schools who are part of an action research team.

By the time I had to present my research proposal to the entire MEd class, I thought I had some presenting skills, so it would not be a problem. The presentation was challenging in that I had to go through and account for every step of my work. My research topic, its goals, the methodology, research techniques, and research questions were all critically analysed. After the presentation I emerged empowered and enlightened.

When I was told that my research proposal had received the go-ahead from the university, I was ecstatic. Little did I know how much more work lay ahead than I had anticipated. My supervisors advised me to conduct a pilot research study of my topic. This exercise was worthwhile and paid dividends. Eliciting prior knowledge during both the pilot study and actual study was challenging. I want to reiterate that the process is easier said than done. I do not by any means imply that the exercise is impossible, but I think that it needs careful conducting during a lesson. One should

decide whether it would be a once-off event or a continuous process that takes place in stages as the lesson progresses.

The focus group interviews revealed a lot about my communication and questioning skills. The fact that I am a stutterer and sometimes my speech is slurred had an effect on the way my learners responded to some questions. How much this handicap has on my teaching and learning practice requires some research. Also, as I am a second-language speaker, the design of the worksheets could have had a bearing on the completion of the worksheets by the learners during the practical activities.

The writing of the thesis was mind-boggling and tiring. At times I wanted to throw in the towel. The writing of the literature review and data analysis will remain indelibly in my mind. A lot of reading had to be done before I could get a better understanding of the learning theories, let alone making critical analysis of such theories. I really enjoyed collecting mountains of data, but its analysis gave me sleepless nights. I found it challenging to write a synchronised analysis from the different data-collecting tools. After a few tips from my supervisors and more reading, there was light at the end of the tunnel. Time was a problem. The request by the District office that I should help with Grade 9 continuous assessment (CASS) moderation made things worse, not to mention my own revision programme at school with my classes, especially Grade twelve.

### **7.3 Conclusion**

As teachers we provide learners with a variety of inputs during our teaching and learning practices through our activities, textbooks and other learning support materials. We then observe what learners do, what they produce and assess what they have achieved. It is important to note that inputs are not the same as outcomes. What we teach is not necessarily what learners learn?

In conclusion, the Master's course has been an empowering and worthwhile experience in that I have become a critical and reflective practitioner. The research skills acquired in this course made me view teaching and learning afresh. How I wish that all other teachers could go through the same process.

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**APPENDIX A**

**WORKSHEET ON ELECTROSTATICS**

**ACTIVITY 1**

**PURPOSE:** To investigate what happens when one insulator rubs another insulator and the objects are brought near each other.

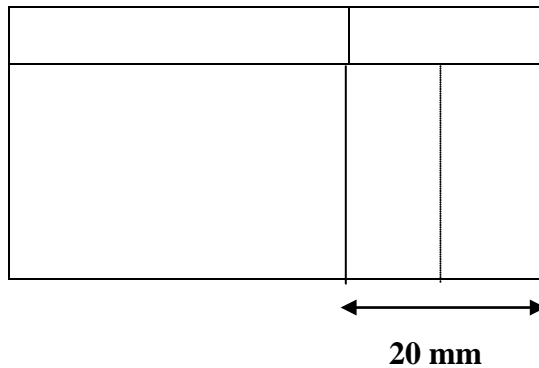
**RESOURCES:**

For this activity you will need

- A firm plastic (transparency).
- A hard plastic ruler.
- A pair of scissors.

**WHAT TO DO:**

Cut a 20 mm strip from the transparency from its breadth as shown below.



Now cut this strip in the middle (10mm) But DO NOT cut the shaded part.

1. PREDICT what will happen when you rub the strips with the inside of your jacket, your jersey, your tie, the outside of your jacket, or your hair etc.

PREDICTION -----  
-----

EXPLAIN YOUR PREDICTION-----  
-----  
-----

Now rub the plastic strips using any of the above-mentioned objects. Rub about 3 times.

WHAT DO YOU OBSERVE? -----

EXPLAIN YOUR OBSERVATION: -----

-----

PREDICT what will happen if you bring the plastic ruler or your finger close to the rubbed plastic strips

PREDICTION -----

EXPLAIN YOUR PREDICTION-----

-----

2. Now RUB the plastic ruler using any of the above-mentioned objects. RUB about 3 times. Bring the rubbed ruler close to ONE of the strips.

WHAT DO YOU OBSERVE? -----

EXPLAIN YOUR OBSERVATION-----

-----

3. Let us go back to the LIGHTNING STORM picture. What charges did we see in the picture?

-----

-----

4. Do you think that the SAME CHARGES are found in other matter? -----

EXPLAIN YOUR ANSWER-----

-----

5. CHALLENGES:

What charge do the plastic strips have after being rubbed using the different types above-mentioned objects? EXPLAIN-----

-----

-----

What charge do the objects have after being used to rub the plastic strips?

EXPLAIN -----

-----

-----

EXPLAIN why a CHARGED object and a NEUTRAL object attract?

-----  
-----  
-----

6. Let us look at the TRIBOELECTRIC SERIES below.  
Scientists have ranked materials in the order of their ability to hold or give up electrons. This ranking is called the triboelectric series

Your hands
Glass
Your hair
Nylon
Wool
Fur
Silk
Paper
Cotton
Hard rubber
Polyester
Polyvinylchloride plastic

NOTE: **The one higher up in the list should give up electrons and become positively charged.**

CONSOLIDATION:

8. Can you write a SUMMARY of your INVESTIGATION? Begin this way:  
When PLASTIC is rubbed with FINGERS or SILK, the plastic gets a  
----- charge  
When PLASTIC is rubbed with a JERSEY or HAIR , the plastic gets a

----- charge  
Charges of the SAME KIND-----  
Charges of DIFFERENT KINDS-----  
A CHARGED object can -----a NEUTRAL object.

9. From the SUMMARY of your INVESTIGATION we can NOTE that:

**Note:** There is a FORCE between CHARGES.

There is also a FORCE between CHARGES and NEUTRAL objects.

## WORKSHEET ON THE FORCE BETWEEN CHARGES.

### ACTIVITY 2.

**PURPOSE:** 2 (a) To investigate the effect on the amount of FORCE when the amount of CHARGE is increased (what happens to the force when we increase the charges)?

2 (b) To investigate what a CHANGE in the DISTANCE between A CHARGED object does on the FORCE.

### RESOURCES:

For this activity you will need

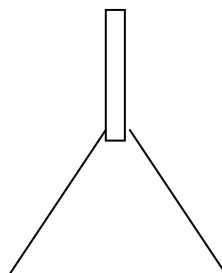
Two plastic strips.

A ruler.

### WHAT TO DO:

Rub the two strips at the same time TWICE with silk or your fingers.

ESTIMATE the distance between the bottom ends of the strips-----



Repeat the rubbing of the strips **THREE TIMES** and then **FOUR TIMES**, record your estimations each time in the table below.

NUMBER OF RUBBINGS	AMOUNT OF CHARGE (small or big or bigger)	WHAT HAPPENS TO THE FORCE

When you increase the number of rubbings what are you doing to the amount of charge?

-----

What can you say about the **SIZE OF THE FORCE** when the amount of **CHARGE CHANGES**?

**EXPLAIN YOUR ANSWER CLEARLY**-----

-----

Now for the next investigation -**RUB ONLY ONE** strip **THREE TIMES** to give it a charge. RUB a plastic ruler to give it a charge. Slowly bring the ruler to the strip. Start from a distance of about 120mm from the strip and record your estimations each time.

Record your findings in the following table:

AMOUNT OF CHARGE	DISTANCE FROM STRIP	WHAT HAPPENS TO THE FORCE
	120 mm	

What can you deduce about the FORCE between CHARGES as the distance between the charges CHANGES?

EXPLAIN YOUR ANSWER CLEARLY-----

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Now, use the information you gathered in Activities 2(a) and 2(b) and write in your OWN words your deductions.

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