

UNIVERSITY OF KWAZULU-NATAL

**THE USE OF INTERACTIVE WHITEBOARDS (IWBs)
IN SCIENCE INSTRUCTION AT HIGH SCHOOLS:
A CASE STUDY**

MOIPUSI MOTEBANG

MED

JUNE, 2009

**THE USE OF INTERACTIVE WHITEBOARDS (IWBs)
IN SCIENCE INSTRUCTION AT HIGH SCHOOLS:
A CASE STUDY**

BY

MOIPUSI MOTEBANG

206520916

PTC (NTTC), ACP (COLLEGE OF PRECEPTORS), B.ED (NUL), B.ED HONS (UKZN).

Submitted in partial fulfillment of the requirements

For the degree of

Masters in Education (Educational Technology)

At the Faculty of Education

In the School of Education Studies

University of KwaZulu – Natal

Edgewood Campus

Durban

Supervisors: Mr. S.B. Khoza

Dr. D. Govender

June, 2009

ABSTRACT

The increasing installation of the SMART Boards (electronic interactive whiteboards - IWBs) in education is an issue that cannot be ignored. South Africa is not an exception in this issue. The IWBs are gaining popularity amongst schools and educators in South Africa. With the growing number of users of IWBs in South Africa, this modern technology might have brought challenges and new opportunities to education and instructional methods at all educational levels.

The purpose of the study was to investigate the use of the IWBs in the teaching and learning science in high schools. The selected schools use modern technologies that enhance teaching and learning such as the IWBs. This study aimed at developing an understanding of educators' experiences on the benefits and challenges posed by utilizing the IWBs in their current practice with a view to drawing implications for possible recommendations for this type of technology. The study adopted a qualitative research design and followed case study methodology. It employed qualitative data collection techniques such as semi-structured individual and focus group interviews and classroom observations with purposively selected science educators in two public high schools in the Durban metropolis. The participants were six educators and eight learners from the two schools. It also followed a guided analysis based on the principles of both Connectivism and Engagement theories that informed the study.

The findings revealed both benefits and challenges on educators. The most prominent benefits which educators recognized included multimedia features of the IWBs; their capabilities in learning; and their support for different learning styles. Alongside these benefits, educators also perceived challenges which involved low level of educators' ICT skills related to insufficient professional development and training, and lack of planning. Generally; the study revealed that the IWBs can be generically beneficial tools provided some major problems are rectified. Recommendations relating to these findings are also provided, with an emphasis on technology planning and professional development as prerequisites to proper implementation of the IWBs in schools.

ACKNOWLEDGEMENTS

First, I would like to thank the Almighty God, my creator, saviour and guide for recognizing the value of allowing me the opportunity to complete my degree. Above all, he carried me when I needed help, provided sustenance when I was desperately in need, and cared for me when I was sick. I can simply never do enough to thank him!

My gratitude extends to the Government of Lesotho for the financial support it granted me. This would not have been possible without such assistance.

I would like to extend my utmost gratitude and sincere appreciation and thanks to my supervisor Mr. Bheki Khoza who tirelessly guided and monitored my progress throughout this study. His support, patience, encouragement and understanding with many of my shortcomings were overwhelming especially during the hard times. I also extend my thanks to Dr. D. Govender for his co-supervision. His wise and constructive remarks have been highly appreciated.

I would also want to thank Dr. E.M. Mgqwashu for his valuable and constructive editing contributions to my work. God Bless you!

I would also like to thank the schools and educators for their participation in this study. Without them this was impossible.

To my parents, Austin & Julia Nyenye, your example as educators enabled me to come this far.

The Dream Team 2007: 'Malerato Ncheke, 'Mabohlokoa Maoba, Pauline Phahamane, Paul Mafata, Peter Sodje, Buhle Chili, Julian Draai, I say to you, the long journey is done, the track to the end has come, and there up yonder we shall reap what we sowed. Let the good team spirit sustain us throughout all our endeavours. Your contribution to this work is highly appreciated. I truly have enjoyed every minute with you.

DEDICATION

To my daughters;

Mpho, Liepollo, Moroesi.

My son, Omphile

I wish this could be an inspiration and motivation to you.

Thank you for your love, patience and support during the long years away from you.

Auntie Lebo, words fail to explain my feelings, only God knows how I feel about you. You had been and I believe you shall continue to be the mother of my children as you devotedly did while I was away from them. You provided them with all the comfort a mother would render her children especially when they had to be on their own without a mother to lean against when tides were tough, and without a father for support, safety and security. Life away from them had been a torture of my soul. “Kea leboha Mofokeng, Molimo o u ruise molemo o sa feleng.” Many thanks.

‘Mammope and Ausi Mapii, thank you for your encouraging words. You never got tired to encourage me and also your care about my life. Ausi Mapii, thank you for your commitment which afforded me a bursary. Thanks are due to all who supported me in all sorts of ways. Finally, I would also wish to thank all those who created hard times and nasty moments for me while studying. Your challenges made me strong. When it was tough, it was then that I had to be myself.

DECLARATION

I, Moipusi Motebang, declare that this dissertation titled “The use of the interactive whiteboards (IWBs) in science instruction at high schools: a case study” is my own original work, and where the work of other scholars / researchers has been used, they have been duly acknowledged. I declare that this thesis has not been previously submitted for any degree in any university.

RESEARCHER

SUPERVISOR

DATE

2009

TABLE OF CONTENTS

| CONTENTS | PAGE NO |
|---|-----------|
| CHAPTER ONE – INTRODUCTION | |
| 1.1 Introduction | 1 |
| 1.2 Background | 1 |
| 1.2.1 Policy Initiatives in South Africa | 2 |
| 1.3 Motivation of the study | 3 |
| 1.4 Statement of the problem | 4 |
| 1.5 Importance of the study | 5 |
| 1.6 The Aims of the study | 5 |
| 1.7 Key research questions | 6 |
| 1.8 Research Design and Methodology | 6 |
| 1.8.1 Research Design | 6 |
| 1.8.2 Research Methodology | 7 |
| 1.8.2.1 Data Collection | 7 |
| 1.8.2.2 Data Analysis | 8 |
| 1.9 Scope of the study | 8 |
| 1.10 Context of the study | 9 |
| 1.11 Explanation of basic terminology | 10 |
| 1.12 Limitations of the study | 10 |
| 1.13 Structure and direction of the study | 11 |
| 1.14 Conclusion | 12 |
| CHAPTER TWO - LITERATURE REVIEW | |
| 2.1 Introduction | 13 |
| 2.2 Models of the electronic whiteboards (IWBs) and their uses | 15 |
| 2.3 Review of related literature | 15 |
| 2.3.1 Technological developments that affect education | 15 |
| 2.4 Revolution of the IWBs | 17 |
| 2.5 Review of existing scholarships | 21 |
| 2.5.1 Effectiveness of the IWBs | 21 |
| 2.5.2 Technical support / ICT skills | 25 |
| 2.5.3 Professional Development / Training | 25 |
| 2.5.4 Pedagogical Change | 28 |
| 2.5.5 Challenges on the use of IWBs | 34 |
| 2.5.5.1 Cost and maintenance requirements | 37 |
| 2.5.5.2 Technical problems | 38 |
| 2.5.5.3 Lack of Confidence | 38 |
| 2.5.6 Key points relating to the literature | 39 |
| 2.6 Implications of findings from the literature | 41 |
| 2.7 Recommendations from the literature | 42 |
| 2.8 Conclusion | 42 |

CHAPTER THREE - THEORETICAL FRAMEWORK

| | | |
|--------------|--|-----------|
| 3.1 | Introduction | 44 |
| 3.2 | Background | 44 |
| 3.3 | Research Paradigm | 46 |
| 3.3.1 | Interpretive Paradigm | 46 |
| 3.3.2 | Engagement Theory | 47 |
| 3.3.3 | Connectivism Theory | 50 |
| 3.3.4 | Model of the theoretical / conceptual framework | 53 |
| 3.3.5 | Conclusion | 58 |

CHAPTER FOUR – RESEARCH DESIGN AND METHODOLOGY

| | | |
|----------------|--|-----------|
| 4.1 | Introduction | 59 |
| 4.2 | Research design versus methodology | 59 |
| 4.2.1 | Research design | 60 |
| 4.2.2 | Qualitative case study methodology | 60 |
| 4.3 | Qualitative approach | 63 |
| 4.4 | Multiple methods | 66 |
| 4.5 | Research setting and sampling | 67 |
| 4.5.1 | The context | 68 |
| 4.5.2 | The participants | 69 |
| 4.5.2.1 | ‘Mamathe High School participants | 69 |
| 4.5.2.2 | Bereng High School participants | 70 |
| 4.6 | Data collection methods | 70 |
| 4.6.1 | Interviews | 71 |
| 4.6.1.1 | Advantages of conducting interviews | 71 |
| 4.6.1.2 | Disadvantages of conducting interviews | 71 |
| 4.7 | Focus Groups | 71 |
| 4.7.1 | Advantages of Focus Groups | 72 |
| 4.7.2 | Disadvantages of Focus Groups | 72 |
| 4.8 | Semi-structured interviews | 73 |
| 4.8.1 | Advantages of Semi-structured interviews | 73 |
| 4.8.2 | Disadvantages of Semi-structured interviews | 73 |
| 4.9 | The process of collecting data using interviews | 74 |
| 4.10 | Classroom Observations | 76 |
| 4.10.1 | Advantages of Observations | 76 |
| 4.11 | Sample lessons observed | 77 |
| 4.12 | Questionnaires | 81 |
| 4.13 | Piloting | 81 |
| 4.14 | Data analysis | 82 |
| 4.15 | Credibility / Trustworthiness / Crystallization | 83 |
| 4.16 | Ethical consideration | 85 |
| 4.17 | Conclusion | 85 |

CHAPTER FIVE – DATA ANALYSIS AND INTERPRETATION

| | | |
|------------|----------------------------------|-----------|
| 5.1 | Introduction | 86 |
| 5.2 | Qualitative Data Analysis | 87 |

| | | |
|------------------|--|------------|
| 5.3 | Findings | 88 |
| 5.3.1 | How do educators utilize the IWBs in providing authentic learning activities / environments in science instruction in two public high schools in the Durban metropolis? | 89 |
| 5.3.1.1 | Active collaboration | 89 |
| 5.3.1.2 | Working in teams | 90 |
| 5.3.1.3 | Learning ecology | 91 |
| 5.3.1.4 | Address diverse learners' needs | 93 |
| 5.3.1.5 | Authentic learning activities | 94 |
| 5.3.1.6 | Project-based activities | 96 |
| 5.3.1.7 | Networking or forming connections | 97 |
| 5.3.2 | Summary of findings from observations | 98 |
| 5.3.3 | What challenges face educators in utilizing the IWBs in science instruction? | 98 |
| 5.3.3.1 | Interview responses | 98 |
| 5.3.3.2 | Conclusion | 103 |
| 5.4 | Interpretation and discussion of the findings | 104 |
| 5.4.1 | Table of summary of the major findings | 105 |
| 5.4.2 | Discussion of findings | 105 |
| 5.4.2.1 | Theme 1: Effectiveness of the IWBs | 106 |
| 5.4.2.1.1 | Multimedia features | 106 |
| 5.4.2.1.2 | Display of information | 107 |
| 5.4.2.1.3 | Support different learning styles | 107 |
| 5.4.2.1.4 | Ability to save notes | 108 |
| 5.4.2.2 | Theme 2: Low level of interactive approaches in the delivery of content | 108 |
| 5.4.2.2.1 | Active collaboration | 108 |
| 5.4.2.2.2 | Working in teams | 110 |
| 5.4.2.3 | Theme 3: Capabilities in learning | 111 |
| 5.4.2.3.1 | Networking or forming connections or network creation | 111 |
| 5.4.2.3.2 | Authentic learning activities | 112 |
| 5.4.2.3.3 | Project-based activities | 113 |
| 5.4.2.4 | Theme 4: Exposure to information sources that promote knowledge construction | 113 |
| 5.4.2.4.1 | Authentic learning ecology | 113 |
| 5.4.2.5 | Theme 5: Lack of planning | 115 |
| 5.4.2.5.1 | Technology planning | 115 |
| 5.4.2.5.2 | Cost | 116 |
| 5.4.2.5.3 | Technical support | 117 |
| 5.4.2.5.4 | Lack of communication | 119 |
| 5.4.2.6 | Theme 6: Insufficient professional development and training | 120 |
| 5.4.2.6.1 | Educators' training and development | 120 |
| 5.4.2.6.2 | Pedagogical shift / challenge | 123 |
| 5.4.2.6.3 | Low level of educators' ICT skills and knowledge | 124 |
| 5.4.3 | Key findings of the study | 126 |
| 5.4.4 | Conclusion | 127 |

CHAPTER SIX – RECOMMENDATIONS AND CONCLUSION

| | | |
|----------------|---|------------|
| 6.1 | Introduction | 129 |
| 6.2 | Methodology | 129 |
| 6.3 | Significance of the study | 130 |
| 6.4 | Summary of major findings of the study | 131 |
| 6.4.1 | Effectiveness of the IWBs | 131 |
| 6.4.2 | Low level of interactive approaches in the delivery of content | 131 |
| 6.4.3 | Capabilities in learning | 132 |
| 6.4.4 | Exposure to information source that promote knowledge construction | 132 |
| 6.4.5 | Lack of planning | 133 |
| 6.4.6 | Insufficient professional development and training | 133 |
| 6.5 | Recommendations | 134 |
| 6.5.1 | Need for technology planning | 134 |
| 6.5.1.1 | Need for collaborative efforts | 134 |
| 6.5.1.2 | Need for consultation | 134 |
| 6.6 | Need for training / professional development | 135 |
| 6.6.1 | Need for pedagogical shift | 135 |
| 6.6.1.1 | Awareness of pedagogical principles | 136 |
| 6.6.2 | Need for reflective practice | 136 |
| 6.7 | Need for further research | 136 |
| 6.8 | Conclusion | 137 |

| | |
|-------------------|------------|
| References | 141 |
|-------------------|------------|

Appendices

LIST OF FIGURES

| | | Page |
|-----------------------|--|-------------|
| Figure 1 | Interactive whiteboard system | 13 |
| Figure 2 | Revolution of the IWB | 17 |
| Figure 5.1 | Interactive Periodic table | 91 |
| Figure 5.2 | Potential energy diagram | 92 |
| Figure 5.3 (a) | Energy diagram | 93 |
| Figure 5.3 (b) | Static graphic | 93 |
| Figure 5.4 | Model from Plato Science Simulations | 94 |
| Figure 5.5 | Simulation of gas kinetics | 95 |
| Figure 5.6 | Submicroscopic levels in solids, liquids, and gases | 96 |

LIST OF TABLES

| Table | | Page |
|----------------|--|-------------|
| Table 1 | Summary of findings from observations | 98 |
| Table 2 | Summary of major findings | 105 |

LIST OF APPENDICES

| | |
|----------------------|---|
| Appendix I | Focus group interview schedule |
| Appendix II | Observation schedule |
| Appendix III | Semi-structured individual interview schedule |
| Appendix IV | Open-ended questionnaire for learners |
| Appendix V | Application letter to schools' principals to use the Schools as research sites |
| Appendix VI | Request for parents / guardians consent for children participation |
| Appendix VII | Request for educators' consent to participate in the study |
| Appendix VIII | Letter of the editor |

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The purpose of educational technology is to improve the efficiency of education by improving the quality of teaching, of educational administration, and of educational research (Thomas & Kobayashi, 1987). It is within this context that educators face the constant challenge of understanding the nature of technologies, their potential, strengths and weaknesses (Thomas & Kobayashi, 1987). Latest advances in educational technology, furthermore, seem to supersede earlier educational technologies (Venkataiah, 1996). A few examples of technologies that have combined to make the communication revolution and information age a challenging era for educators are, among others, computers, electronic mail, interactive video, laser discs, satellites, and teleconferencing (Venkataiah, 1996).

Interactive electronic whiteboards (IWBs) programmed to be interactive with additional technologies such as the computer and the projector to facilitate “inter technological communication” (Venkataiah, 1996, p.14). Furthermore, the boards provide spontaneous access on an individualized basis and / or a group of learners to meet the needs of a diverse population because they allow learners to express their “curiosity and demonstrate creativity” (Venkataiah, 1996, p.14). They also allow individuals to work in a risk-free environment, which is necessary to avoid embarrassment. For instance, in the teaching of science; multimedia can help avoid hazards and students can safely investigate radioactive materials, explosive chemicals or harmful micro-organisms when they are working in the “virtual world of multimedia” (Sang & Frost, 2005, p.61).

1.2 BACKGROUND

Given the effects of inventive computer technology, the face of education is changing rapidly (Anton, 2006). Under these circumstances, the nature of learning and the acquisition of knowledge are changing due to the transformation in the tools of teaching and learning. The new technology is providing the tools which best facilitate different types of learning such as collaborative learning, project-based and authentic learning

(Anton, 2006). It is for the reason that the traditional classroom structure is changing for both learners and educators.

Technology in the classroom has brought considerable changes in the teaching and learning process (Anton, 2006). The electronic whiteboards (IWBs) in the present days have become one of the commonly mentioned technologies in education (Keller, 2007). Interactive whiteboards make it easier to engage the entire class in a technology-based lesson (Knode, 2006). Knode (2006) refers to the electronic whiteboard as a significant breakthrough to learning. However, each technology is considered in the light of its advantages, limitations and a range of applications. No technology is good, bad or superior to the other (Clark, 1984). For Clark (1984) the superiority of the technology lies in the way it is used in the classroom.

The gradual spread of IWBs in education, both nationally and internationally is in fact hard to ignore (Wood & Ashfield, 2008). This is supported by Diem (1999) who argues that over the past several years a great deal of progress has been made toward integrating technology and education and that we are “living in a time of instructional revolution where the changing nature of information and new techniques of presenting it to learners enable us to change teaching environments” (p.2). This is partly because they provide a very visually stimulating way to encourage student learning, with the ability to highlight key elements during animations and videos and to save key frames to use later. If the potential of IWB as a learning resource is great, so are the challenges it poses.

1.2.1 POLICY INITIATIVES IN SOUTH AFRICA

Pandor (2004) asserts that Information and Communication Technology has opened up new learning opportunities and provided access to educational resources well beyond those traditionally available. This means the integration of computers in teaching and learning could make this possible. In August 2004, the South African Government set out its response to a new information and communication technology environment in education. This seemed to be a stepping-stone for the government to transform education through ICTs. Nevertheless, the policy does not stipulate clearly as to what technological resources it would identify for its schools in order of their priority except for the

provision of computers in e-schools. Instead, it puts the initiative it is to embark on. To substantiate this, 13% of the schools in South Africa have one or more computers, and out of these schools, only 2% are highly resources (Lundall & Howell, 2000). The Gauteng Department of Education has launched another initiative recently. The initiative focuses on the introduction of computers into schools in the province. About 600 000 computers will be delivered into schools over the coming years (Lundall & Howell, 2000). On the similar vein, Howie, Muller and Paterson (2005) signify that only the Gauteng and the Western Cape provinces have made the most progress with regard to the introduction of ICTs in education. This move indicates the government's commitment to transforming education. It is also an indication that the government of South Africa is aware of the challenge it faces of providing for schools the modern technologies that would enhance teaching and learning such as the interactive whiteboards. This would require a significant investment that would cater for on going costs to provide access to technology, including teacher development (capacity and skills building), pedagogical and technical support.

1.3 MOTIVATION OF THE STUDY

The interactive whiteboard is a relatively innovation that is gaining popularity amongst schools and educators in South Africa. In KwaZulu-Natal, for example, Kearsney College in Bothas Hills has installed sixteen interactive whiteboards, Kingsway High School has five, Glenwood High School has five, and a numerous number of high schools and colleges have at most two IWBs. In Johannesburg, Pridwin Preparatory School for boys has installed 14, and Atlantis Secondary school in the Western Cape has five interactive whiteboards (SMART Technologies, Inc 2007). This indicates an increase in the installation of this teaching tool in schools. Notwithstanding the growing number of users of interactive whiteboard in South Africa, this modern technology has brought challenges and new opportunities to education and instruction methods at all educational levels (Kramarski & Gutman, 2006). Various books, magazines, journals and web articles report on the use of the SMART Board in teaching and learning (Bell, 1998, 2002; Weimer, 2001; Gage, 2005; O'Leary, 2006; Hartley, 2007). It is within this context that various perceptions internationally are raised on the use of the interactive whiteboards (Bell, 2002). In addition, a policy on transforming teaching and learning through

information and communications technology in South African schools has been developed (Department of Education and Training, 2004).

The researcher's motivation has to do with the desire to extend an understanding of ways in which educators and learners use the IWB as a learning resource. Since the IWB is a recent innovation and educators are still not familiar with the technology, the assumption that educators benefit from using the IWBs and meet challenges in utilizing this technological resource is further explored by describing the experiences of educators from Bereng High school and Mamathe High school in the Durban Metropolis. The names of the schools used above are fictitious for the purpose of anonymity and non-traceability, and will be used through out the study.

1.4 STATEMENT OF THE PROBLEM

Chalkboards have been, and are still, by far the most widely used medium for presentation of lectures at different levels of education (Glover & Miller, 2001). The chalkboard allows educators to communicate almost all or part of the content materials in natural handwriting. With the advancement of technology, Chong and Sakauchi (2000) observed that when presentations of slides are available, from either overhead projectors or PowerPoint, the use of the chalkboard reduces during the course of the lecture. Furthermore, when it comes to facilitating questions and answers, Chong and Sakauchi (2000) assert that the chalkboard is used again to demonstrate facts, confirm equations, and diagrammatically illustrate flowcharts.

Both locally and internationally learning institutions are approving the integration of the electronic whiteboards into their classrooms and South Africa is not an exception in this issue (Mohammed & Ottmann, 2005). There are also reports in the emerging body of literature identifying that both vendors of education and educators find the electronic whiteboards relatively easy and compelling to use (Becta, 2003; Glover & Miller, 2001). However, Mohammed and Ottmann (2005) caution that becoming confident in the use of electronic whiteboard requires effort and commitment in terms of both training and independent exploration. Hence, educators' benefits and challenges on the use of the

board needed investigation in a holistic and integrated manner to obtain a thorough understanding within the South African context.

1.5 THE IMPORTANCE OF THE STUDY

This modern technology has brought challenges and new opportunities to education and instruction methods at all educational levels (Kramarski & Gutman, 2006). Many schools today strive to integrate appropriate technologies into classrooms such as the interactive whiteboard (IWB), especially in South Africa. Despite the cost in hardware, software and supporting infrastructure, very little is known about its role and practice.

According to Partridge (2004), the little available research on the Internet comes in the form of reports on the qualities and virtues of teachers and students who are utilizing the IWB. The focus in these discussions is on the introduction, integration and utility of the IWB technology resource. Currently, there is very little literature, particularly South African, on the use of IWB in teaching and learning science in particular. This study may thus contribute to the limited literature on the use of the new technology device, in particular South Africa. The study hopes also to contribute to the literature concerning the pre-service and in-service preparation of educators to use IWB in teaching science in South Africa. Most of the research available on the Internet comes from developed countries such as the United Kingdom, the United States of America, and Australia (Partridge, 2004). The study may serve as a practical guide and a resource for guiding future instructional technology practices in educational institutions in South Africa. Most importantly, the study aims to develop recommendations for effective implementation of the interactive whiteboards in educational institutions.

1.6 THE AIMS OF THE STUDY

The main purpose of this study was to investigate both benefits and challenges presented by the use of the IWB, with the goal to understand how educators and learners cope with such challenges. The study seeks to understand further ways in which educators utilize the IWB in terms of student learning and teacher practice. In conducting this study, the researcher ascertained the nature of practice in utilizing the IWB in teaching Science in public high schools, explored the effects of using the IWB in Science classrooms, and

provided a view of the challenges facing educators. The results from this study could serve as a guide for the researcher, educators, policy makers and other interested parties to:

- ✓ give valuable insight into the role of IWBs for different teaching styles that can promote the quality of teaching and learning;
- ✓ provide understanding on how technological resources can enhance teaching and learning;
- ✓ serve as a practical resource to guiding future instructional technology practices in educational institutions; and
- ✓ inform the decisions regarding the educational authorities in South Africa and in developing countries like Lesotho on ongoing and future commitment to the installation, and support of classroom – based technologies such as the IWB.

1.7 KEY RESEARCH QUESTIONS

This study investigated the use of the IWBs in the teaching of science in the public high schools in Durban metropolis, South Africa. The study focused on understanding both benefits and challenges as reiterated by the educators in their practice in using the IWBs in teaching science. The case study schools had different brands. The concern was not on the different types of IWBs the schools used, but interested on the ways educators use the boards since these are very new in the education system in South Africa. In order to explore the aims of this study, the researcher addressed the following research questions:

- (1). How do science educators utilize the IWB in providing authentic learning activities / environments for Science teaching and learning in public high schools?
- (2). What challenges do science educators face in utilizing the IWB in teaching and learning Science in public high schools in Durban metropolis?

1.8 RESEARCH DESIGN AND METHODOLOGY

1.8.1 RESEARCH DESIGN

This study adopted a qualitative interpretive framework in order to understand the challenges posed by the use of the IWBs in the teaching of science. The qualitative interpretive research design is open-ended, with flexible procedures and the scope

(Mouton & Marais, 1990). In this manner, the researcher was able to obtain a deeper understanding of the use of the IWBs in teaching science. The research was conducted in the two public secondary schools in the Durban metropolis. The researcher used the qualitative approach in this research to study things in their natural settings. This means the use of the IWBs in teaching science in the classroom situation where educators were able to interpret their use of the IWBs in teaching science in terms of their experiences, perceptions, and attitude (Denzin & Lincoln, 1994). The qualitative approach allowed for the use of a variety of methods of data collection so that believable data are obtained in order to acquire enhanced results.

1.8.2 RESEARCH METHODOLOGY

In the context of the purposes of the study, a case study methodology was adopted. This type of study is an in-depth exploration of a 'bounded system' (bounded by time and place), a single, or multiple cases over a period of time (Creswell, 1998, p.61). Multiple sources of data were used in the design to bring out the details from the viewpoint of the educators (Stake, 1995). Furthermore, the case study approach appeared relevant for an individual researcher because it provided the researcher with the opportunity to research a specific aspect of a phenomenon in some depth within a limited time scale (Bell, 1994). Furthermore, the case study methodology allowed the researcher to plan for the case study, prepare for the collection of data, to analyze case study evidence, and develop conclusions and recommendations (Yin, 1994; Stake, 1995). Another advantage of case study is that it is based on reality even though it was somehow complicated to organize this type of study.

1.8.2.1 DATA COLLECTION

A spectrum of techniques such as observation, interviews and open-ended questionnaires were used to collect the required data that responded to the research questions. Semi-structured individual interviews and observations were used to capture all the relevant details collected by these instruments. An interview schedule for individual educators (appendix III) was used together with focus group interview schedule (appendix I), observation schedule (appendix II) and open-ended questionnaire for learners (appendix IV). The identified data collection methods afforded the researcher the opportunity to

collect the data that enabled the presentation of solid descriptive data to ensure that the researcher leads the reader to understand how educators use the IWBs in the teaching of science in some schools in South Africa.

1.8.2.2 DATA ANALYSIS

The data collected from the interviews and field notes were transcribed. The data were then analyzed in order to identify and discuss themes and categories. The researcher read the transcripts several times. Following this, notes of themes that emerged were made. Similar themes were grouped together and, at the same time, categories were identified, resulting in the main themes. Each theme and the categories that formed it were accompanied and supported by some verbatim quotes. In qualitative research, the issue of crystallization is vital. Crystallization refers to the truth and accuracy of findings and interpretation (Creswell, 2005). For this research, Guba's model, as propounded by Krefting (1991) was considered. The aspects of crystallization / trustworthiness identified were credibility / truth-value, applicability, consistency and neutrality.

1.9 SCOPE OF THE STUDY

The study investigates the use of the interactive electronic whiteboards in teaching science in some public secondary schools. Using ethnographic methods, a case study of two public high schools was conducted. Educators and learners were identified as participants. The researcher selected six educators and ten learners. However, only four learners contributed their views in the form of filling in a simple questionnaire. These participants have been sampled purposively because of their typicality (Cohen, Manion & Morrison, 2007). The selection was based on their experiences, attitudes, perspectives in using the IWB in their teaching and learning science. Field data was produced from audiotaped interviews, observations and interactions and simple questionnaires to determine and understand how educators utilize the IWB technology.

The two public high schools were at different stages of implementation and usage of the IWBs. Mamathe High school, for example, have used the IWB for three years, though they use two different brands, while Bereng High school had just installed them and have not been used due to some technical factors. The researcher thus considered their use of

the IWBs with these aspects in mind. Additionally, the study does not investigate the pedagogy used in the teaching of science per se, but generally looks at factors that influence the use of the IWBs in teaching science both, positively and negatively with the assumptions that this technology is quite new and educators are not so familiar with using it. Therefore, the study intends to describe what actually took place at the two public high schools at that particular moment of the study.

1.10 CONTEXT OF THE STUDY

The study focused on the use of the IWBs in the teaching and learning of science in public high schools in the Durban metropolis. It is therefore important to give the profile of the schools selected for this study since they constitute the research context. The area of study is the Durban Metropolis, Bereng High School and Mamathe High School. The former school opened for the first time in 1953. It is an English-medium, co-educational high school situated 2 km north of the Amanzimtoti business centre and along the shores of the Indian Ocean. It has modern, well-equipped buildings and extensive playing fields. It caters for more than a thousand learners and more than fifty members of the staff to include auxiliary members, both males and females of different nationalities. It has a reputation for sound scholastic achievement and an enviable record in the sporting and cultural fields. As for the time of the research, the school had installed five interactive electronic whiteboards to be used in Science and Mathematics instruction.

The latter is a multi-cultural high school situated in Pinetown. It was founded in 1955. At the time of the research, the school had two boards, namely: the Promethean ACTIVBoard and e-Beam Board. They are both utilized in the teaching of mathematics and science. The school accommodates more than a thousand learners from all places around the Pinetown district, and a multicultural staff of approximately forty members. It has a well-equipped computerized Media Centre, which promotes self-studies and independent learning. The school follows the new curriculum introduced by the Department of Education and Training. It offers the learners education in two phases; namely: the General Education Training (GET) and the Further Education Training (FET). It offers a variety of activities such as sporting activities - volleyball, indoor hockey, basketball, badminton, netball, over and above academically related activities.

This affords the school a good reputation in both academically related activities and sports.

1.11 EXPLANATION OF BASIC TERMINOLOGY

Interactive electronic whiteboard (IWB) – refers to different brands of the interactive electronic whiteboards, for example, SMART Boards, Promethian ACTIVBoards, e-Beam, Mimio (O’Leary, 2006; Gage, 2005; Bell, 2002).

Interactive learning environments – Contexts that promote social interaction, peer collaboration, discussions, active participation, connections between learners, learners and educators, learners and resources that would help in the construction of knowledge. Furthermore, also these contexts cater for diverse learners with different backgrounds and learning styles (Chilcoat, 1989; Kearsley & Schneiderman, 1999; Beauchamp and Parkinson (2005).

Multimedia – combination of graphics, video, sound, clips, simulations, models, etc (Mayer, 2001, 2005; Leask & Pachler, 2005).

Information and Communications Technology (ICT) – the hardware and software applications that can make teaching and learning effective (Percival, Ellington & Race, 1984; Sang & Frost, 2005).

Software – Applications such as file management, word-processing, database, spreadsheet, educational materials, graphics packages, PowerPoint, Clips, Internet (Percival, Ellington & Race, 1984; Collis, 1996; Kearsley, 2000).

Hardware – computers, projectors, IWBs, laptops, mouse, pens (Percival, Ellington & Race 1984).

Pedagogy – (underware) methods, techniques, principles of teaching science, and theories of learning (Percival, Ellington & Race 1984).

N-Geners – These are learners who live in this digital era that is influenced by technology, with the ability to use electronic networks to access resources and to communicate with others (Tapscott, 1998).

1.12 LIMITATIONS OF THE STUDY

This study had some limitations that need to be acknowledged. Firstly, the use of IWBs in education in South Africa is still new and educators appear to be not familiar with the

use of this technology. A second limitation is that the literature on the use of IWBs in science instruction is so limited that in-depth analysis was not possible. The researcher had to adopt some information such as methodologies and findings used in other subjects especially mathematics. A third limitation relates to the sample size. The sample population was restricted because not all schools use the IWBs, and schools which have IWBs in Durban refused to grant permission to use them as research sites. The sample size limited the scope of the study. The researcher conducted limited interviews and observations with the participants because of some problems especially with one school where IWBs were not used at the time of the research. A fourth limitation was time factor. The researcher was able to carry out the study after a long struggle to get schools to conduct this research. As a result, the time in which the study was undertaken was limited.

1.13 STRUCTURE AND DIRECTION OF THE STUDY

This research report is divided into six chapters: The first chapter is an introductory part of the study. It highlights the background of the study briefly noting some important characteristics of the revolving technology in education. It outlines the policy initiatives of South Africa; the motivation of the study, the statement of the problem, the importance of the study, the aims of the study, the context of the study, the scope of the study, the key research questions, the research design and methodology, the limitations of the study, the structure and direction of the study, and conclusion.

Chapter two reviews the related literature. It highlights and defines the IWB technology system; the types of the IWBs; the review of pertinent literature on the use of the IWBs in science instruction from developed and developing countries, both national and international; major findings from the literature on IWBs, implications from the literature; recommendations from the literature, and conclusion.

Chapter three outlines the theoretical framework that guided the study. It presents the research paradigm, which is interpretive; the background of the theories of learning; the theories of learning - connectivism and engagement. The theories propose how learning should take place in the digital age. The two theories were chosen for their relevance in the teaching of science and learning in the digital age. It discusses the conceptual

framework, and its model that include active collaboration; working in teams; learning ecology; authentic learning activities, project-based activities; addressing diverse learners' needs and forming connection or networking, and conclusion.

Chapter four discusses the research design and methodology used for data elicitation. This is a qualitative case study. It discussed the selected research instruments: namely semi-structured individual and focus group interviews, observations and questionnaires, highlighting the advantages and disadvantages, criteria of selection of participants, context; measures of trustworthiness of the data, data analysis procedures, ethical considerations and conclusion.

Chapter five presents the findings of the study. This involves analysis and interpretation of data from the interviews, observations and questionnaires. Guided analysis is used in the interpretation of the data. Categories of themes were formed, interpreted, and extended by the use of theoretical explanations and the literature review.

Chapter six concludes the whole study and makes recommendations based on the findings. It also relates the results to literature and theories that were used to explain the findings. It reiterates on the methodology adopted to answer the critical research questions, the significance of the study, summary of findings and presents recommendations and conclusion drawn from the data collected on the use of the IWBs and the areas that need further investigations.

1.14 CONCLUSION

This chapter has attempted to give highlights on each part of the components of the study. It has presented an outline and the background of the research, provided motivation of the study, statement of the problem, importance of the study, aims of the study, the research questions that guided the study, the research design and methodology to include the data collection and data analysis procedures, the scope of the study, the context of the study, limitations of the study, structure and direction of the study and conclusion. The next chapter presents the review of related literature on the use of the IWBs in the teaching of science, both locally and internationally.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses a review of related literature on the use of the IWB technology in the teaching of Science. In selecting research studies for inclusion in this literature review, the following parameters were deployed: studies with direct relevance to the topic, that is, those that involve the discussion and / or exploration of the use of IWB in science education. The parameter included studies examining the practice and challenges that IWB usage in the classroom brings to science teaching. These are studies conducted locally, regionally, and internationally, with a focus on science education at secondary level. These, furthermore, include empirical studies from different methodological traditions, including surveys, descriptive studies, interpretive, ethnographic, and qualitative and case studies, literature reviews and conceptual pieces. The subsequent section discusses the composition of the IWB system; the definition of IWB; different models of IWBs and their use; review of related literature; the revolution of the IWBs; key findings from the literature; implications and recommendations from the literature and the conclusion

INTERACTIVE WHITEBOARD (IWB) SYSTEM

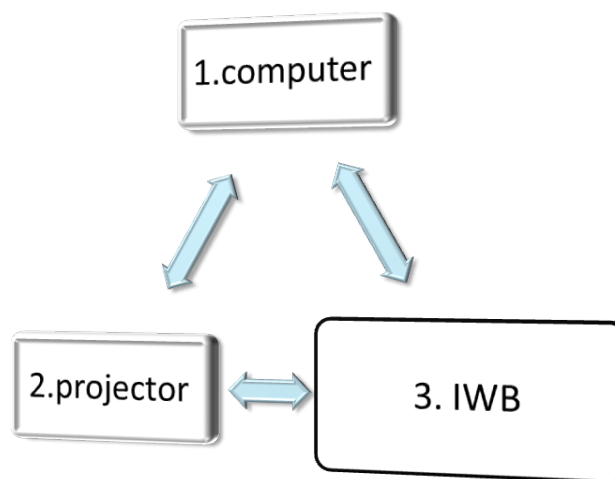


Figure.1

The set-up for an interactive whiteboard system drawn by the researcher.

An interactive electronic whiteboard system (see figure. 1) comprises the board, which is touch-sensitive, a digital projector and a computer (Gage, 2005). The projector displays images from the computer screen onto the board. The computer can be controlled by touching the image on the board either directly or by using a special pen. Interestingly, O'Leary (2006) and Bell (2002) define an interactive electronic whiteboard as a presentation device that interfaces with a computer. They further state that computer images are displayed on the board by the digital projector where they can be seen and manipulated. For O'Leary (2006) this resembles the traditional whiteboard and it is used in a similar manner. According to Heinich, Molenda, Russell and Smaldino (1999, p.17), an interactive whiteboard is "a high-tech variation of the multipurpose board." This refers to the device of advanced technology that requires an application of advanced methods that are flexible and adaptable. This means the board requires other things such as the software packages and the Internet that would make the board interactive.

Furthermore, an electronic whiteboard is the equivalent of a chalkboard, but on large, wall-mounted, touch-sensitive digital screen that is connected to a projector and a computer (Smart Technologies, Inc., 2005). Other known terminologies of the electronic whiteboards include the "eBoard," "digital whiteboard," "smart board," or "interactive whiteboard." These terms generally describe the group of technologies that are brought together to support classroom activities. Their meanings are slightly different to different people; it all depends on their environment of application (Mohammed & Ottmann, 2005). There are also tools such as Mimio, e-Beam, Clever board and Promethean ACTIV Board that make normal whiteboards interactive.

It is vital to categorize the above definitions into human skills and technology. The human skill is assumed to involve a series of abilities, interests and needs towards the organization of materials that could enhance learning, even though it appears broad and not specific to define any specific activity. An individual requires a high degree of intellectual approach to integrate various materials to be meaningful in the learning (Mayer, 2005). Similarly, in some definitions, the focus is on identifying various technological materials that could influence learning. However, the researcher is of the

opinion that the above definitions should state the characteristics and usability of the interactive whiteboard to identify their relevance in learning, especially science.

2.2 MODELS OF IWBs AND THEIR USES

- ✓ Mimio – It is not an interactive board, but a system that enables writing and displaying materials on existing boards. They can be annotated and edited. This type of whiteboards is inexpensive, light and portable. It can be used with a mimio system to create the effects of an interactive board from a computer display (Gage, 2005).
- ✓ Cleverboards – The Mimio board packed with a standard dry-wipe whiteboard is marketed as a Cleverboard (Gage, 2005).
- ✓ E-beam system – The e-beam board is very similar to the Mimio board, and is available as a package with a standard dry-wipe whiteboard (Gage, 2005).
- ✓ SMARTBoard – A touch-sensitive whiteboard comes with a range of interactive features and software. This board can be operated by touching the screen with a finger, and writing can be done using fingers. The fundamental feature to this type of board is the ability to point and touch as part of the learning process (Gage, 2005).
- ✓ Promethean ACTIVBoards – These are the interactive whiteboards also known as smart boards. They use electromagnetic technology that offers digital, rather than analogue control, increase speed and accuracy. They have physically durable long lasting surface resistant to climatic changes. They usually come with the intuitive ACTIV Software, which is the most dynamic interactive whiteboard software on the market (Gage, 2005).

2.3 REVIEW OF RELATED LITERATURE

2.3.1 TECHNOLOGICAL DEVELOPMENTS THAT AFFECT EDUCATION

As a point of departure in this study, it is important to define the concept technology for it is central to the purposes of this thesis. The renowned educational technologist, Finn (1960, p.10), defines technology as “not only machinery, but processes, systems, management and control mechanisms, both human and non-human.” It is clear that

technology involves all human activities. The major issue to be addressed in this context is the role technology plays in human activities. It provides instructional applications through different techniques (Anglin, 1995), thereby increasing the power of mind and body. Engler (1972) alludes to this idea when he identifies the relationship between students, teachers, and the environment in which they operate. In this process, he asserts that it is obvious that the relationships are largely defined by the prevailing technology of instruction. The technology of instruction could be associated with approaches, methods, and new tools that can make teachers and the learning process effective and interactive, all of which could be by means of either printed or electronic means (Anglin, 1995).

According to Percival, Ellington and Race (1984), educational technology comprises hardware, software and underware. This could be further classified as technology in education (hardware, software) and technology of education (underware). Technology in education consists of technical equipment such as computers, data projectors, keyboards, whiteboards, and so on, and software aspects such as educational materials that are designed for use with hardware. Technology of education is concerned with design, processes, methods, and theories of learning (Percival, Ellington & Race, 1984). This study thus fits well into the descriptions made above because it focuses on the IWB as the device that presents educational material used in the processes of teaching and learning (technology in education), and the design, approaches, techniques as the underware (technology of education).

Reiser and Demsey's (2006) focus is on defining and explaining the history of instructional technology which is the most crucial aspect to this study. This is because it provides the historical perspective on ways in which the current field of technology has evolved. The emphasis is on the foundations, theories, and trends of instructional technology. Other authors such as Anglin (1995), Percival, Ellington and Race (1993) define instructional technology and instructional design by focusing on describing interpretations in terms of systematic processes and end processes, all of which leaves confusion in terms of differentiating between instructional technology and instructional design.

Different authors use terms instructional design and technology to define the field, various instructional and learning theories, competences and resources. The research questions in this study are designed to develop more on human and technical explanations towards the use of the interactive electronic whiteboard. They are designed to form a base for pedagogical challenges of the interactive whiteboard for educators who use the IWB during science instruction.

2.4 REVOLUTION OF THE IWB

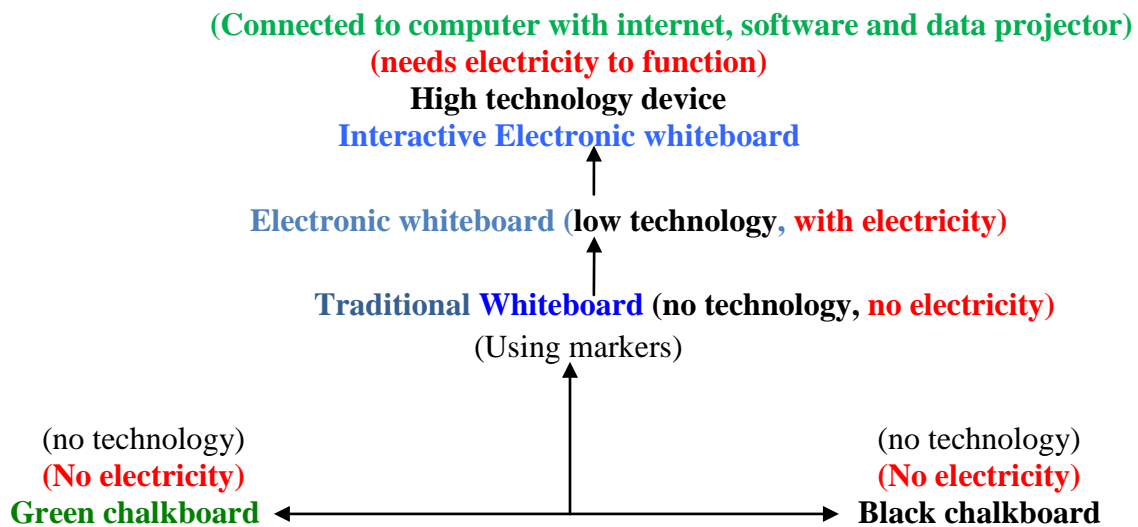


Figure.2

As implied by figure.2, IWB technology is an invention that seems to affect education currently. It has evolved from what had been a blackboard, or lately green board (or chalkboard). The Blackboard was one of the first communication devices that enabled educators and learners to view the same material and content simultaneously (Anglin, 1995). The blackboard or green board is a 'no technology' tool, for it does not require electricity to function. It is just a sheet of masonite mounted on the wall or on a supportive moveable wooden frame referred to as an easel. The piece of board is commonly painted in black or green. Pieces of chalk, either white or coloured are used to write or draw on the black or green board. The chalkboard or blackboard evolved as technology is altering into a whiteboard (fig.2). A whiteboard is a glossy white surface, usually mounted on the wall or on a steel frame. It is slightly more expensive than a chalkboard. It uses non-permanent markers, which do not generate dust to write on

(commonly known as whiteboard eraser markers), as against pieces of chalk, which generate dust while these markers do not generate dust. Both boards, however, use an eraser such as a duster to clean off the information on it, but the functions and relationships to the learners have essentially not changed.

Whiteboards or traditional whiteboards, as commonly referred to, store information that is physical rather than digital (Slay *et al*, 2008). This means traditional whiteboards do not have a technique for saving notes made on the board or cannot connect to a computer or other resources to access stored materials. Gradually, whiteboards became electrified and evolved into interactive electronic whiteboards (IWB) devices of high technological standard. These boards are more expensive than chalkboards and traditional whiteboards. The interactive electronic whiteboard system comprises a computer and a data projector. (Anglin, 1995). The data projector projects the information from the computer onto the board or screen for all learners to see and interact. The traditional whiteboards cannot perform this function because they are not digital. In this manner, discussion and collaboration are said to be possible in a way that is not possible when everybody is looking at their own monitor or screen (O'Leary, 2006).

There are numerous literature reviews and papers on the use of the interactive whiteboards in the classroom. Most of the published research comes from the United Kingdom, and little is said to come from the United States (SMART technologies Inc., 2007). The Media Release (2007) identifies that the SMART Board interactive whiteboards are used to teach over 15 million students in more than 450 000 primary and secondary classrooms in the United States, Canada, United Kingdom, and in more than 100 countries worldwide.

The first study on the use of the interactive electronic whiteboard in instruction was conducted in Texas in the United States of America (Bell, 1998). Results indicate a high degree of satisfaction with most aspects of the SMART Board and its uses in the classroom. According to Bell, the interactive whiteboard has gained recognition as an attractive instructional aid. In her article *Why Use an Interactive Whiteboard? A Baker's Dozen Reasons*, Bell (2002) summarizes the function of the IWB and lists the benefits of

such technology. Bell's (2002) findings were also supported by other research discoveries in Australia, China, Hong Kong, Spain, and the United Kingdom. These studies revealed evidence of effective practice of IWB in education. For example, Queenswood School for Girls in Sydney, Australia, first installed the interactive whiteboards in 2003. By mid 2005, the school had installed 55 interactive whiteboards (Media Release, 2005). This indicates an increase in the installation of the tool in schools. The question that arises is what influences or determines effective practice and or what factors may promote satisfaction in the use of IWBs?

Eltham College of Education in Victoria, Australia is one of the first schools to use the interactive whiteboards. The findings revealed that the tool enabled easy access to digital resources that support the school's initiative to encourage research-based learning (David, 2005). McNeese (2006), from the University of Southern Mississippi, reported on a survey undertaken on the impact of the SMART Board technologies. The study revealed that 90% of the participants agreed that the product is an important piece of classroom technology. It enhances student participation, improves students' engagement, and results and supports student learning. Knowlton (2007), the SMART's president and co-CEO, declared that one of the greatest benefits of using the SMART Board interactive whiteboard in the classroom is to improve the students' engagement, diverse learning styles and outcomes. Given its usefulness as discussed above, to what extent do IWBs enhance student participation and improves students' engagement. Moreover, what features of the IWBs enhance student participation, what educators do to enhance student participation and engagement?

Apart from the positive contribution of the study reviewed above, the findings of this survey do not really give a picture of what could be considered as realistic because it does not really reveal how the IWB enhances students' participation as well as improves students' engagement. Furthermore, the study is silent in terms of the criteria used to measure the improved performance in students. In addition, the findings go without mentioning the criteria that was used to determine and justify the mentioned factors of participation and engagement. The methodology used had restricted the learners to verify or confirm the views about the usefulness of the IWB to their learning. The researcher

assumes that more data collection methods, such as interviews and observations, could have been used in order to prove the findings credible. The survey identified the breadth of the usage of the IWBs yet giving deep understanding of the nature of practice with different learning areas. The findings are not specific, but general. The researcher strongly believes that the depth into this study would have been important to shed light onto those individual institutions to make informed decisions from a constructive conclusion on the purchase of the board.

Glover and Miller (2001) provided some basic guidelines for good practices and outcomes of engaging classroom interaction and participation with the electronic whiteboard across the curriculum. Such are:

- ✓ To transform learning by creating new learning styles stimulated by interaction with the electronic whiteboards;
- ✓ To extend learning by using more engaging materials to explain concepts and;
- ✓ To increase efficiency by enabling instructors to draw upon a variety of ICT- based resources without disruption or loss of space.

Given these views, the issue is use of the electronic whiteboard in the teaching of Science. This means educators are challenged to transform, extend learning and increase efficiency by enabling them to draw upon a variety of resources. The issue here is; is the South African National Department of Education ready to render such support as in the United Kingdom, for instance? Are educators prepared in terms of skills and knowledge to do the above? On what grounds do they need to transform? What support do they have in place in order to transform?

The South African Minister of Education, Pandor (2004) sets out the government's response to the new information and communication technology environment in education. The document asserts that many schools are exploiting the benefits of ICTs to enhance the quality of teaching and learning. The government poses a challenge that a significant investment is required to provide modern technologies to schools in order to enhance the quality of teaching and learning. With large investment at stake, the results

from this study will inform the policy-makers to take informed decisions regarding the government's ongoing and future commitment to the installation, maintenance and support of classroom based technologies such as the IWB.

2.5 REVIEW OF EXISTING SCHOLARSHIPS

2.5.1 EFFECTIVENESS OF THE IWBS

A team of researchers from Rhodes University undertook a feasibility study on behalf of the Eastern Cape Department of Education in 2007. The study investigated teachers' and learners' perceptions of both primary and secondary schools with regard to the potential benefits and the drawbacks of using the IWBS, particularly the e-Beam technology. Slay *et al* (2007) focused on these subjects during their observation in different grades and levels: English, Life Orientation, Business Economics and Mathematics. The classes observed had class rolls of 22, 29, 30 and 54 learners, respectively. Findings from this study revealed that IWBS have the potential to be beneficial in the South African classroom by affording educators and learners a new medium through which they can create, capture, and share knowledge (Slay *et al*, 2007). These seemed possible because learners had easy access to different sources of information and were able to work collaboratively with the teacher to produce and capture knowledge.

There are many case studies describing some aspects of interactive whiteboard (IWB) use on the internet (Gage, 2005). Gage has identified some of the advantages suggested by its advocates as follows:

- ✓ It helps educators to structure their lessons;
- ✓ It enables ICT use to be more integrated into lessons;
- ✓ It provides large attractive text and images that can be moved around, or changed to help to attract and retain learners' attention.
- ✓ Many boards have additional software which provides a variety of additional graphics such as maps, specialist background, and a wide range of images;
- ✓ It supports collaborative learning, and help learners develop cognitive skills;
- ✓ It saves time taken up in note-taking or scribing and;

- ✓ Work can be saved to be used later or printed out.

Furthermore, according to Gage (2005), some research suggests that high IWB use leads to more questioning, of learners and educators, more stimulating discussion, and better explanations. Learners enjoy the additional variety, which IWB use allows. Many different resources can be used in a lesson and these can be returned to whenever necessary. Moving frequently between resources helps learners to refocus their attention if they were distracted helping them to stay on task for longer. Some learners benefit from being able to touch the board, and physically move objects around it. Using audio and video files further enable voices from outside the classroom to be heard, again refocusing attention. All learners can benefit from the increased opportunities for more auditory learning, more visual learning and more kinesthetic learning.

Anton (2006) reports that learners of the 21st century are more advanced than other generations by learning visually. He further states that interactive whiteboards seem to be an excellent addition to the learning environment of the high school. Educators are able to access the internet to show materials to the class, hence become challenged, both practically and pedagogically. In addition, the chairperson of the department of one school that has been researched asserts that viewing makes understanding subject matter more efficient. Inquiry based learning, which displays a situation on the board; creates numerous questions and answers that enhance learning.

In another study conducted in North America by Tapscott (1998), young people who were to turn between the age of 2 and 22 in 1999 seemed to be influenced by the use of technology particularly computers in every thing they do. According to Tapscott (1998), their use of computers has spread so much that it seemed to have affected many aspects of this N-Geners's life. Such aspects directly relate to learning, play and recreation, family life, employment and shopping (Tapscott, 1998). The argument that Tapscott (1998) puts forth in this regard is that this age group's immediate environment is the digital media, which they can hardly escape. Increasingly, this is the generation with the ability to use electronic networks to access resources and to communicate with others. It is true of the established fact that these users of technology have a wide scale access to

computers and the Internet either at home or at school. They explore the Internet on their own with neither educators nor parents. They surf the Internet to get information they need from different sources. They explore their cell phones, they use the communication technology such as Mxit, they also explore movie, games etc. They can play games and listen to music from the computers simultaneously. They are capable of performing many tasks at the same time.

One of the most important benefits this generation gets from the use of technology is education. Insofar as education is concerned, Tapscott (1998) identifies and lists aspects that directly relates to how this type of generation learns. He posits that their perceptions on how they learn have brought changes that have an enormous impact on the ways they express ideas and perceive the world. The changes are what Tapscott (1998, p. 143) refers to as “shifts of interactive learning.” The exploration of the Internet by this generation seems to have influenced their learning from the traditional way of doing things to an interactive approach. At the look of things, it is hardly surprising then that it is also true that the culture of the N-Geners as Tapscott (1998) refers to them, is at variance with that of their parents as well as their educators. One obvious issue around this is that the parents of the N-Geners specifically did not have access to computers hence were technologically disadvantaged. Following is the shift of learning as reiterated by Tapscott (1998):

From linear to hypermedia learning

From instruction to construction and discovery

From teacher-centred to learner-centred education

From absorbing material to learning how to navigate and how to learn

From school to lifelong learning

From one-size-fits-all to customized learning

From learning as torture to learning as fun

From teacher as transmitter to teacher as facilitator (p.143).

Clearly, what the above shift implies is that this generation can be interpreted as competent users of available hardware and software. It also becomes clearer that with the widespread access to computers and the Internet, the N-Geners live in a context of

freedom to choose, to learn because it is fun, interesting and inspiring. These changing learners are described as:

Open and accepting, multi-taskers or time slicers, curious, willing to experiment, fiercely independent, capable of thinking and investigating, self-reliant, assertive discovery learners , extensive users of technology who are prepared to learn everywhere, at anytime (Alberta's Commission on Learning (2003, p.32).

Educators may no longer have the right to control learning. This may have resulted in the current attitudes to education as influenced by technology. The argument advanced here centers on the view that recently learning is no more seen as linear but multidimensional and multimedia and which is no longer fixed but infinitely changeable. This is also advocated by the theory of connectivism. Again, education through technology seems to create new wants and these challenge learners' ability to satisfy them.

In terms of skills, Tapscott (1998) postulates that these 'digital kids' also acquire skills that would afford them to interact freely in the digital world. In the similar vein, Wilson, Wallin and Reiser (2003) assert that the way this young people communicate, interact and socialize with others is influenced by the introduction of the Internet. The argument raised here is that, the reality is that learners have changed everywhere, at home and at school. On the correct supposition, this may be so because they have "grown up with technology all around them" ([.smarttech.](#)). To them there is no life without computers (Knowlton, 2006).

Information and communications technology (ICT) can transform science teaching because it allows educators to do things, which cannot be done in other ways (Sang & Frost, 2005). They further illustrate that static diagrams can come alive, large amounts of data can be gathered, numbers can be crunched, ideas can be represented on screen. The Internet can be explored, thereby affording learners greater independence in their work and their thinking. In addition, ICT is important because learners are going to live and work in a world where these new technologies are increasingly important even

universally. This means that teachers with no practical preparation or experience in issues surrounding digital technologies create another area of concern (Cunningham, 2002).

2.5.2 TECHNICAL SUPPORT / ICT SKILLS

According to the studies compiled by Glover and Miller (2001), teaching with interactive electronic whiteboards instills anxiety in the learners for effective learning, but unduly places the pressure onto the educators when it comes to delivering the content. The report confirms that this can be a problem, especially if the writing environment of the interactive electronic whiteboards is not sufficiently supported with the necessary tools.

Furthermore, in a study conducted by Slay *et al* (2007) in the Eastern Cape in South Africa, all educators involved in the study were trained prior the observation to ensure that they had adequate skills and knowledge. Educators from a local independent school demonstrated the use of the IWB to the group of educators who were to participate in the study, the schools' principals and the researchers as well. Subsequently, the trainee in turn demonstrated the use of the IWB, they were observed on their ICT skills, and support was provided to those who were not familiar with the board. Basic instructions on presenting lessons with the IWB were given. They learned how to calibrate, assemble and disassemble equipment.

On the other hand, Schenck (2007) highlighted that educators needed to know that if they come across a problem, someone is committed to helping them through it, that is, someone leading the project and taking responsibility for troubleshooting as a high priority. Schenck (2007) also asserts that, while all educators have embraced the use of IWBs with varying level of enthusiasm, some of the barriers to the implementation should be acknowledged. Again, almost all educators mentioned the lack of time available to learn to use the new technology. Educators acknowledged that even though making a file takes time initially, it saves time in the end if they can reuse it.

2.5.3 PROFESSIONAL DEVELOPMENT / TRAINING

A group of researchers engaged in a research as part of the Technology School of the Future in 2005. The research attempted to investigate the kinds of support structures that schools can put in place to encourage and assist educators to use the interactive

whiteboards (IWB) as powerful tools in their classrooms to improve students learning. The findings of the study revealed that training and development strategies are essential for the implementation of the IWB into classrooms. From a list of many strategies compiled by the staff members, such as play to learn, structured learning, step-by-step guide, one-to-one tuition, training after school, to mention a few, were considered as either essential or helpful to the implementation. It is indicated that schools need to look at implementing some of the training and development strategies as identified above if they wish to have staff that are comfortable utilizing the technology in their classrooms. In support of this idea, Slay *et al* (2007) conducted a study in the Eastern Cape, South Africa. Participants in this study were selected educators. They were given some training before the actual observation in order to ensure that they are equipped with the necessary ICT skills to use the board confidently and support was solicited to those who did not have the required skills to operate the board to reveal what was expected. This shows that professional development and / or training should be considered a prerequisite in the planning and implementation of the IWBs in schools.

Furthermore, in a study conducted on the introduction of interactive whiteboards into schools in the United Kingdom Glover and Miller (2001) postulate that undertaking professional training was as important as installing the technology itself. Their article further advises that a variety of different structures, such as to organize resources, to build a culture of interactive teaching, to involve the whole school community need to be in place to assist a whole staff to implement IWBs effectively in their classrooms. Moreover, there were other features identified that reckoned imperative. Literature indicates that availability alone is not sufficient to ensure continuing, consistent and effective learning to the use of IWB in teaching (Glover & Miller, 2002). Some other features identified were:

- ✓ Whole school familiarization presentations conducted by commercial companies' representations or by local education authority advisors can be held;
- ✓ Smaller groups of staff could be involved in training, which could range from half a day to three days of intensive training;

- ✓ A technologically and pedagogically competent advisor is needed. Such a person could work alongside with educators in the development and use of IWBs within specific subject areas and;
- ✓ Collaboration amongst staff is integral to the implementation of technology. Stein (2005) who believes that sharing is an essential part of the implementation process also supports this view.

The preparation that Slay and colleagues engaged in with the educators before observing them appeared to be a collaborative effort and support, as well as professional development. However, the researcher is of the opinion that the choice of the training and development strategies depend on different situations and can be influenced by some other factors. On the other hand, one school may find whole school presentations relevant to their needs, while another school may consider small group of staff relevant. Sometimes both approaches may be adopted. Cost, furthermore, appears to be a determinant in this case. Conducting whole school presentations may be cheaper than having a small group of educators and vice versa (Glover & Miller, 2002).

Research indicates further that the use of IWBs in teaching can transform education. This means that schools, districts, organizations, the Department of Education needs to provide support and training to their staff. In this regard, Schenk (2007) identified that one of the major reasons for the failure of technology to transform education is the educators' resistance in using technology, and this behaviour could be a result of lack of training provided by schools when acquiring the technology. Training sessions and professional development workshops seem vital in supporting educators to use the technology effectively.

Some issues raised above are not practical in the context of South Africa because the Department of Education is at the initial stages of equipping schools with computers, so there is still a long way to go to provide schools with IWBs. Now only the so-called advantaged schools manage to purchase these types of boards, but still there are some issues such as professional development, cost and maintenance, issues of pedagogy, to mention a few; that need to be addressed in order to consider IWBs as an effective

teaching tools and that could be recommended to other schools. Nevertheless, it appears that it remains the obligation of different departments of education in different provinces of South Africa to support their schools to use the IWBs effectively and with confidence.

2.5.4 PEDAGOGICAL CHANGE

From the Technology Aids Teaching – Lifestyle by Kennedy (2008), the challenge is when some educators that are close to retirement and are scared to use technology and change their traditional ways of teaching. The biggest challenge was to educate some educators that are stuck in their ways, or get them to vary their methods of instruction, instead of always falling back on the same old tools like PowerPoint.

Authors of many reports such as Glover and Miller, 2001; Bell, 2000; Damcott, Landato and Marsh, 2000, Slay *et al.*, 2007), caution that educators who use or intend to use the IWB technology with confidence, need to be highly committed in sorting out efforts for training and also independent exploration for the effective use of the IWB in learning institutions (Glover & Miller, 2001; Bell, 2000; Damcott, Landato & Marsh, 2000). In addition, studies conducted and compiled by Becta (2003) reveal that teaching-using IWBs infuses some apprehension in learners to learn, while on the other hand, it puts pressure onto the educators when it comes to delivering the content. Glover and Miller (2001) further assert that this maybe so if the writing surface of the IWB is not sufficiently supported by the necessary tools.

Moreover, Clyde (2004) identifies that educators are challenged with the ability to modify and change the content materials. To clarify this, most IWBs have accompanying software fixed into the boards for use in the classrooms, for example, SMART Technologies Inc., Promethean ACTIVstudio. It is on this basis that the researcher argues that educators are faced with the challenge to select the most relevant content data to enhance students' learning. However, the study focused on the reaction of support systems in providing valid and useful assistance to instructors, while this particular study was intended to investigate the benefits and challenges on the use of the IWB technology in teaching and learning of science. It is obvious that there is a problem of rigidity with the use of the board. They appear not to be flexible, therefore restrict creativity in terms

of the choice of the content material that is appropriate to the context. Presently, there is not relevant software that responds to the context of the South African curriculum. Most software is international. Therefore, this means the effectiveness of the IWBs remains a question to be addressed in South Africa.

Schenk (2007) emphasizes that integrating the IWBs into the classrooms can affect the way lessons are prepared and delivered. In order to achieve the goals of utilizing the IWBs in teaching, educators need to divorce themselves from their traditional teaching methods, adopt, and adapt to recent pedagogical skills, taking into account the technology. Similarly, recently in England, Glover *et al* (2005) conducted a study on the effective use of the IWBs in mathematics lessons, with the focus on the presentation and pedagogy. In terms of pedagogical influence, the findings of the study reveal that different pedagogic phases were reached at three levels, namely: supported didactic, interactive and enhanced interactive. The results of the study, however, revealed that there was an increase in understanding mathematics. So in order to promote such learning; educators need to be confident with the technology and pedagogy. Though the study was based on mathematics, the researcher assumes that the results and findings may have the same impact, and could be adopted into the teaching of science, because the researcher's focus was on the challenges posed by the use of the IWBs in teaching science. Educators are therefore challenged to identify the relevant pedagogy for the teaching of science using the IWBs. The issue is, are educators well prepared for this practice in South Africa?

Damcott *et al* (2000) conducted a study at William Rainey Harper College. This was a comparative study where two control groups of students, both men and women, were identified. One group used IWB while the other group did not in all class activities. The authors observed poor student understanding for several topics in physical science. The findings were that the use of the IWBs helped women gain knowledge in physical science lessons. The women's scores appeared higher than those scored by men in all activities. However, the researcher was not interested in the gender difference and the performance as such, but mainly concerned with the IWB features that aided learners to gain knowledge. The researcher intends to use this study as reference to ascertain the effects

of IWBs in helping learners acquire knowledge in science instruction. Features of the IWB such as the drag and drop; colour differences, integration of websites into lectures were identified to help learners gain knowledge. Additionally, the researcher was also interested in the relevance of these features in the context of South Africa. Their relevance will be noticed in their application.

Damcott *et al* (2000) and Robinson (2000) stress the need for changed approaches to teaching in order to enhance the effectiveness and the value of teaching and learning science-using technology. They collectively demonstrate the use of interactive technology within mathematics as a subject area with diverse ability groups. In the similar vein, Sutherland (2004) further expounded on the idea that there is a need for changed pedagogic approaches in ICT rich environments.

In a report compiled by 'futurelab' on Interactive whiteboards in the classroom, Burden (2002) illustrated three stages on the use of the IWB:

Infusion: The use of IWB in this context is seen to be used essentially as an instructive or informative tool where learners are overall passive. IWBs are used to reinforce the existing practice in order to gain popularity.

Integration: The use of the IWBs is greatly being applied in ways in which the boards can support a particular subject or learning goal. This centers around the idea that learners participate more actively in the use of the board. Hence, implies that IWBs become rooted within the school and the curriculum.

Transformation: This is whereby the use of IWBs enhances the whole learning process. In this case, educators create and make use of a range of other resources that enhance the learning process through a more inquiry-based approach where learners become actively involved in the use of the IWB, thereby assisting them to actively construct knowledge through interaction. Given the above view, educators are largely faced with challenges that trigger their pedagogical approaches in order to transform teaching using the IWB. Rudd (2007) supports that some educators do not always promote more interaction,

collaboration and participatory learning in the classroom. Therefore, they are faced with such challenges:

- ✓ How can hardware and software developers, training providers and educators better exemplify practices that may be more transformative?;
- ✓ Are there clear examples of the various stages and pedagogical insights into how to move beyond mere infusion?;
- ✓ Is there enough compelling evidence of improved learning that can be used to inspire those educators who may feel that this requires a change of approach and a significant investment of their time and effort?;
- ✓ Is there a compelling argument to demonstrate that the use of as IWB allows them to deliver that which they cannot achieve by the other means? and;
- ✓ How might hardware and software developers, educators and trainers sketch out the broader political and educational rationales to support educators to move in this direction? For example, how could and does the concept of personalization impact on practice when using the IWBs.

Beauchamp and Parkinson (2005) work was on developing interactivity with the interactive whiteboard. Their purpose was to raise the issues of how teachers can maintain motivation using the IWBs by increasing pupils' engagement in learning. The following issues were identified:

Focusing attention: large IWBs screen acts as a focus for learners' attention. Information such as class notices, homework reminders, and lesson objectives can be pasted up. Learners can manipulate words and images on the IWB. Starter activities could be posted up. Games can be displayed on the IWB to help learners to become familiar with science words.

Scaffolding learning: IWB screen provides information that acts as a stimulus for classroom discussions. This can promote the production of new information that can be stored on the flipchart pages ready for use later in the lesson. Simulation software can be used to demonstrate what happens when a solid is heated. Learners need not set the apparatus, rather, concentrate on interpreting the results. In this manner, IWB can provide

an environment where focused learner-educator and learner-learner talk is promoted, leading to a situation where learners' goals are achieved more readily. It is apparent that the features of the IWB can promote scaffolding through motivating learners to carry out the tasks, breaking down the learning into manageable chunks, keep learners motivated, highlight the main points of the lesson content and also can allow the educators to model how to solve part of the problem or show how similar problems can be solved.

Changes in pedagogy: IWB can promote whole-class or group discussion by exposing images and rich sources of information. It can help the learners to reason and think through scientific explanations with the support of the educator and colleagues. The exploration of resources from the internet requires educators' ICT skills. As they develop their ICT skills, they also need to accept changes in their role and in the interaction with learners. This adjustment to coach, observer and facilitator afford learners a greater responsibility for their own learning.

In South Africa, the Eastern Cape Department of Education commissioned studies that explored various types of interactive whiteboard systems in order to encourage evidence-based policy and evidence –based practice. As part of this initiative, Slay, Sieborger and Hodgkinson-Williams (2007) undertook a feasibility study in Eastern Cape schools, particularly Grahamstown schools, where three previously disadvantaged schools were involved. The study investigated how and why the e-Beam enables or constrains teaching and learning in South African primary and secondary schools. According to the authors, most studies have been undertaken on the use of the more expensive SMART Board technology. The study identified five common technical problems experienced by educators and learners who use the e-Beam interactive whiteboard technology as calibration and infrastructural issues; hardware and software; training and support; timetabling and portability. Then the benefits and drawbacks of the two interactive whiteboard systems were compared. The overall finding revealed that as prerequisite, prior to the installation of the interactive whiteboard technology in schools, educators should be ICT literate and be equipped with integration skills to support the optimal use in classrooms. With these problems at hand, South Africa faces a great challenge of installation and related issues. Professional development and training to include

pedagogical shift incur huge expenses. Optimal use of the IWBs thus remains questionable because the South African government has not attempted to invest funds as in other international governments such as the United Kingdom, to support schools in the use of the IWB technology. However, there are policy initiatives set out to respond to transforming education through information and communication technology. These, however, go without mentioning and catering for the installation and use of this type of technology except for provision of computers in all schools. The policy also stipulated the commitment of the government to engage in improving the physical infrastructure of the schools in order to support the new technology. The question of professional development and training needs to be addressed.

In a case study conducted by Slay *et al* (2008), three schools, one primary school and two secondary schools in Grahamstown area, participated in this study. This study highlighted on learners' and educators' enthusiasm about the IWB and the multimedia options. As in the previous study, the issue of lack of ICT literacy shown by the educators and learners cropped up, as well as the issue of the cost of technology was also identified. Furthermore, educators and learners preferred using a combination of the laptop and data projector to using the interactive pen technology. The study suggests that there should be thorough preparation for the use of the IWBs in terms of the type of technologies that would form the basis for the use of the IWBs as well as the shift in ICT related pedagogies. Therefore, schools seem to have gone too far into more advanced technologies when they were supposed to have the basics of the technology such as starting with a data projector and a computer as a preparation for more advanced technologies such as the interactive whiteboard technologies. Moreover, the South African government's provision of modern technologies seems impossible currently if capacity and skills building (professional development) and pedagogical support to include access to the technologies are not considered and rendered.

The InterActive Education project in Bristol commissioned two separate projects to examine how educators exploit computer-based technologies in supporting the learning of science at secondary level. The projects were conducted by Hennessy, Wishart, Whitelock, Deaney, Brawn, la Velle, McFarlane, Ruthven and Winterbottom (2007). In

the first study, four educators were selected as participants. They all used multimedia simulations in their lessons. In the second study conducted as part of the wider SET-IT project in Cambridge, eleven educators in eight schools were observed using multimedia simulations, data-logging tools and interactive whiteboards. In both cases, educators were interviewed to get information on their reaction from their pedagogical thinking about their classroom use of ICT. Results out of these studies suggest that educators are shifting away from using only 'real' experiments in their practices. Educators are exploring the use of technologies to encourage learners to engage in 'What if' explorations where the outcomes of 'virtual' experiments can be immediately accessed, for instance, through using a simulation. Educators in the studies used simulations, data-logging, projected animations and other dynamic digital resources as tools to encourage and support prediction and to demonstrate scientific concepts and physical processes, thereby bridging the gap between scientific and informal knowledge. They also integrated technology carefully with other practical activities to support stepwise knowledge building, consolidation and application.

While developed countries and pioneers of IWBs in the teaching and learning environments are still struggling with identifying pedagogical strategies to support science learning, developing countries like South Africa then still have a long way to go in identifying these strategies, particularly those that are relevant and specific to our situation. This challenges the issues of professional development and change in pedagogy.

2.5.5 CHALLENGES ON THE USE OF IWBs

Having explored the usefulness of the IWBs in teaching and learning, the following discussion is based on barriers or obstacles associated with the use of IWBs in teaching.

There are also numerous studies that reported on poor usage of IWBs. To substantiate this view, the European Commission in 2006 released a report comprising of a review of ICT impact on schools in Europe. The authors reported among many positive effects on the use of ICT some barriers for effective use of ICT in schools. The perceived barriers were reported under three categories, namely: teacher-level barrier, school-level barriers and system-level barriers. Under the first category of teacher-level barrier, the following

aspects were highlighted: lack of ICT skills, the report revealed that the use of technology is affected by lack of ICT educator skills more than pedagogical aspects (European Schoolnet, 2006), and this incapacitate the educators in their practice. In Netherlands, alternatively, educators ICT knowledge and skills are more perceived as problem to the use of ICT (European Schoolnet, 2006), However, there is still lack of follow-up on how educators use the acquired skills.

Furthermore, educators who use the IWBs are in principle aware of how IWBs can engage learners in an interactive manner. Nevertheless, the use of IWBs seems to be a great problem. Their potential has been hindered by the way educators use them. According to Moggach (2006), educators tend to use the IWB to perpetuate the “chalk and talk” approach to delivery of instruction. Hynes (as cited in Moggach, 2006) supports that the position of the IWBs accelerates the problem. Learners have lessons in which they are passive. They simply watch the educators who control all the process and do the talking mostly. Hynes further emphasizes that educators appear knowledgeable and authoritative and learners are just empty vessels. He ascertains that although the whiteboards have come to relieve educators, but they have not yet changed what they do. This practice does not promote any interactivity because learners seem not to be engaged in the learning process. The reason for such practice may be associated with lack of training (Moggach, 2006). In support of the view, Allen (as cited in Moggach, 2006) further argues, “If teachers do not understand how the boards work, it is not fair to expect them to incorporate the boards into their teaching ...” [://www.tom-moggach.co/edu-tel-boards](http://www.tom-moggach.co/edu-tel-boards).

Another barrier identified is lack of motivation and confidence in using ICT (European Schoolnet, 2006). In this case, educators were found to have limited ICT knowledge hence become less keen to work and feel incompetent; as a result, they are unable to practice effectively. This view is supported by a survey conducted by Becta (2004) where among other perceived barriers educators were even scared and shameful to disclose their limited knowledge of ICT. To substantiate the issue further, some statistics in some countries still show that more than half of the educators are still incompetent to use ICT

in classrooms, for instance, Greece has 70%; Portugal – 70%; Hungary – 71%; and France – 76% Empirica (as cited in European Schoolnet, 2006).

Insufficient basic computer skills are another issue that contributes to poor usage of the IWBs. As proof of the above-mentioned obstacle, Slay *et al* (2007) identified that educators who are not ICT literate attempted to use computer but failed. They got dejected and eventually gave up using all the ICT resources. Hall and Higgins (2005) who accentuates that insufficient ICT skills in educators can result in poor use of the technology further substantiate the view. Another similar view is shared by Sharma (2003) who draws attention to the fact that the low level of ICT knowledge in education contributes to the bad use or becomes a barrier to the effective use of the ICTs in education. Alternatively, Watson (2001) argues on the fact that the knowledge of ICT skills does not guarantee the application of these skills. Since a skill is something that is acquired through practice, educators need to practice the learned skills in order to avoid forgetting hence loose of confidence.

Another study was conducted on social studies teachers in Omani. The focus of the study had been to examine the knowledge, skills and attitudes of the teachers using computers in instruction. The result of the study revealed that the teachers were very positive towards using computer in their teaching but they lacked computers skills (Al-Rabaam, 2008), which made them feel inferior. This became evident when half of these social studies teachers could not identify any social studies websites and other related resources (Al- Rabaam, 2008). In the light of this, the study recommended developing computer skills and knowledge in teachers. In the same view, Lundall and Howell (2000) identified in South Africa one of the inhibiting factors to the implementation of ICT in schools is lack of teacher knowledge and skills – lack of computer literacy among teachers.

With the advent of the computers, Khoza (2001) has observed that it is important for educators to have computer skills. Such skills are essential. They tend to help educators to control their activities, to gain control. Nonetheless, Khoza (2001, p.60) cautions, “If the technology controls us, then it may harm us.” The important point here is that computer literacy is the backbone of the effective use of technology. Therefore, relevant

training is essential. Training programmes should involve both, technology in education (the use of hardware & software) and technology of education (application of underware - methods, principles and theories of learning).

Concisely, acquisition of basic computer skills should be considered a prerequisite to the use of ICT, in particular, the IWB. The National Department of Education in South Africa is therefore, faced with a challenge to equip educators with basic computer skills so that optimal use of the IWB is achieved. Conversely, limited budgets in education is one of the challenges and also a constraining factor relating to staff development in South Africa (Holler, Muller & Paterson, 2005).

The poor use of IWB technology is linked to shallow educators' training to include acquisition of ICT skills and limited development of IWB teaching skills (Smith *et al*, 2005). Educators are missing some fundamentals because some are unskilled while others are under skilled. The argument here centers on the reason why this technology should be purchased by institutions when the educators are not ready. Therefore, it is wise of the authorities not to "parachute in" the boards so that they do not become a burden unto educators and the schools themselves [://www.tom-moggach.com/edu-tel-boards](http://www.tom-moggach.com/edu-tel-boards).

On the other hand, it is hard to ignore the fact that in the very near future, the medium of instruction will be mainly through technological devices. Therefore, higher institutions of teacher training need to revise or rethink about their curriculum in order to meet the requirements of the digital world and to respond to the needs of the N- Geners.

2.5.5.1 COST AND MAINTENANCE REQUIREMENTS:

Recently, the price of IWBs has drastically dropped, but they still affect the schools' budget (Leask & Pachler, 2005). Nevertheless, it may be cheaper to buy one IWB connected to a computer rather than having each learner with computer. In terms of practice as the focus, one IWB connected to thirty computers would better facilitate interaction amongst learners. For example, learners can be able to have instant messaging with classmates and colleagues around the world, search for information they need from the Internet, and this promotes interactivity. Indeed, these could be afforded by the first

world countries, it is impossible with South Africa yet because such a combination appears very expensive. For a start, one IWB and a computer could still serve the purpose provided educators are optimistic in what needs to be done. To substantiate this view, O'Leary (2006) postulates that IWBs enable discussion and collaboration in a way that is not viable when learners are looking at their own computers. International governments such as the UK's, Australia's, are investing some significant amounts of money into this area, but it is still not possible to have each classroom with its own board (Leask & Pachler, 2005). Interactive whiteboards use special tools to function effectively. They use only special pens not mere whiteboard markers that need some maintenance. The filters need to be checked and cleaned every month, hence require funds. Such issues need to be considered in the planning when schools decide to install this technology, to avoid embarrassment and inconveniency later.

2.5.5.2 TECHNICAL PROBLEMS

Any use of ICT is characterized by the risk that problems may arise. Leask and Pachler (2005) identified technical problems to be:

- ✓ A computer may crash, which means that it can stop working or cannot respond in the normal way;
- ✓ Network failure: network or internet connection may be completely lost or down;
- ✓ Problem with the projector: A projector may fail because the bulb could be blown. This can be caused by failure to clean the filters. The school technician should be responsible for such services and;
- ✓ Problem with the board: The board can sometimes fail to function due to the driver, which enables the computer to recognize input from the board, or could be a technical problem with the board itself.

2.5.5.3 LACK OF CONFIDENCE

Using the board can be a struggle if educators lack confidence in their ICT skills and sometimes educators become stuck when it comes to using the IWBs. Should IWBs be in full use depending on the availability of resources and expectations, that educators will

use this technology; then educators will be expected to use what is available. Schuck and Kearney (2007) confirm that not being confident with the whole technology is a problem. It has been said that IWBs can save time (Gage, 2006; Steed, 2002; Bell, 2002). Glover and Miller (2001, p.268) note that amongst educators “there is a feeling that they have insufficient time to develop the technology and the materials for its successful use.” According to Leask and Pachler (2005), this is true, particularly when educators begin to use the board for the first time, especially if they have a low level of ICT skills. Similarly, in a study conducted by Schuck and Kearney (2007) at the Sydney University of Technology, educators mentioned that the most common factor that constrained the use of the IWBs was the lack of time to prepare lessons, to teach students how to use the board, to develop resources, to develop knowledge, and so on. Therefore, if educators do not create and manage their time for the development of lessons and skills, then the use of the IWBs can be a failure.

Briefly, studies conducted by Becta (2004, 2006) identified some drawbacks associated with some practical or logistical nature of the IWBs. They proved difficult to maintain and, as a result, they presented difficulties when they are out of order. Initially, lesson preparations tend to take a lot of time and experience to become technically accomplished (Glover & Miller, 2001c; Levy, 2002). Comparatively, IWBs are more costly to purchase as compared to other presentation or display technology devices, which might have the same qualities.

2.5.6 KEY POINTS FROM LITERATURE ON IWBS

The effectiveness of the IWBs (Slay *et al*, 2007, Knode, 2006; Anton, 2006; Gage, 2005; Sang & Frost, 2005; Sutherland, 2004; Glover & Miller, 2001; Damcott *et al*, 2000):

- ✓ Continuing, consistent and effective learning – breakthrough to learning;
- ✓ Easy access to digital resources and multimedia options that support learning;
- ✓ Instructive and informative tool – saves information to view later;
- ✓ Provides large attractive text and images – visual impact, and allows manipulation of text and images thereby focuses attention;
- ✓ Supports diverse learning styles (auditory, visual, and kinesthetic) by drawing upon a variety of resources;

- ✓ Enhances student participation, improves students' engagement by extending learning by using more engaging materials to explain concepts and;
- ✓ Stimulates interaction and active involvement and facilitates different types of learning to construct knowledge actively – collaborative, project-based and authentic learning.

Factors that affect the use of the IWBs (Becta, 2003, 2004; Hall & Higgins, 2005; Mohammed & Ottmann, 2005; Smith *et al*, 2005; Slay *et al*, 2007; Schenck, 2007; Al-Rabaam, 2008):

- ✓ Insufficient ICT or computer literacy skills;
- ✓ Poor use of the IWBs;
- ✓ Lack of professional development or training of educators in the use of the IWBs, particularly in their specific subjects to ensure good access and to build confidence in them;
- ✓ Significant investment in terms of cost, maintenance;
- ✓ Support with suitable technical help and systems that allow educators to share ideas and resources.

IWBs advocates for interactive pedagogy (Glover *et al*, 2005; Clyde, 2004; Beauchamp & Parkinson, 2005; Hennessy *et al*, 2007):

- ✓ Preparation and delivery of content; selection of content (modifying and changing content material);
- ✓ Adoption of recent pedagogical skills considering the technology;
- ✓ Promotes whole-class teaching or group discussion and;
- ✓ Some educators do not always promote more interaction, collaboration and participatory learning

Technical support (Schenck, 2007; Rudd, 2007; Slay *et al*, 2007; Stein, 2005; Glover & Miller, 2001).

- ✓ Collaboration by educators seems essential to the implementation of the IWBs.

2.6 IMPLICATIONS OF FINDINGS FROM THE LITERATURE

The literature reviewed identified both benefits and barriers to the use of the IWBs in teaching, though not all specific to the teaching of science, but rather stated generally.

The benefits identified were:

- ✓ Access to a wealth of resources to include multimedia resources that support learning;
- ✓ IWB is an instructive and informative tool that saves information to view later;
- ✓ Provides large attractive text and images – its visual impact;
- ✓ Allows manipulation of text and images, thereby focuses attention;
- ✓ Support diverse learning styles (auditory, visual, and kinesthetic) by drawing upon a variety of resources;
- ✓ Enhances / improves students' participation and engagement by extending learning by using more engaging materials to explain concepts and;
- ✓ Stimulates interaction and active involvement and facilitates different types of learning to construct knowledge actively through collaborative, project-based and authentic learning.

In addition, other factors identified to affect the use of the IWBs are:

- ✓ Professional development and training of educators in the use of the IWBs, particularly in their specific subjects to ensure access and to build confidence;
- ✓ Significant investment in terms of cost and maintenance requirements;
- ✓ Need for support with suitable technical help and;
- ✓ Need for systems that allow educators to share ideas and resources.

IWBs advocate for interactive pedagogy in terms of:

- ✓ Preparation, selection of content and delivery of content;
- ✓ Adoption of recent pedagogical skills considering the technology such as scaffolding, focusing attention;
- ✓ Promotion of whole-class teaching or group discussion, interaction, collaboration and participatory learning.

Promotion of Need for technical support in terms of:

- ✓ Support with necessary tool and;

- ✓ Collaboration by educators is essential to the implementation of the IWBs.

The problems or barriers were identified as follows:

Technical problems:

- ✓ A computer may crash which means it may stop working or cannot work in a normal way, or network may fail;
- ✓ A projector may fail because the bulb has been blown. Need for school technician to be responsible for such services;
- ✓ Lack of ICT skills which may result in lack of confidence in using the board and;
- ✓ Lack of time to prepare educational materials.

2.7 RECOMMENDATIONS FROM THE LITERATURE

The body of literature reviewed reveals major themes that need further research in the context of South Africa. The major findings identified were from developed countries such as Australia, United Kingdom, and United States of America. There is very little literature from South Africa. This particular study looked into how these challenges as revealed from the literature prevail in South African schools. The study investigated the challenges educators face in the utilization of the IWBs in science instruction. It sought to understand how educators use the IWBs in providing authentic learning environments in the public high schools in the Durban metropolis in South Africa under the following issues: active collaboration, working in teams, authentic learning activities, project-based activities, forming networks, creating IWB-based learning environment and addressing learners' diverse needs. It also explored issues of professional development and training to include ICT literacy, pedagogical change / shift, cost and maintenance requirements.

2.8 CONCLUSION

The literature reviewed on the use of IWBs in teaching has been drawn mainly from the context of developed countries such as the United Kingdom, United States of America, and Australia. Literature search on the use of IWBs in teaching and learning environments in Africa and, in particular in South Africa, produced very limited results. Since the inception of the IWBs in educational settings in 1991, countries that spear-headed the use of the IWBs such as the United Kingdom, United States of America, and recently Australia, still meet with some challenges, such as professional development,

cost, pedagogy. Therefore, South Africa is not an exception in meeting the challenges, even though there were reports in place already that could have served as guidelines to the particular schools that have implemented the use of the boards in their teaching in South Africa. Whatever may seem possible in the developed countries may appear problematic in South Africa. The effectiveness of the IWBs depends on a number of factors as revealed by the literature. The predominant factor has been identified as cost, which covers the purchase of the IWBs, training of educators (in terms of acquisition of ICT or computer skills) and maintenance of the equipment. This aspect challenges the need for technology planning which is to cater for all aspects of installing and implementing the IWBs in schools.

By conducting this literature review, the researcher was able to ascertain what has been taking place in other countries identified earlier on. These countries are developed countries, which have used the IWBs in teaching and learning since 1991. Challenges in this context can be conceptualized as the factors that may affect the use of IWBs in science instruction. From the literature reviewed, the IWBs in general are characterized by enhancing learning through collaborative engagement, in authentic, challenging wealth of resources to include activities and tasks. This requires the creation of authentic environment that can promote learners' inquiry. Nevertheless, this can be achieved with proper use of the IWBs in terms of professional development and pedagogy.

This chapter has reflected on the possible benefits and challenges that educators face in the utilization of the IWB in teaching based on reports and literature reviews. However, the challenges are not so relevant to the teaching of science in secondary schools. The literature revealed a gap in knowledge with regard to challenges posed by the utilization of the Smart board technology in teaching science, particularly in the context of South Africa. The following chapter illustrates and discusses the paradigm and the theories of learning and the conceptual framework that the researcher has seen fit and relevant to influence and guide the study.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 INTRODUCTION

This chapter illustrates the paradigm and the theories of learning adopted and how they are used in this study. The focus is on the interpretive paradigm and the two theories of learning in the digital age, namely: Engagement Theory as propounded by Kearsley and Schneiderman (1998) as well as Connectivism by Siemens (2004). The section begins with offering the background of learning theories of the past in relation to the developments in technology, their relevance to these new directions, the development of the new learning theories and their relevance to learning in the digital age, and some of the limitations thereof.

3.2 BACKGROUND

At the end of the 1900s, the predominant paradigm of learning was classical conditioning, which evolved into behaviorism as, originated and contributed to by Watson, Pavlov, Thorndike, Hull, Skinner, and many others (Kearsley, 2000). The central idea of the theory is that learning occurs when there is a measurable change in the observable performance caused by external stimuli in the environment (Yvette, 2003). Furthermore, behaviourists claim that it is the observable behaviour that indicates whether or not the learner has learned something, and not what is going on in the head. This means they look at the evident behaviour that can be observed and measured as an indication whereby learning is achieved (Anderson & Elloumi, 2004).

Various forms of constructivism pioneered by Tolman, Bruner, Piaget, Dewey, Newell and Simon, and Anderson (Kearsley, 2000) later replaced this. The contention of this theory is on concept development and / or knowledge construction and deep understanding. Constructivists generally assert that individuals actively construct knowledge and the social interactions with others play an important role in the construction process (Mayer, 1996). Another view of learning is that learners learn by adding new information to their long-term memories. This information-process theory of learning is based on learning as knowledge acquisition (O'Neil & Perez, 2003). The key

proponents of this view, Wertheimer, Kohler, Ausubel, Gagne, and others commonly refer to this as cognitivism. Learning in cognitivism involves engaging with a series of thoughts / cognitive processes that are applied to mental representations, resulting in transformation of the mental structures (O'Neil & Perez, 2003). In this manner, the learner is viewed as an information processor just like a computer. In the similar vein, Patru (2002) asserts that learning occurs when there is interaction that stimulates development of cognitive capabilities.

In the process of designing or structuring instructional environments, the three main theories of learning are always considered. These theories are behaviourism, constructivism, and cognitivism (Siemens, 2004). However, he contends that these theories were developed in the time when learning had not been impacted through technology. There have been some considerable developments in learning which have taken place over the past twenty years. As a result, these theories proved to be insufficient in terms of addressing the way people learn in the digital era (Siemens, 2004). They failed to address learning that occurs outside of people, for example, they cannot mention anything about learning that is stored and manipulated by technology and fail to describe how learning happens within groups (Siemens, 2004). In fact, there was a need for a paradigm shift.

When considering the changes that have taken place in the theories of learning over the past century, Kearsley (2000) advises that it is important to realize that the nature of knowledge and expertise has changed dramatically. This may be associated with the introduction of technology. He argues that knowledge used to be something acquired based on experience over time. Nevertheless, in today's world, there is too much information that changes rapidly. Today the most up to date information is useful. Experts are more likely to be young than old because of the current information they get timeously. Knowledge becomes out-dated quickly as there is a lot of information coming up (Siemens, 2004).

Apparently, the old model of learning that emphasizes the orderly accumulation of knowledge, as discussed earlier, or the practice of well-known skills, are no longer

appropriate. Instead, models that focus on how to acquire, evaluate, and synthesize information are needed. Learners need to know how to learn collaboratively with others, not as a single initiative (Kearsley, 2000) In addition to these general trends, current approaches emphasize collaboration, interactivity, and authenticity in student learning activities (Kearsley, 2000), hence, the researcher's choice of engagement and connectivism theories of learning in the digital age. Kearsley (2000) postulates that these theories are heavily influenced by computer technology and they are reasonably different paradigms of learning from the previous century. In addition, the new learning theories propose for interactive learning environments with the new culture that respond to the diversity of learners (Kearsley (2000). Such environments should promote access of learners to relevant resources / tools and helped by facilitators / mentors, while the old paradigms for learning and knowledge were about absorption of content material where the teacher was the sole transmitter of knowledge (Kearsley (2000). Siemens' (2004) Theory of Connectivism guided this study: A Learning Theory for the Digital Age, as well as Kearsley & Schneiderman's Theory of Engagement (1998) were used to guide this study. These theories, together with others, form the theoretical framework and serve as tools of analysis for this study.

3.3 RESEARCH PARADIGM

A paradigm refers to “a more concrete conceptualization of an underlying idea or theory involving definitions, statements and interrelationships between the statements” (Hartley & Davies, 1978, p.16). A paradigm is usually qualitative in nature, may be expressed in words, in numbers, or even in some other type of visual display (Hartley & Davies, 1978). In this way, a unique description of the phenomena can be portrayed; underlying methodologies indicated and research questions worthy of further study suggested (Hartley & Davies, 1978). The paradigm may also be used to help explain events previously unexplained. It represents a dramatic new orientation and attempts to offer a “world view” (p.17) or wide embracing perspective of the nature of reality.

3.3.1 INTERPRETIVE PARADIGM

The researcher chose to conduct the study within the interpretive framework. Henning (2004) and Denzin and Lincoln (1994) argue that the interpretive framework is

qualitative in nature and human actions (as individuals or groups) are studied, constructed and interpreted in real-life contexts. In the context of this study, are the classrooms in which the educators use IWBs for teaching science. In addition, the interpretive (constructive) paradigm places emphasis on learning as an activity that is enhanced by shared inquiry (Brna & Aspin, 1997). The interpretation is based on a relativistic, constructivist ontology (Krauss, 2005), and this means reality in the interpretive paradigm is socially constructed since there are multiple realities. The forms of knowledge – epistemology are based on the belief that the best way to understand the ways in which educators utilize the IWBs is to view them in their context where they are used. These enabled the researcher to grasp the point of view of participants and give interpretations of participants' point of view from conducting interviews and engaging in observations (Denzin & Lincoln, 2003).

3.3.2 ENGAGEMENT THEORY

Engagement theory is a conceptual framework for technology-based teaching and learning (Kearsley & Schneiderman, 1999). The focus of this learning theory is its emphasis on learning that has important effects. The significance of learning can be seen when learners have the opportunity to interact with each other while learning and also interact with learning activities and tasks that are valuable (Kearsley & Schneiderman, 1999). In this context, learning that is characterized by engagement involves processes that promote acquisition of knowledge. Such processes as reiterated by Kearsley & Schneiderman (1999) include “creating, problem solving, reasoning, decision-making and evaluation” [://home.sprynet.com/~gkearsley-/engage.](http://home.sprynet.com/~gkearsley-/engage/). In point of the fact that engaged learning could still take place in the absence of technology, but technology can facilitate engagement in ways that are difficult to achieve in any other way. The theory adapts similar approaches to those of constructivism such as experimentation, authentic or situated learning, problem-based instruction, peer collaboration, etc (Kearsley & Schneiderman, 1999). The approaches involve and promote communication, management, and planning, social skills. These skills are the hallmarks of teamwork, and are critical to these learners in the end where they will be expected to contribute to strategic planning in the organizations they would be in (Knowlton, 2006).

Engagement theory is mainly concerned with life-long learning. In this regard, learners work together on those projects that are motivating, challenging and those that are directly applicable and relevant to the world of work (Kearsley & Schneiderman, 1999). Such projects or activities should take place where learners work together in pairs or as a group. Learners learn from each other as they investigate issue together and these provide peer support, which cannot be found in individualized environments. The activities should be authentic and should require some time and effort to plan and implement strategies (Kearsley & Schneiderman, 1999). This theory is characterized by the principles of Relate, Create and Donate, which are discussed below.

‘Relate’ is the first principle that draws attention to learners working in teams. It is in this case whereby communication, management, and planning, social skills are likely to be promoted. Learners need to be proficient in these skills as a demand of the modern workplace (Kearsley & Schneiderman, 1999). This means what learners learn should be relevant to what is taking place in the world of work. Individual learning has no place recently; rather experiential learning seems to supersede most styles of learning. Furthermore, ICTs such as the IWBs are important because today’s learners are living and working in a world where these technologies are increasingly important (Sang & Frost, 2005).

In the research conducted by Kearsley (2000) working in teams or collaborative learning is a process of learning whereby learners are required to explain in detail their problems together, to simplify or break down complex issues so that they become simpler and easier to understand. As they embark on these tasks, they in turn make it easier for them to get the solutions as a team. Furthermore, normally group members or team members are from different backgrounds, they have different exposure as well as experiences. These attributes afford learners opportunities to quite different viewpoints (Kearsley, 2000). As learners work together in teams; their motivation to learn increases as they are exposed to greater challenges, also they develop an attitude of liking each other from working together and this increases their motivation to learn. The challenges they face as team members inspire them to express their views and respond to each other’s ideas, thus

allowing them to construct new ideas and thoughts (constructivism), and increase their chances to provide solutions to their problems.

Engagement theory and connectivism are similar in nature because they both encourage collaboration among team members and a community of learners who have common goals and interest. Both theories underscore social interactions and collaboration as essential components in the social learning process (Kearsley & Schneiderman, 1999). These skills can foster good relationships throughout their lives. In support of this view, IWBs have features that offer greatest benefits such as engagement of learners, diverse learning styles and outcomes and support collaborative learning (Gage, 2005; Knowlton, 2007).

The second principle of 'Create' considers learning as a skillful, imaginative and original endeavour. Learners come up with strategies to solve or find solutions to the problem at hand. This involves critical thinking. Learners need to develop the ability to think about problems and make decisions in a reasonable way. This implies that learners have to come up with alternative ways to solve problems. They need to put those alternatives into test before they could consider them appropriate to solve their problems (Kearsley, 2000). In teaching science, conducting projects could be interesting in learners. They become interested to conduct their own projects than merely answering book problems. As they engage in projects, they develop skills and ability to produce something new, for example, new ideas to solve problems; they have a sense of control over their learning, which is lacking in traditional classroom instruction (Kearsley, 2000).

'Donate' is the third principle underlines the importance learners to make an input to their learning by contributing their views, opinions in the process of learning; so that the results or the goals of the lesson are achieved (Kearsley & Schneiderman, 1998). Learners become enthusiastic, curious and eager to learn when they are exposed to authentic learning situations. Learners need to apply what they have learned to real-life situations. They also need to explore and share information to promote knowledge construction and acquisition of skills to solve problems. This is what Kearsley (2000) refers to as increased student motivation.

Engagement theory sounds different from other older models of computer-based learning in which the emphasis is on individualized instruction and interactivity. The relevance of this theory to this study is that the IWBs have features that engage learners, address diverse learning styles and outcomes and support collaborative learning (Gage, 2005; Knowlton, 2007). Engagement theory encourages interaction, but interaction in situations where group activities take place. Furthermore, engagement theory stresses the importance of providing authentic and meaningful setting for learning. Engagement theory is ideal for the interpretation of teaching and learning in science – the focus of science being natural phenomena. In addition, terminology in science is usually new to learners. The IWB can be used to advantage learners in conceptualizing science and visualizing difficult-to-understand concepts. The board on its own cannot promote conceptualizing science concepts unless educators can select activities that can help learners understand science concepts, especially abstract concept through the use of clipart, models, simulation. This may involve the use of the interactive periodic table to identify metals and non-metals, their protons (atomic number) and electrons they contain and chemical elements, chemical reaction, how molecules move and collide, and so on.

In support of the above view, Gage (2005) states that an IWB is a tool which, when used well, can help educators teach well. Gage (2005, p.18) asserts, “No piece of equipment, however wonderful, can make anyone a better teacher by itself.” In essence, engagement theory is concerned with learners that participate with each other, work together in order to create knowledge. Therefore, to achieve this, learners need to be exposed to a rich environment with activities that will initiate them to participate actively and practice together. Thus, the IWBs can be used to facilitate the engagement of learners as a communication device rather than a medium to disseminate information (Kearsley & Schneiderman, 1998), hence the relevance of this theory to this study.

3.3.3 CONNECTIVISM

Technology has appeared to be an important channel for the improvement of teaching, learning and training. Connectivism considers this possible through active collaboration, networking and working in teams (Siemens, 2004). Learning in connectivism is a networked process, it also advocates for free and unbounded style of learning. It

emphasizes different target audiences, different areas of focus and even different outcomes (ubiquitous pedagogy) (Siemens, 2004). The theory is connected with the notion of lifelong learning. Learning does not take place only between the four walls of a classroom but it takes place anywhere, anytime. This is the idea that learning should be learner-centred, it should be structured to suit everybody, it should cater for individual differences, it should be about constructing own knowledge and discovery, it should occur in different contexts (Siemens, 2004). All of the above should allow learners to form networks that promote conceptual change through instructional practice and interactive demonstration designed to help learners overcome misconceptions permanently. As a result, connectivism seems an appropriate theory for interlinked and non-linear type of learning required in the digital age.

The researcher regards this theory as a significant basis to the research because it combines relevant elements of many learning theories, social structures, and technology to create a powerful theoretical construct for learning science in the digital age (Perrin, 2005). As Siemens (2005) puts it, as knowledge continues to grow and evolve, access to what is needed is more important than what the learner currently possesses.

However, connectivism has some limitations. It has been identified as not a learning theory, but a didactic or instructive thought (Verhagen, 2006). Verhagen (2006) contends that connectivism has appeared to address the levels of curriculum, which is, what is learned and why it is learned, whereas learning theories should propose how people learn, and not the instructional level of the curriculum. Another criticism of the theory is that there was no need for such a theory, although technology seemed to affect the learning environment; the theories of learning that exist are sufficient (Kerr, 2007). He further asserts that what is happening, such as the pace of knowledge, the changed nature of knowledge, are not very new at the level of learning theory. Furthermore, Kerr (2007) argues that equally the existing learning theories place processing of knowledge on the individual doing the learning. Parallel to the criticisms, Siemens (2007) poses a firm stand for connectivism that information and knowledge do not only lie in human brains, but in electronic networks, for instance, computers and the Internet. The information frequently changes so that it becomes current and relevant. Again, he states that

connectivism does not follow a linear style of learning. It is about openness, large quantity of and access to information.

The concepts that the researcher interrogated in this study were identified as follows: active collaboration, working in teams, learning ecology, networking or forming connections, authentic learning activities, and project-based activities. These concepts have been derived from Connectivism and Engagement theories of learning which dictate learning in the digital age. The concepts were adopted to guide the study. The concepts of diverse learners' needs, working in teams, learning ecology and networking or forming connections were drawn from Connectivism theory. For the reason that Connectivism does not address the nature of activities that learners need to engage in; this implies that the theory seemed to be lacking in concepts that would best address the needs of this particular study. Due to these inadequacies, the researcher decided to incorporate other concepts such as authentic learning activities, project-based activities, and active collaboration in order to form a comprehensive framework. These three concepts were drawn from the Engagement theory in order to complement the framework that guided the study. For the purpose of this study, the researcher has developed the model below to represent how learners learn in the digital age.

3.3.4 Model of the theoretical / conceptual framework

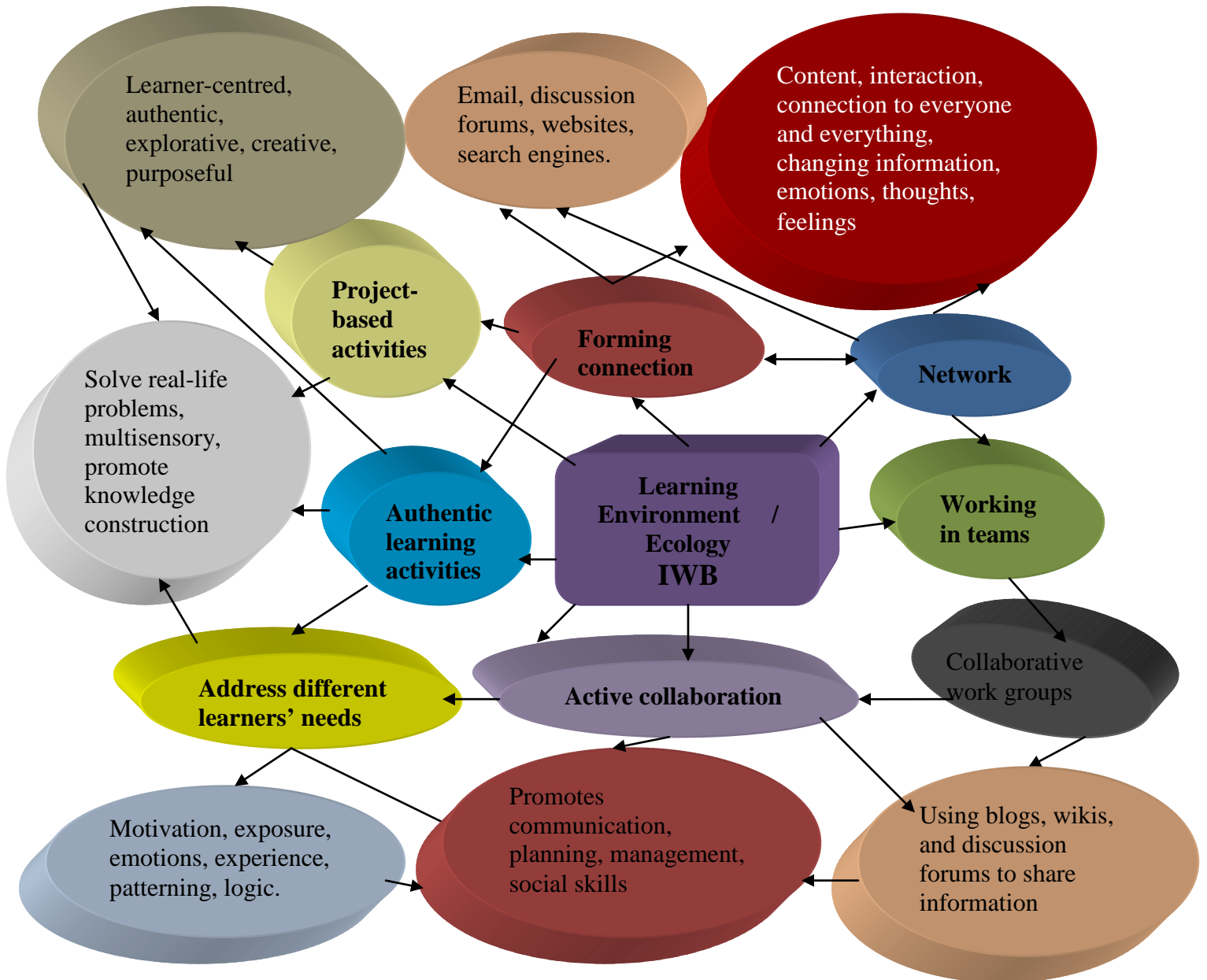


Figure. 3 Model drawn by the researcher to represent how learners learn in the digital age based on the theories of connectivism and engagement.

Figure. 3 above illustrates how learning takes place in the digital classroom. The following are definitions attached to the concepts as illustrated in Figure. 3 to suit the needs of the study:

At the center of the model is the learning environment, which refers to the technology-based classroom such as a classroom with an IWB. This technology can be used as a communication device as well as a medium to disseminate information (Kearsley & Schneiderman, 1998). This is an environment that utilizes technology tools such as the IWB and internet in the teaching of science and demonstrates ways to bring inquiry into the classroom, scaffolds concepts, and illustrate instructional models (Chilcoat, 1989). Additionally, learning should be multisensory; that is, the learning environment should provide information that involves sounds, graphics, audio, video, and animation, which respond to different learning styles. The IWBs can support a variety of learning styles and learners' backgrounds (Slay, 1997). This is so because it can provide authentic environment for learning (Kearsley & Schneiderman, 1998). The use of the internet can make this possible since it can facilitate collaboration, interactivity and project-based learning. Internet tools such as the Web Quest and WebCT can facilitate active learning (Damoense, 2003). The IWB learning environment should promote creation of knowledge and acquisition of skills that are directly connected to real world. Such learning environments are ideal to learning as they are capable of accommodating all kinds of intelligence.

A technology-based environment for teaching science should be characterized by real or authentic learning activities that allow social interaction, peer collaboration, discussions, active participation, and flexibility. The learning environment should provide activities that make it possible for learners to seek information, to conceptualize science concepts and visualize difficult to understand concepts through peer support. Clipart, simulations, multimedia features and models can be relevant in this matter. These activities should lead learners to solve real-life problems beyond the educator and the classroom (authenticity, unbounded and life-long learning) (Kearsley & Schneiderman, 1998, Siemens, 2004)). Furthermore, activities that encourage engagement also incorporate collaborative work among peers, for instance, active collaboration and working in teams that fosters active participation of learners with the content, with learners themselves and the IWBs. Authentic tasks such as simulations increase learners' level of interest, thereby improve their motivation to learn.

Learning environment in the digital age should enable learners to connect to each other (connectivity), to self-organize, to form discussion groups where learners can share insights and explore learning topics together - thus promote forming connections or networking (shared knowledge) (Siemens, 2005). The use of the IWB should enable learners to connect to everyone and everything through e-mail, discussion forums, websites, search engines, file-uploading (Kearsley, 2000). Additionally, the use of the IWB should promote connections between learners, learners and educators and between learners and the resources that would aid in the construction of knowledge. Access to rapidly updated information contributes to recent content that motivate learners to learn and hence enhance their critical and creative thinking in order to solve problems. In addition, frequent interaction with the changing information or content also promotes knowledge construction and active learning and successful learning experiences.

The use of the IWB should be seen to promote either learning that involves structured instructional interactions – active collaboration, among two or more learners, educators, and the environment such as the IWB or the learning materials afforded by the IWB so that knowledge construction is enhanced in order to achieve a learning goal (Kearsley, 2000). This could be reached through the addition of information that is multisensory and involve sounds, graphics, visuals, animation and other multimedia features to respond to different learning styles.

Collective intelligence helps learners to conceptualize information (Siemens, 2004; Kearsley & Schneiderman, 1998). As learners investigate problems together, they in turn provide peer support. It is in this situation where learners are exposed to diverse opinions, experiences and exposure that will lead them into taking informed decision. Collaboration also promotes interaction in the context of group activities, not individual interaction (Kearsley, 2000). Additionally, in the process of collaboration, learners help each other to diagnose and solve problems, by incorporating diverse viewpoints into their understanding of subject matter, thereby facilitate solutions (Kearsley & Schneiderman, 1998). In collaboration, communication, planning, management, and social skills are important. They are skills required in the workplace. As learners work together, they are able to acquire such skills that in turn contribute to the process of solving problems, and

hence their motivation to learn increases (Kearsley & Schneiderman, 1998). Since there is increased inclusion and participation, learners are able to learn from others, solve problems together, and share information to come up with solutions. The IWBs in this case become communication tools that provide authentic, meaningful environment for learning.

The use of the IWB should inculcate participation in collaborative work with groups, working in teams to share information using blogs, wikis, and discussion forums. This encourages willingness to share and critically discuss aspects of practice and curiosity of concepts (Siemens, 2004). When learners work in teams, they have the opportunity to work with others from different backgrounds and this facilitates an understanding of a range and various perceptions (collaboration) (Kearsley & Schneiderman, 1998, Siemens, 2004). In this framework, the role of IWBs is to make possible all aspects of engagement. The use of e-mail, blogs, wikis, and discussion forums increases the extent and makes interaction amongst learners near and far easy and possible to include access to information. For instance, the use of e-mail to exchange ideas on a given task is an extension of collaborative learning. In this study, the IWBs again provide a learning situation that can foster creativity and communication necessary to promote engagement.

The use of the IWB should provide activities that allow learners to work in groups – project-based activities to solve challenging authentic tasks, which challenge learners' experiences, and conceptions so that they are able to reconstruct explanations or new concepts, apply them and evaluate them (Kearsley & Schneiderman, 1998, Siemens, 2004). Learners should make a useful contribution while learning (donate) (learner-centred) Kearsley & Schneiderman, 1998. According to Damoense (2003), project-based activities provide a channel for learning new information in a context that is meaningful, that exposes learners to real problem –oriented cases relevant to their learning outcomes. The IWBs can provide web-based resources that can enhance problem-based activities. They should be encouraged to seek knowledge (exploration). Again, learning should be learner-centred, creative and purposeful (Kearsley & Schneiderman, 1998). In science teaching, conducting projects could be interesting in learners than merely answering textbook problems. For instance, learners can take a virtual tour on the Internet, to look at

erosion from the sea or river; they could develop questions and, investigate on what they see. As learners engage in the projects, they have a sense of control over their learning, which is lacking in the traditional classroom instruction (Kearsley, 2000). Such activities should address learners' different learning styles (Kearsley & Schneiderman, 1998; Schneider *et al*, 2002). Engaging in such activities involves motivation; satisfaction, emotions, exposure, patterning, logic, and experience, hence address different learners' needs (Kearsley & Schneiderman, 1998). This also allows diversity in learners. Following that, when learners gain connections among concepts and explanatory principles, their interest in the content increases (Siemens, 2004). In addition, interaction and collaboration of learners contribute to positive attitudes and perceptions, motivation, confidence and participation. These aspects lead to successful learning experiences. Furthermore, access to rapidly updated information as identified by Siemens (2004), interactivity and collaboration are opportunities provided when using the internet in learning (Damoense, 2003), which enhance construction of knowledge and active learning (Kearsley & Schneiderman, 1998).

The components of learner-centred, authentic, explorative, creative, purposeful instruction require interactive methods of instruction using the IWBs. This type of instruction actively engages learners and promotes collaboration (Kearsley & Schneiderman, 1998). Again, the instruction should promote originality. This means that learners are encouraged to construct and produce new meaningful conceptions, create new strategies to solve problems, make decisions, and apply knowledge. Within this framework, the IWB can help learners to build meaningful understanding of difficult content material, come up with new strategies, apply critical and creative thinking and solve problems (Slay, 1997).

The researcher conducted the study under the interpretive paradigm. There is a relationship between the interpretive paradigm and these learning theories. Interpretive paradigm is "fundamentally concerned with meaning and it seeks to understand social members, definitions and understanding of situations" (Henning, 2004, p.21). This ties with the purpose of this study of gaining a deep level of understanding of individual participants' experiences, that is, educators who use the interactive electronic whiteboard

in their teaching of science, and perceptions of their professional roles as experienced in their day-to-day working environment, from the standpoint of their unique contexts, and backgrounds. Given this information, it is apparent that these approaches as discussed together with the paradigm embrace some common characteristics as identified by Kearsley (2000) such as:

- ✓ Collaboration – learners often work together.
- ✓ Connectivity- learners are connected to everyone and everything.
- ✓ Learner-centred- Learners choose what and how they learn.
- ✓ Authenticity- Learning in a real world.
- ✓ Community- groups defined by common interest.
- ✓ Unbounded- classroom walls do not limit learning.
- ✓ Exploration- learners are encouraged to seek knowledge.
- ✓ Shared knowledge- there is an easy way to share knowledge (on global basis).
- ✓ Multisensory- information can involve sounds, graphics, audio, video, and animation that respond to different learning styles.

Kearsley (2000) and Collis (1996) both agree that these characteristics as identified above are enabled by technology: email, discussion forums, conferencing, websites, search engine, plug-ins, file uploading, etc. Collectively, these characteristics define a new culture of learning (Kearsley, 2000; Collis, 1996), an internet-based culture as Tapscott (1998) rightly puts it.

3.3.5 CONCLUSION

This chapter has presented a theoretical perspective that informed the study. The study is conducted under the interpretive paradigm, and guided by theories of Connectivism and Engagement. Both theories are suitable to learning in the digital age. The conceptual framework has also been presented. It consists of principles of active collaboration; working in teams; addressing diverse learners' need; authentic learning activities; project-based activities; networking and learning ecology. The next chapter presents the research design and the selected methodology that involved a reflective investigation of the experiences of two public high schools educators who use the IWB in teaching science that was adopted to collect and analyze data in order to answer the research questions.

CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

This chapter discusses the position of the study in terms of the paradigm, the design and methodology that were adopted in order to elicit data that was used to respond to the key research questions that guided the study. The inquiry adopted a qualitative case study design and methodology. The researcher used interviews, questionnaires, and observations as techniques of collecting data from educators and learners, and reasons out for the choice of the methods by extrapolating on its strengths and limitations in practice. Furthermore, the chapter discusses clearly how the data was produced from the two schools by presenting brief descriptions of lessons and the problems that the researcher encountered in the process of conducting this study. Following that is the discussion on the data analysis procedures and how issues of credibility and trustworthiness were taken care of, to include the ethical considerations. Finally, conclusion is drawn.

4.2 RESEARCH DESIGN VERSUS METHODOLOGY

Research design is different from methodology. The former is a plan of action that a researcher lays or puts down as a guide towards the study to undertake (Terre Blanche & Durrheim, 2006). Usually such a plan is drawn before the data collection or analysis can begin. This work plan includes all the necessary applicable steps and activities the researcher intends to embark upon in order to complete the study; not only that, but also collect the required data that will address the problem at hand (Terre Blanche & Durrheim, 2006). Therefore, research design ensures that the evidence obtained enables us to answer the initial question unambiguously (de Vaus, 2001). Research design is a plan that starts with a research problem and then concentrates on the evidence basic to answer the research question. Alternatively, Henning (2004, p. 36) defines methodology as

the coherent group of methods that complement one another and that have the goodness of fit to deliver data and findings that will reflect the research question and suit the research purpose.

What the above definition implies is that methodology addresses the choice of methods, critically discussing the rationale behind choosing and using such methods. To summarize the difference between the two concepts, a research design covers research questions, methodology, theoretical and conceptual framework, population and sampling, data production and analysis methods, time plan and budget while methodology concerns the approach to employ in order to collect the required data. What this means is that the type of data necessary to answer the research questions determines the methodology to use such as a case study, which provides a unique example of real people in real situations. This affords the readers to understand ideas more clearly (Cohen *et al*, 2007).

4.2.1 RESEARCH DESIGN

The qualitative research design is open-ended; the procedures and the scope are flexible (Mouton & Marais, 1990). This study adopted an interpretive research design. It involves interpreting the social life in natural settings, for example, the two public high schools in the Durban metropolis. The educators informed the study by interpreting and making decisions about the actions that are undertaken in the classrooms based on their own experiences and their behaviours. The interpretive research design was relevant to the study because it allowed for collection of qualitative information, observing the educators in their social world [classrooms] and talking to them through interviews (Cohen *et al*, 2007). The interpretive paradigm is concerned with social interaction in social settings [educators and learners in school situation].

4.2.2 QUALITATIVE CASE STUDY METHODOLOGY

Scholarships on case study have come up with many different definitions of case study; all equally emphasizing the usefulness and efficiency of each to achieve their own purposes and that they have different orientations and solve different problems. The researcher has identified a few definitions including the following:

A case study is a problem to be studied, which will reveal an in-depth understanding of a “case” of bounded system, which involves understanding an event, activity, process, or one or more individuals (Creswell, 2002, p.61). Eckstein (2002, p.124) defines case study in technical terms “as a phenomenon for which we report and interpret only a single

measure on any pertinent variable.” According to Yin (2003, p.13) a case study is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and the context are not clearly evident.”

All the above definitions are naturalistic (Terre Blanche & Durrhein, 2006). In the first definition, the researcher is urged to begin the research process with a predicament, which will bring to surface some understanding about the ways educators utilize the IWB in the teaching of science. The case being the utility of the IWB, then the researcher is challenged to select an activity or process (such as observations of lessons) around the usage of the IWB to clarify it, hence involves an understanding. The second one highlights that a case is a focused object of interest, a significant flexible phenomenon. Therefore, in this case study, significant phenomenon under investigation is the use of the IWB, which may differ from school to school. The last definition requires the researcher to engage in any practices essential to define the situation from the natural background, for example, engage in activities of using the IWB - through observations; the educators themselves through interviews, and so on.

A case study is one type of qualitative research (Merriam, 1998). Similarly, Bertrand and Hughes (2005, p.253) define case study as “a detailed and intensive study of a single case, usually by a combination of methods such as document analysis, interviews, observations or participant observation and often resulting in thick description.” Therefore, this means that case study is not a method because a case study itself cannot be used to collect data, rather utilize numerous research methods as identified above by Bertrand and Hughes (2005). For this particular study, the researcher used interviews; individual and focus group, observations and simple open-ended questionnaires. The emphasis of the study was to obtain in-depth description of educators, their behaviours, experiences and perceptions within the natural settings or contexts (the respective schools and particular classrooms) (Cohen, Manion & Morrison 2007; Creswell, 2003).

In this study, the researcher conducted a case study to identify and understand the use of the IWBs in teaching science in some public high schools in the Durban metropolis. The

researcher had intended to review and analyze documents such as tuition policy, school improvement plans, technology plans, but unfortunately, both schools did not have such documents. Furthermore, the researcher also interviewed the key informants who were the educators who utilize the interactive electronic whiteboard in teaching science in the two public high schools in the Durban Metropolis. In addition, the researcher engaged in observation of educators using the IWB. In the similar vein, Cohen, *et al* (2007, p.254) postulate that case study gives a feeling of ‘what it is like’ to be in a particular situation, to catch the close up reality and thick description. In addition, learners shared their feelings and reflections about their learning science using the IWB. An open-ended questionnaire was used in this situation.

According to Yin (2003, p.4), case study is “the method of choice when the phenomenon under study is not readily distinguishable from its context.” For this reason, the case study was chosen as a research method. The adopted methodology is twofold: on one hand it may regarded as an exploratory case study aimed at ascertaining the nature of practice in utilizing the IWB in teaching science, and also to gain insight into the challenges of the educators at their different schools, hence a qualitative design that was contextual. On the other hand, it could be regarded as a descriptive case study, in that it provides as overall picture of a phenomenon within its context – teaching science using the IWB in a classroom with learners and educators. In this manner, the researcher attempted to learn about and understand the benefits and challenges of using the IWBs as educators describe them (Coe, 1991).

The case study is most appropriate and suitable for the proposed study because it allowed the researcher to focus on a specific situation and attempts to identify the various interactive processes at work (Bell, 1999). In the similar vein, Cohen *et al* (2007) argue that case studies can penetrate situations in ways that are not always susceptible to numerical analysis. In addition, one of the strengths of case studies is that they allowed the researcher to observe effects in real contexts, recognizing that context is a powerful determinant of both causes and effects (p.253). Again, the researcher was able to get as close to the subjects of interest as possibly can, by means of direct observation in natural settings and also by access to subjective factors (thoughts, feelings and desires)

(Merriam, 1998). This case study allowed the researcher to investigate and report the “complex, dynamic and unfolding interactions of events, human relationships and other factors in a unique case in point” (Cohen *et al*, 2007, p.253).

The case study has been recommended for its appropriateness and suitability to the study as discussed above. Notwithstanding its advantages, there are weaknesses associated to case study and cannot be ignored.

- ✓ The results may not be generalized except where other readers and researchers see their application;
- ✓ They are not easily open to cross-checking; hence they may be selective, biased, personal and subjective and;
- ✓ They are prone to problems of observer bias, despite attempts made to address reflexivity (Cohen *et al*, 2007, p.256).

4.3 QUALITATIVE APPROACH

This study adopted a qualitative research approach. The choice for this approach was that the research hoped to understand the lived experiences of thoughts about, feelings, and perceptions of educators who use the IWBs in teaching science in public high schools in Durban (Cohen, *et al*, 2007; Creswell, 2005). Again, the approach enabled the researcher to conduct the study in its natural setting, which is the schools and the classrooms. The qualitative research approach allowed open-ended methods to explore and understand the attitudes, opinions, feelings, and behavior of individuals or a group of educators (Lauer, 2006; Mouton & Marais, 1990).

The educators were able to use different ways of expression. Educators told their stories as guided and probed by the researcher whereby semi-structured individual and focus group interview schedules were used. Educators were also able to present concrete narrative details of actual events (Boehrer, 1990). A qualitative research approach is like a play or a drama; it is more practical than theoretical; it has a plot, this means it is made up of series or events which are planned or designed by the researcher to guide the study, that is, the researcher was able to determine what kind of data to collect in order to answer the critical questions, how and when the data are to be collected, from whom to

collect the data and how the data were to be analyzed and presented. Additionally, the qualitative approach considers the exposition. This is part of the study where the researcher explained the background and the research setting. It is at this time that educators as characters were observed presenting and demonstrating their knowledge and skills using the IWB in teaching science in real classroom contexts. Again, qualitative approaches allow for communication between people. The researcher also engaged in some dialogue with educators and educators among themselves had their own conversations. Educators discussed and exchanged ideas on their experiences and perspectives of teaching science using the IWBs. The researcher opted for this approach to gain an in-depth understanding of educators' behaviours and the reasons that led to their exhibited behavior. Thus, the researcher was not interested in the causal relationship (Maree, 2007).

Due to failure to get permission to use some schools as research sites, the researcher ended up with a very small sample for the study. In this study, only two public high schools and six participants were involved. Qualitative approach allows for the use of a small group of people especially when there is a current focus within a real-life context (Merriam, 1998). Therefore, there was a need for an approach that would allow a smaller but focused sample like a qualitative case study approach. Furthermore, the study findings were interpreted following a conceptual framework and major issues from the literature. Therefore, qualitative research approach became relevant in this study since the researcher was able to categorize data into patterns as the primary basis for organizing and reporting results (Miles, & Huberman, 1994).

Again, a qualitative approach allowed the researcher to use text and other literacy techniques such as quotes, samples, artifacts and events to describe, elicit images, illustrations, and models and analyze situations instead of reporting findings in numerical data (Merriam, 1998). In addition, qualitative approach best fit the purpose of the study. It allowed for collection of qualitative data that appeared to be descriptive in nature (Merriam, 1998). This type of data were collected and recorded by the researcher at the moment as things happened using the common qualitative instruments of data collection such as interviews, individual and focus group, observations and open-ended

questionnaire. The data that the researcher collected was in the form of words, quotes, pictures, and diagrams. Similarly, Cohen *et al* (2007) contest that qualitative data often focus on smaller numbers of people than quantitative data, yet the data tend to be detailed and rich. The data collected are unique to the two public high schools that participated in the study, therefore cannot be generalized.

Generally, the researcher decided to choose the qualitative approach because the researcher was primarily interested in the educators' perspectives and experiences with regard to their self-perceptions and ethnic experiences in teaching science using the IWBs. Qualitative approach has provided insight into the underlying issues that are most significant to educators who use the IWBs in teaching science (Eckstein, 2002). In support of the choice of the methodology for this study, Miles and Huberman (1994) assert that qualitative research has been recommended as the best approach for discovering and exploring a new era. In qualitative studies, the researcher is recognized as being the "data collection instrument, as the ethnographer and participant observer" (Stanfield, 1993, p.4). So in this study, the researcher was the sole data collector who used interviews, observations and questionnaires to "build upon tacit knowledge" (Lincoln & Guba, 1985, p.187). In this situation, Bell (1994) confirms that a qualitative research approach is particularly appropriate for an individual researcher. It provides the opportunity to research a specific phenomenon in some depth within a limited time scale.

The research adopted a qualitative approach also because of the fact it pays more attention to the context of data gathering in order to enhance its value (Yin, 1994). Analysis of qualitative material is "more explicitly interpretative, creative and personal than in quantitative analysis" (Walker, 1985, p.3). Apparently, qualitative approach shows more interest in personal experiences and shows more respect and concern toward human beings that are both emotional and highly flexible (Cohen *et al*, 2007). The researcher spent some time in each school before the actual data collection to be familiar with the settings, educators and learners hence affording the researcher knowledge of whom she / he will be working with, at what time and at what point. This and other issues were made possible because the researcher considered negotiating access to people in the plan as per Cohen *et al* (2007). Relevant gatekeepers were approached and permission

was granted. Consequences of the study were made explicit. Anonymity of participants was ensured in order to protect participants. Pseudonyms are used for both participants and the schools. Ownership of data was negotiated in terms of assuring confidentiality in the data provided (Cohen *et al*, 2007). Another issue that the researcher considered was the conduct of the study. The researcher identified the use of primary and secondary sources of data, the opportunities to check data, triangulation, and peer debriefing of the findings. Finally, the conduct of the study also entailed data analysis and report writing (Cohen *et al*, 2007).

4.4 MULTIPLE METHODS

The use of multiple methods in research is a way of applying two or more techniques when collecting, interpreting and analyzing, and in presenting data (Cook & Fonow, 1990). Multiple methods and sources of data were used through out the research process. Often the incorporation of both qualitative and quantitative techniques characterizes triangulation, with the findings from each complementing the other (Cook & Fonow, 1990). For instance, in this study interview data was used to confirm the observation as well as questionnaire data.

In this study, the researcher used more than one method and source of data collection in order to allow for triangulation. This contributed to the credibility and trustworthiness of the study (Nieuwenhuis, 2007). One of the qualities of a case study research approach is the capability of triangulating data (Feagin, Orum & Sjoberg, 1991). For this research, both data triangulation and methodological triangulation have been used. The researcher considered to have triangulated data from simple questionnaires with the data from interviews and observations; and on the other hand, triangulated the interview method with the observation method as well as the questionnaire method. It also allowed for thick description of the challenges faced by the educators concerned (Merriam, 2001). Multiple methods mean the researcher can discover the realities of people's lived experiences from many different angles and from different sources. This allowed the research to become richer and credible (Nieuwenhuis, 2007).

4.5 RESEARCH SETTING AND SAMPLING

This in-depth study focused on two research settings: two public high schools in the Durban metropolis. These, however, are very far apart, with one school situated in the south, while the other one is towards the north. The learner population in both schools is composed of Indians, Africans and Whites. The researcher did an internet search for the schools that have IWBs and used them for teaching. The researcher identified more than eight schools, of which three of them were visited to place applications for conducting research. E-mails were sent out to seek consent from school authorities to grant permission for their schools to be used as research sites. All applications were turned down.

Deeper investigations were further done until the researcher was able to identify these two schools, which participated in the study. A request (appendix V) to the principal of Bereng High school was sent through e-mail, which was responded to positively after a day, and the informed consent was faxed to the researcher on the 14 February 2008. With Mamathe High school, the researcher came to know about the school while sharing with a friend whose application was turned down on the ground that the school does not use videos anymore; instead, they have recently opted for using IWBs in the teaching of Mathematics and Science. Then the researcher e-mailed an application (appendix V) to Mamathe High school whose response was solicited by the Head of the Science Department on 25 April 2008 and the informed consent was sought out on 30 April 2008.

Arrangements to visit the schools for the purpose of introduction were made. The researcher met with the principals of the two schools as per arrangement. With Bereng High school, it was arranged that the researcher would meet with the participants on 29 April 2008 at 3.00pm, while with Mamathe High school participants' meeting was scheduled for 2 May 2008. Participants met with the researcher and appointments were set for the data collection to take place. In order to respond to the ethical issues of the study, letters of consent (appendix VII) were issued out to prospective participants to read. The letters contained all the details of the study, its purpose, and the anticipated period in the field, confidentiality and anonymity were assured. The researcher sought informed consent and permission from the principals, educators and parents / guardians

for learners who were interested to participate (see appendices V, VI, VII respectively). In both schools, the Heads of the Science Department were assigned to work with the researcher through out the data collection period. In this write-up, pseudonyms are used for non-traceability of participants as well as of the two schools. The two schools are referred to as Bereng High School and Mamathe High School respectively as used earlier.

4.5.1 THE CONTEXT

According to Merriam (2001), the typical feature of qualitative research is that it is richly descriptive. The qualitative case study focused on two high schools. It is a research design focusing on one case - schools with educators who utilize the IWB for teaching science. It is therefore important to give the profile of the schools selected for this study since they constitute the research context where the data were collected. Bereng High School opened in 1953. It is an English-medium, co-educational high school north of the Amanzimtoti business centre and approximately a kilometre from the shores of the Indian Ocean. It has modern, well-equipped buildings and playing fields. It caters for more than a thousand learners and more than fifty members of the staff to include auxiliary staff members. It has a reputation for sound scholastic achievement and an enviable record in the sporting and cultural fields. The school has been recognized for promoting and achieving greater access to Mathematics and Physical Science for its learners particularly those who were disadvantaged in the past. As for now, the school has installed five interactive electronic whiteboards. The boards are currently intended to be used in the teaching of Science and Mathematics. However, the other boards were placed in the Mathematics room and the Computer room.

The latter is a multi-cultural high school situated in Pinetown. It was founded in 1955. It has two boards, namely: the Promethean ACTIVBoard and e-Beam Board, both utilized in the teaching of mathematics and science. The school accommodates more than a thousand students from all places around Pinetown district, and a multicultural staff of approximately forty members. It has a well-equipped computerized Media centre, which promotes self-studies and independent learning. Similarly, this school has created itself a good reputation in the outstanding performance in Mathematics and Science at Grade 12. The school seemed to be well resourced. It has other technology resources that have been

used, such as overhead projectors, videos, for which the latter have been faced out and had opted for IWBs. However, the school has only two boards, but the Head of Science Department assured that more boards will be installed in the near future with the intention of having at least a board in each learning environment.

Both schools received an excellence award in Mathematics in 2007. The awards were presented on the schools' consistent excellence and performance in Mathematics. Again, the schools have been recognized as Dinaleli Schools for promoting and achieving at their best in Mathematics and Science especially towards learners who were disadvantaged in the past.

4.5.2 THE PARTICIPANTS

The researcher chose the participants by using purposive sampling. The educators were chosen based on their availability as well as convenience in reaching them at their respective schools. This seemed to be advantageous for the study because in-depth data was obtained since educators were personally involved in the teaching process using the IWBs. Therefore, personal involvement permits first-hand experience and understanding. The participants in this study were three educators; two Grade 11 and 12 science teachers and one Grade 10 from Mamathe high school; all of which were female and three Grade 10 science teachers from Bereng High School; one male and two females. Eight learners were selected to share their reflections about learning science using the IWBs. However, due to some constraints in Bereng High school pertaining to the use of the IWBs, it was not possible to get learners interviewed because they have never used the IWBs. Pseudonyms have been used to protect the identities of educators as well as of the schools.

4.5.2.1 'MAMATHE HIGH SCHOOL

The participants at this school were Tara, Dolling and Irene. Tara is in her early forties. She was teaching Science at Grades 11 and 12 and Mathematics at Grades 10 and 11. She has taught for more than ten years. Tara was usually in both formal and casual outfit especially during the sporting activity days as the time of the data production seemed to be a very busy time where the school was involved in different sporting activities such as hockey, basketball to mention a few. She seemed very busy at all times. Apart from the

teaching routine, she had other special responsibilities such as hockey coach, a member of the disciplinary committee where she was concerned with the relationships of educators and learners for the smooth learning of learners. She demonstrated a good relationship with her colleagues as well as the learners. She was assigned to assist and work directly with the researcher through out the data production period and she was the very first participant to agree to take part in the study. Tara also had primary responsibility for supporting educational technologies in the school as part of the formal responsibilities.

Dolling is both Grade 11 and Grade 12 Science teacher. She is in her late thirties and has taught for more than five years. She looked very shy but very approachable and open when talked to. Irene is a Grade 10 science and mathematics teacher. She is in her middle thirties with an experience of five years. At the time of the data production, she was not in good health. As a result, the researcher was not able to observe her teaching sessions; equally, it was also not so easy to get her for interviews. Fortunately, she was interviewed on the very last day of the data collection period.

4.5.2.2 BERENG HIGH SCHOOL

In this school, the participants included John, Portia and Cathy. John is in his late forties, he is the head of department of sciences and he is a pastoral science teacher in Grade 10. He has fifteen years of teaching experience. At the time of the study, one of the special responsibilities he held was the preparation of the examination; allocating invigilators, setting up the rooms and so on. He was very humbled and seemed to have good relations with the rest of the staff as well as learners. Portia and Cathy both teach Science. The former is a science assistant teacher in Grade 10 while the latter teaches Physical Science in Grade 11.

4.6 DATA COLLECTION METHODS

The main types of primary data collection techniques that the researcher chose to use for this multi-method study were: focus group discussions, audio taped individual interviews, classroom observations - non- participant observations as well as a simple open-ended

student questionnaire. The use of different sources of data is a way that compensated for potential bias or error in the use of any single method (Guba & Lincoln, 1981).

4.6.1 INTERVIEWS

Interviews were ideal data collection tools because they helped the researcher to find out what knowledge and information educators have about their utilization of the IWB. Furthermore, the researcher was able to find out what values and preferences the educators have for the IWB in science instruction, and attitudes and beliefs educators hold about the use of the IWB in teaching science.

4.6.1.1 ADVANTAGES OF CONDUCTING INTERVIEWS

The researcher was able to get in-depth data from educators, that is, to collect detailed and descriptive data. It was also easier for the participants to communicate with the researcher and vice versa to seek clarity and for the participants to elaborate on their responses where it was not clear. The researcher was also able to probe more in order to get more information when the participants have not given sufficient details (Cohen *et al*, 2007). Furthermore, the researcher was able to understand the experiences of educators by listening to them share their stories, present issues, reiterate their involvement and personal experiences. Additionally, interviews offered the researcher the opportunities for asking and possible opportunities for probing and the possibility that the participants gave the similar answers to the same questions increased the comparability of responses (Cohen *et al*, 2007).

4.6.1.2 DISADVANTAGES OF CONDUCTING INTERVIEWS

The data generated from interviews come in large amounts of textual data (Cohen *et al*, 2007). The researcher ended up with many pages when transcribing from the audiotape, which was quite an overwhelming exercise. To conduct an interview is not an easy task because the researcher needs to take care of some factors that may affect the collection of expected data.

4.7 FOCUS GROUPS

The researcher conducted focus group interviews mainly to gain insights by listening to a group of educators talk about their perspectives, experiences, attitudes, and behaviours

relating to the utilization of the IWB in the teaching of science in public high schools (see appendix I). Only two focus group discussions were conducted per school during the research period. Each of the focus groups was composed of three educators per school.

4.7.1 ADVANTAGES OF FOCUS GROUPS

Conducting focus groups allowed the researcher to gain deeper understanding of educators' perceptions on their use of the IWBs in teaching science (Morgan, 1996). This was achieved when the researcher was able to observe the nature and the extent to which educators agree and disagree about an issue (Morgan, 1996). Again, educators were able to compare their experiences and views and the researcher was able to probe for meaning (Dreachslin, 1999), and educators were able to question and explain themselves to each other (Morgan, 1996; Wilson, 1997) more naturally and openly (Stokes & Bergin, 2006) through group interaction (Wilson, 1997).

4.7.2 DISADVANTAGES OF FOCUS GROUPS

More than often, educators seemed to move towards a consensus rather than true expression of individuals' point of view (Stokes & Bergin, 2006). Sometimes, the researcher would have to guide the discussion and this likely turned up to sort of make it difficult for the interaction to continue in the normal way (Morgan, 1996). However, it was important to keep the focus of the interaction because at some point the educators lost some direction. As much as an interview is a social interpersonal encounter, some educators were shy to speak in the presence of their other colleagues, whereas their colleagues easily influenced others. Additionally, as it is a case in-group setting, in the two schools, Tara from Mamathe High school seemed to dominate the discussion because she appeared to be more advanced than the other two educators, Dolling and Irene. Whereas at Bereng High school, the head of department, John had to say most of the things and the other two educators, Carthy and Portia tend to follow suite. Since the researcher was interested in everyone to give their experiences and views, the researcher had to direct questions to each individual educator so that they all got the chance to share their beliefs and attitudes. However, the researcher being an outsider had an influence on the input from the educators especially where matters were administrative.

4.8 SEMI-STRUCTURED INTERVIEWS

Semi-structured interviews (see appendix III) were used with individual educators for the researcher to gain information from individual educators away from the influence of others as it likely happened with focus group interviews. In all, six educators were interviewed, three from each school. Three semi-structured interviews were audio taped and each session for each participant took about 40 minutes on average. All the interviews were transcribed verbatim. The transcripts were returned to the actual participants on the next visit at each school. This was a way for them to verify, acknowledge and clarify some facts and their feelings, and also to see if the interpretation makes sense or reflect their experiences, and also the researcher shared the data with the peers by asking them to listen to the analysis in the process and feedback was sought (Nieuwenhuis, 2007). These interviews enabled the researcher to collect a rich descriptive data that helped in understanding the social reality behind using the IWB in the teaching of science in some public high schools.

4.8.1 ADVANTAGES OF SEMI-STRUCTURED INTERVIEWS

Semi-structured interviews were used as a follow-up to clarify some concerns and aspects, and to get accurate interpretation (Cohen *et al*, 2007). Such an exercise promoted enhanced expression since it allowed free communication that provided sufficient details (Cohen *et al*, 2007; Nieuwenhuis, 2007). The researcher was able to rephrase questions where the educators could not understand what the question says. Again, the researcher would also paraphrase the responses in order to understand what the participant had said. During the interviews, some educators did not like to be audio taped, so the researcher had to take notes. In the process, the researcher was able to read what has been written to seek assurance of educators' views.

4.8.2 DISADVANTAGES OF SEMI-STRUCTURED INTERVIEWS

Taking notes during the semi-structured interviews seemed to take a lot of time. The researcher had no control over participants' interpretations.

4.9 THE PROCESS OF COLECTING DATA USING INTERVIEWS

On the 29 April 2008, the researcher visited Bereng High school as arranged. The meeting was scheduled for 14h30. Upon arrival, the researcher was told that the Science department is having a demonstration from one Consumer Company to show some software packages that they sell, so that the school may buy because the boards do not have any. So the researcher was invited. The presentation was held in the science lecture hall where subsequently the focus group interview took place. The company representative had all the information on the laptop, which was projected onto the IWB. What happened here is that the board was just used as a screen. The board itself was not functioning. The show only lasted for thirty minutes after which the researcher was able to meet with the participants. The interview was not successful in the sense that the educators said they had nothing to share since they are not using the boards because they do not have software and they cannot even operate it because they cannot access it due to the pin that it is unknown. Free sample software on CD was left for the school to try to use with the board. The researcher had to set yet another appointment to come when the boards are functioning.

On the 8 May 2008, the researcher went back to the school. The Head of Department was met and explained that the sample software that was left did not function either on a computer or on the laptop. John reported that they had to phone that company about the problem they have met, and there was a promise that someone would come to help them out, but all in vain. Therefore, they are still waiting.

On the 22 May 2008, the researcher phoned John, to find out how the situation is. John reported that they are still stuck. Nobody has turned up. Another appointment was set for the 4 June 2008 at 11h00. John called other two participants, Carthy and Portia to discuss the matter and the way forward. They were vociferous that the use of the boards remains a problem until when the software is available. They are looking up to having it as soon as it is available, but they also have a problem with finances even if they can get at least cheaper software, the school is still in debt with the boards.

On the 22 July 2008, the researcher met with the educators again for the last time. Individual semi-structured interviews were conducted. Portia and Carthy sacrificed their lunch break for the interviews, which lasted for twenty-five minutes per educator. John was interviewed at 14h30. Everything went well except for that the educators did not have much to say about their use of the boards in the teaching science. Notes were taken for all the interviews. The three educators were willing to participate and share all they know about the IWBs but there were prevailing circumstances that affected the whole situation, the unavailability of software and the issue of finances to get things run smoothly.

However, in Bereng High school it was not possible to audiotape the conversations with the educators because of the load shedding that prevailed in those days. The researcher was allocated the same time to interview the educators and this coincided with the load-shedding schedule in that area. Therefore, the researcher simply made notes of what the participants had to say.

On the 2 May 2008, the researcher visited 'Mamathe High school to meet the educators there. The meeting was at 12h40. The focus group interview went well and the discussion was audio taped upon the approval of the educators. The interview took place in Tara's classroom and it lasted for an hour. The educators allowed each other a chance to answer the questions and where they had the same view they would come to an agreement by first discussing an issue among themselves then a consensus would be reached.

On the 13 May 2008, the researcher went back to the school to conduct the individual interviews. This was arranged in the last visit. Only two educators were present. Irene was not at school because of ill health. The first session took place at 13h35 and lasted for roughly 40 minutes in Dolling's classroom. The second session took place in Tara's classroom at 13h55 and only lasted for 35 minutes. All the sessions were audio taped because there was not enough time as this was a very busy time in the school. There were sporting activities to attend to as well as other administrative cues as the two educators were involved in other extra-curricular duties.

4.10 CLASSROOM OBSERVATION

The classroom observations are twofold; namely participant and non-participant. Time did not allow for participant observation. Therefore, the researcher resorted to non-participant observation using a semi-structured observation schedule (see appendix II). Even though the researcher did not take an active part but was part of the setting because there was not any other way observations could be conducted without her / /him being there. The researcher engaged in classroom observations whereby two sessions were observed in a week in each school. Even though the researcher was aware of what she /he was looking for when lessons were observed, and know how to record the information, some field notes were taken as description of what happened in the classroom.

There are a number of possible ethical issues associated with using observation as a data collection method. Primarily, the researcher obtained permission to conduct the research from the relevant authorities. Subsequently, full, informed consent from participants with all the necessary details such as the purpose of the study, proposed methods of data collection, data analysis procedures and ethical considerations was given and signed as an agreement to participate in the study. The researcher had a meeting where the above aspects were discussed so that everyone was clear of the expectations if they were to participate in the study. Again, a request to use materials such as audiotape and video tape was made and permission was granted. However, videotaping was not done due to lack of time and technical problems such as load shedding. The protection of educators was ensured and the anonymity of educators will be preserved by using pseudonyms to prevent identification. The research findings were shared to ensure accuracy and to promote honesty (Cohen *et al*, 2007; Nieuwenhuis, 2007).

4.10.1 ADVANTAGES OF OBSERVATION

Observation is a technique of producing data in real time (Cohen *et al*, 2007). The researcher used the observation data to verify the self-reported data from the interviews (Lankshear & Knobel, 2004). Again, observation enabled the researcher to gather information about the educational environment (learning styles, use of different resources); the interactions that took place (active collaboration, working in teams). The researcher was able to obtain first-hand information rather than what may be collected

from other people through interviews or questionnaires (Cohen *et al*, 2007; Lankshear & Knobel, 2004). The researcher was able to see things that may not be talked about in interviews as they are predetermined (Cohen *et al*, 2007). The observations conducted helped the researcher to collect the most basic data that led the researcher to understand the reality of utilizing the IWB in teaching science, hence answer the research questions.

4.11 SAMPLE LESSONS OBSERVED

The lesson observations began on 5 May 2008. Tara was observed first from her ordinary classroom of 26 Grade 12 learners. The learners were seated in rows in front of the IWB, the Promethean ACTIVBoard that was mounted on the wall with front projection. The board was connected to the data projector and a computer that was kept in the cupboard and operated from there. There were also magnetic pens. The set up was normal; nothing was arranged for the lesson. The lesson was observed from 08h35 to 09h30. The section below presents brief descriptions of lesson observed as per observation schedule.

Example lesson 1

Lesson topic: Science: Matter – Chemical reaction

The lesson began with learners seated as normal. The lesson started with a review of the previous lesson. For example, phases of matter – solid, liquid, gas and their familiar bulk properties. The learners shared these. Tara revealed some illustrations to review the submicroscopic levels in solid, liquid and gas. Following, a screen from Sunflower Learning was displayed. Learners could see the particles packing together to make solids and liquids, and moving freely as gases. There were coloured particles that learners could see as particles move randomly, colliding with one another, and filling a space gradually. The use of the board in this case presented authentic information, the displayed screen offer learners to see what could remain invisible through other means. The educator did everything by herself without involving learners, the only time learners were involved was when they responded to questions. They remained seated for the rest of the lesson.

Example lesson 2

Lesson topic: Science: Elements of the periodic table

The seating arrangement was still the same. The lesson was observed at 08h40 up to 09h30. Tara displayed the periodic table on the IWB. It was accessed from the Virtual ChemLab. Tara was able to explain aspects such as element, atom, the difference between the two, atomic mass (electrons, protons, neutrons) using the periodic. On a click on an element, like Na, all the information that relates to that element would be displayed. This was followed by an online periodic table quiz, which learners worked on, collectively from the board. One learner volunteered to lead the exercise. They would debate on the right option and agree, and then go for online response to confirm their answer. In the process, Tara would be intervening and explaining some points for clarification. Discussion and questioning seem to dominate the lesson.

Example Lesson 3

Lesson topic: Science: Chemical reaction

The seating arrangement was still the same. The lesson began 08h35 - 09h30 with a review of background knowledge on the elements of the periodic table, for instance, giving symbols for different metals, etc. Tara drew different graphs on the board to explain the stages and the rate of chemical reaction. Commonly, questioning and discussion dominated the lesson. Textbook examples were used mostly. Learners never used the board. As the lesson progressed, learners were asked to copy down some important facts of the lesson. Finally, they worked on an exercise from the science textbook. Learners then shared their answers, and to those who got wrong answers, Tara had to explain. However, the presentation was more of a lecture than any other method such as active collaboration, use of authentic activities, and so on. A PowerPoint presentation from a CD was done to give a summary on chemical reaction highlighting aspects such as endothermic and exothermic reaction, how to get the value of activation energy, potential energy of the product, potential energy of the activated complex.

Grade 11

Example lesson 4

Lesson topic: Science: Equation of motion Time: 08h35 – 09h30

Dolling had to use the Promethean ACTIVBoard in Tara's classroom because her e-Beam board was not functioning. She struggles with the use of the board as she claimed

she was not used to it. The seating arrangement was as in Tara's class. The lesson began with a review of concepts of displacement, velocity and acceleration. Equations below were displayed on the IWB. Dolling guided the learners with questions to identify the relationship between the concepts and how others are used to define others.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

$$V = \frac{S}{T}$$

$$\text{Displacement} = \text{Velocity} \times \text{Time}$$

$$S = VT$$

$$\text{Time} = \frac{\text{Displacement}}{\text{Velocity}}$$

$$T = \frac{S}{V}$$

From this introduction, Dolling worked out some problems on the IWB, that is, few examples were modeled. This involved the whole class with the educator at the board doing everything. Learners only responded to Dolling's questions and would do some calculations in their books at their seats. Then, they would give their answers, which Dolling could accept or refute. She would then correct the wrong answers from the board. At the end of the lesson, learners were assigned an exercise to work on individually from their textbooks, which was later corrected with learners giving a response that was then evaluated. The use of the IWB was just like using a traditional whiteboard. The approach to the lesson was dominated by discussion and questioning with learners mostly passive.

Example lesson 5

Lesson topic: Science: Equation of motion: The Pendulum Time: 12h40 – 13h30.

The lesson began with a review of comparing a speed-time graph and a distance-time graph drawn by Dolling on the IWB. Through questioning again, learners were able to identify the difference by reading the labels on the axes. Following, a pendulum motion model was displayed on the board. It comes out with a graph that records the movement of the pendulum at different angles. Dolling would slide the slider bars to change the initial displacement, velocity, mass, length, and acceleration due to gravity. The results of displacement, angular velocity, angular acceleration were viewed on the graph. Learners were able to construct their own understanding of how these aspects can be identified and

calculated. With a click, graphs can be changed to show minimum and maximum range, the model could also change the amount of time the model runs.

A physical exercise was done which was not as clear as using the model because it would be easy to stop a pendulum at a particular point to illustrate displacement, acceleration and velocity more clearly. The learners engaged in, in pairs but still referring to the board an activity. For example, as the parameters of the pendulum changes by altering the initial values of the length and the acceleration due to gravity, learners were able to explain what happens to the acceleration, path of the pendulum, velocity, and so on, as the initial displacement is increased. The activity was done until the end. The use of the IWB in this lesson was useful as it highlighted some important features of motion by referring to the pendulum model, which clarified the processes.

The researcher had planned to observe three lessons per educator, but during the observation, there were some problems encountered at 'Mamathe High school. On the second round of the data collection process, while the researcher have gone for classroom observation, the IWB was not working, the educator concerned tried all possible solutions to make it work but all in vain. Tara phoned the manufacturer in Johannesburg who came to her rescue after an hour because at the time she reported the problem the technical advisor was out of the office. In any case, Tara was able to follow the directions she was given to make the board work again. One morning when the researcher got to the class the projector was not there and this was not brought to the attention of the educator. These problems contributed to the failure to observe the lessons as planned by the researcher. This required the educator's flexibility to get teaching going despite the obstacle that came her way. She used some small pieces of whiteboards mounted in front of the class. The researcher then had to leave. In the next session, there was no electricity to run the IWB system.

In another incident, the researcher did not succeed in observing lessons as planned with the Grade 12 class. The lesson was planned to take place in the laboratory where learners were to conduct an experiment. The researcher had to leave because the lesson was out of the scope of the study; the concern was mainly on the use of the IWB. The other problem

that was encountered was that Irene could not be observed because she mentioned her lack of confidence in using the Promethean ACTIVBoard since she uses the e-Beam, which was out of order during the data collection period. Additionally, Irene was not available most of the time because of ill health, the last moment she was available she was not ready to use the other board.

At Bereng High school, observations were not possible as mentioned earlier that the boards have not been in use because of the unavailability of the software. Using the board as a screen could not contribute anything to the requirements of the study. However, in most cases, educators used the IWB more than engaging learners. The researcher is of the opinion that the board is still used like a traditional board. Nevertheless, the lesson on the pendulum was very good. The resourcefulness and usefulness of the board was seen from this lesson, attention of learners was maintained, the activity kept learners engaged throughout the lesson.

4.12 QUESTIONNAIRES

This is a research tool in which questions could be either open or closed (Cohen *et al*, 2007). For this study, the researcher used an open-ended questionnaire (appendix IV) to encourage qualitative responses from learners rather than the structured ones, which can give quantitative answers (Cohen *et al*, 2007). The learners were able to comment on the questions in a general way. This seemed to be the only technique that the researcher could use to get the views of the learners in learning science using the IWB due to limited time. Interviews would have taken a much longer time as they were involved in sporting activities that were entertained during break, lunchtime and sometimes after school and later were curious about preparing for their approaching examinations.

4.13 PILOTING

The learners' questionnaire schedule was pilot tested with similar learners. The trial run respondents commented that the questions were rather too long to answer. Then the researcher had to restructure the questions to make them a bit shorter, and they piloted again to see if there is a need for change. They were accepted and then administered by the researcher to the actual participants.

For ethical consideration, permission from parents / guardians was obtained by sending informed consent letters (appendix VI) which spelled out in details the purpose of the study, how issues of confidentiality and anonymity will be taken care of, and that participation is voluntary. Only six letters of consent were signed and returned to the researcher.

The researcher distributed the questionnaires among learners who showed interest in participating. The selection of learners to participate was based on their willingness to participate. There was not enough time for them to fill the questionnaire on the spot. The only thing that was done was to let them go through it and then ask questions where they thought they have problems. No misunderstandings were raised. They had to take the questionnaire home with them to collect after two days. Only four learners out of six were able to return the questionnaire. This affected the input of data into the study. Because the learners had to go away with the questionnaire, the researcher was not able to probe them where they could not understand what they were supposed to say. Some responses need some clarifications. Some learners were not willing to share their information that is why not all the questionnaires were returned, even though the researcher made explicit why the information is collected and how beneficial the results would be.

4.14 DATA ANALYSIS

The process of data analysis began as early as the first day of data production. Earlier analysis reduced the problems of data overload as well as of forgetting some significant issues (Cohen *et al*, 2007). Field notes, interview data were transcribed. Then the researcher read the field notes, transcripts and observed data in order to get an initial sense of the data. Qualitative data is voluminous and unorganized, so the researcher brought some order to the data so that it is manageable by organizing it in a meaningful manner; the data was named and coded on the document. The data was organized by groups. Cohen *et al* (2007) argue that this is the only one way of organizing qualitative data analysis. The advantage of this method is that it automatically groups the data and enables themes, patterns to be seen at a glance. Later similar responses were summarized.

These emerged from the indicators of categories in educators' experiences in using the IWB and also attitudes and feelings about the IWB. Then, the codes were compared in order to find consistencies and differences. The consistencies between the codes revealed categories, which is to mean organizing it into categories and identifying patterns among categories (Miles & Huberman, 1994). Some categories were derived from the theoretical areas of interest devised in advance of the analysis, while others were developed from the data itself (Cohen *et al*, 2007). Themes and categories were used to represent the data. Direct phrases and sentences were used to 'keep the flavour of the original data' as Cohen *et al* (2007, p. 462) rightly put it.

4.15 CREDIBILITY / TRUSTWORTHINESS / CRYSTALLIZATION

Issues of establishing rigour when engaging in this methodology are imperative. In this study, the researcher used strategies such as prolonged engagement, triangulation, peer debriefing and member checking as ways to crystallize the data produced (Creswell, 1998; Lincoln & Guba, 1985). In order to enhance trustworthiness of this study, multiple data sources were employed. The researcher triangulated the data from educators' interviews and observations with focus group interviews and learners' open-ended questionnaires. Campbell and Fiske (as cited in Cohen, Manion & Morrison, 2007) contend that triangulation in qualitative research is a powerful way of demonstrating concurrent validity. However, member checking and peer debriefing seemed significant at increasing the credibility of the findings. Seale (2002, p.108) substantiates that "if there is one thing that produces poor studies, it is a researcher who is blind to the methodological consequences of research decisions." This implies that the researcher is faced with the responsibility of reflecting or interrogating with the data to an extent that it will make sense to the readers. So for this study, methodological triangulation, and data triangulation were employed to make sure the data from which the results are eventually drawn from are credible (Merriam, 1998). Moreover, rigour in qualitative research involves engaging in efforts - as identified by the researcher above; to increase confidence that the research findings represent the meanings presented by participants (Creswell, 1998; Lincoln & Guba, 1985). In addition, case study employs its own

measurements as a way to judge the credibility of the data, terminology such as credibility, dependability, transferability and conformability is used (Cohen *et al*, 2007).

In a qualitative case study research, trustworthiness refers to the truth and accuracy of the findings and interpretations (Creswell, 2005). In this study; as part of the case study methodology, the researcher employed the Guba's model based on four aspects of trustworthiness namely: truth-value, applicability, consistency, and neutrality.

Truth-value or credibility of the research was maintained by considering the findings related to the participants and the context in which the study was undertaken to be true. Again, the findings were checked against the literature. Peer debriefing and member checking were also employed to ensure adequate representation of multiple construction of reality; the data was shared with the two colleagues and also the researcher went back to the actual participants to check if the analysis or interpretation made sense to them and also reflected their experiences (Cohen *et al*, 2007; Maree, 2007).

Applicability or transferability of the findings to other contexts or settings was considered in this study. Purposive and availability sampling was used to achieve a degree of applicability. Transferability was further ensured by providing comprehensive, detailed and accurate data that were rich and thick in description (Krefting, 1991), so that comparisons to other research could be made, and by comparing the findings with the literature (Krefting, 1991). For consistency, the researcher identified that if the participants hold the same opinions, then the findings would not be altered.

According to Lincoln & Guba (1985), findings could be replicated if the study were repeated in the same setting and with the same participants. Neutrality in this study was maintained by assessing the extent to which the research findings and the perspectives of the researcher are free from bias (Cohen *et al*, 2007) and it is determined by the criterion of conformability (Krefting, 1991). The researcher also compared findings of this study to other research literature as another way of increasing the degree of conformability.

4.16 ETHICAL CONSIDERATIONS

Collecting data from people raises ethical concerns in research. The researcher took care of the following ethical measures in this study: obtaining permission from schools concerned to use as research sites; gaining informed consent of the participants – educators and parents or guardians to allow their children participate in the study. The consent included assurance of anonymity and confidentiality of participants and the data respectively; this meant that the participants will not be identifiable to anyone reading the eventual report, fictitious names for both participants and the schools are used, voluntary participation and freedom to withdraw at any time and without any penalty.

4.17 CONCLUSION

This chapter has argued the importance and value in the selection of appropriate research design and methodology as a process critical to the success of data collection of this qualitative cases study. The study followed an interpretive research design, a qualitative research approach and a case study methodology. Six educators participated in the study. The educators were interviewed individually in semi-structured individual interviews and in two groups of three educators in each school. It had not been possible to have the educators from the two schools together to share their views because of the distance; the schools are too far apart. The researcher thought this would have been more constructive to have the educators share their views from different backgrounds.

The researcher has argued the importance of choosing methods that are relevant and appropriate to elicit evidence and support to answer the research questions that guide this study, equally discussing their advantages and disadvantages in context. The chapter also presented how the data was collected using the identified methods. The sample lessons were presented as observed. Issues of trustworthiness and ethical considerations were also discussed and how they were taken care of in the different techniques. The following chapter presents major findings; describes the ways in which the researcher analyzed the collected evidence and interpreted it following the conceptual framework and other research literature and considering emerging themes as data were analyzed.

CHAPTER FIVE

DATA ANALYSIS AND INTERPRETATION

5.1 INTRODUCTION

This qualitative case study aimed at developing an understanding of educators' experiences in utilizing the IWB. This includes the benefits and challenges posed by the board in their current practice, with a view to drawing implications for possible recommendations for this type of technology. The study was guided by the following research questions:

1. How do science educators utilize the IWB in providing authentic learning / environments in Science teaching and learning in public high schools in the Durban metropolis?
2. What challenges do science educators face in utilizing the IWB in teaching science in public high schools in the Durban metropolis?

The data that addressed the research questions were collected through individual and focus group interviews for educators, observations of science lessons and simple open-ended questionnaires for learners. This chapter presents a summary of primary data collected from educators and learners, as well as the observations of lessons at the two public high schools in the Durban Metropolis. First, it gives an overview of the process of analyzing the data, following a qualitative approach. The researcher intends to present what educators had said about the benefits and challenges they face in utilizing the board in the teaching of science. Subsequently, data interpretation based on the framework or tool of analysis adopted from the principles of the two theories that guided the study, namely: Engagement and Connectivism follows. The tool defines the components of the theories that are assumed to dictate how learners learn in the digital age from the new technologies that are emerging and transforming education such as the interactive electronic whiteboards. Major findings as well as major themes that emerged, other than those pre-defined from the theories, are also identified and included in the tool of analysis. Finally, major findings presented as major themes and categories that support them are summarized.

5.2 QUALITATIVE DATA ANALYSIS

Before the actual analysis, interview data were transcribed. The text from the interviews, both individual and focus group and questionnaires, were typed into word-processing documents. The transcriptions were given to the actual participants to check if the analysis reflected their own views. In addition, this was a way to verify the raw data by submitting the transcripts to the participants to correct errors of fact (Neiuwenhuis, 2007). The researcher expected the participants to comment on the transcriptions by adding some missing information or deleting exaggerated information if any. The nature of the study allows such an exercise (member checking) because it is entirely based on the participants' perceptions, beliefs, attitudes and behaviours hence they can better express their views. The analysis gave a holistic picture of the nature of practice of utilizing the IWB in the teaching of science and the challenges they face in using the boards in the teaching science (Kerlinger, 1986). This included both benefits and challenges. The researcher highlighted thoughts, words, phrases and actual quotes that reflected possible themes. Major categories were identified into which units of meaning relating to them were underlined and placed. Sub-categories within the major categories were then identified. Relationships between major and sub-categories were identified and reflected as themes. The researcher then gave the transcripts to peers for their independent analysis (Neiuwenhuis, 2007). The exercise involved two colleagues who later met with the researcher after completing their analysis of the data to reach the consensus on the findings.

However, the researcher is aware of the fact that an interview is a social encounter, not just a mere process or exercise in which data are collected. In transcribing the interview data, a record of data rather than a record of social encounter is created (Mishler, 1986). Transcriptions do not actually portray what happened in the social settings of the interview (Scheurich, 1995). Data tend to lose its value right at the beginning of the data collection process, rather in the planning stage where the researcher decides to use certain instruments of recording the data such as audiotape or taking or writing up notes. This is the stage where the contextual factors are neglected, for instance, the visual and non-verbal aspects of the interview are left out (Mishler, 1986). Nevertheless, the researcher is not against the transcriptions, but rather indicating that the transcriptions do not tell

everything that took place in the interview. The issue here is to caution that it is equally important to transcribe other types of data and not only spoken data (Kvale, 1996).

The researcher explored some discourses on the benefits and challenges educators face in the use of the IWB in the teaching of science in some public high schools. As a result, the researcher focused the analysis on guided analysis, this means eliciting meaning from the data in a systematic, comprehensive, and rigorous manner (Henning, 2004). The conceptual framework that was adopted has been derived from the theories of Connectivism and Engagement, which guided the analysis. This does not restrict the framework of analysis to the pre-defined concepts but allows room for emerging concepts to be included, hence the hallmarks of a qualitative nature of this study (Cohen, *et al*, 2007). Again, the study was proposed within and guided by the interpretive paradigm, which focused on how educators uncovered their perspectives, constructed meaning and interpreted their experiences towards using the IWB in the teaching of science from their own unique perspectives (Neumann, 2000). In the similar vein, Henning (2004) asserts that interpretivist theory of knowledge assumes that knowledge is constructed not only by observable phenomena but also by descriptions of people's intentions, beliefs, values and reasons, meaning making and self- understanding. The analysis of the interview responses was guided by Miles and Huberman's analysis model including transcribing, identifying themes, and revising results based on member checking and peer debriefing. Tables are used to show findings from the data analysis. Data represented in these forms were explained. A few questions that required the participants' expression were also explained and whenever possible were also cited / quoted.

5.3 FINDINGS

In this section, the data that were presented for analysis and interpretation were elicited from the semi-structured individual interviews with educators, and observations of lessons in the classroom. The focus group interviews and the learners' open-ended questionnaire were used to corroborate the educators' views and opinions as well as the observations. Guided analysis as well as the literature review was used collectively to interpret the data obtained from interviews and observations in order to ascertain and understand the nature of practice in utilizing the IWB in the teaching and learning and to

explore the effects to using the IWB in science classrooms. The data were presented by research questions.

5.3.1 How do science educators utilize the IWB in providing authentic learning activities /environments in science teaching and learning in two public high schools in the Durban metropolis?

The section below provides key concepts (derived from the theoretical framework) which were interrogated by the researcher during the classroom observation on the use of the IWB in teaching science.

5.3.1.1

Active collaboration

According to Foot *et al* (1994, p.295), active collaboration “is learning in groups towards investigative learning in science.” It is about learners working together on a problem. It involves collective engagement with worthwhile tasks, peer interaction, shared decision-making in constructing knowledge. The researcher observed that the IWB could facilitate active collaboration but to a little extent. This was evident because learners at the same time were able to share information and other sources of information such as the internet through the IWB. However, learners were not given chance to search for information themselves; the educators searched and displayed the information. It was also observed that the IWB allowed learners to share reflections on their activities; the educator visited a website (electronic science tutor) found on [.physchem.co](http://physchem.co) on chemical change or equilibrium. In Grade 11, learners were exposed to an online periodic table, which was followed by an online quiz. Learners worked on the activity as a whole class group and then showed their responses on the board. The responses were confirmed by soliciting the responses online. When the response appeared incorrect, they would then go for the second attempt and so on until their response would match with that which the board would display. In this manner, the IWB was able to exchange feedback with the learners as well as offer encouragement to learners to persevere until they get the correct answer. The learners showed some eagerness to strive to get the right answer; also, the board was able to focus their attention.

However, only one learner could go to the board to lead an activity, never in pairs or as a group very close to the board, they would be seated in their seats. These was the case with all the grades observed.— In learning science, collaboration and competition of many individuals result in collective intelligence which helps learners to conceptualize information. It allows for problem solving that enhance knowledge construction through the addition of visual information and interaction with others (Carin, Bass & Contant, 2004).

5.3.1.2

Working in teams

According to Watson and Downes (2000), participation in collaborative work groups whereby learners use blogs, wikis, etc to share information is vital. This involves participation in collaborative work groups (Watson & Downes, 2000), e.g. using blogs, wikis to share information. In this aspect, the researcher expected to see learners work in small groups of 6-8 learners; paired learning; discussion with others, solve problems together. Generally, the expectation was to observe small groups of learners working together and paired learning to achieve a common goal. It was not evident that the IWBs encourage the learners to participate in collaborative work groups as illustrated above. The provision of instant feedback on activities motivated them to place more effort in their attempts to the right answer. They would then debate on the right option until they reach a consensus. The mode of presentations was only whole class teaching which was more passive.

The collaborative instruments such as the blogs, wikis were not used through out the observation period. Sharing of information was among learners; the use of the IWB did not facilitate sharing of information, nothing came from the IWB. If practiced correctly, working in teams would encourage willingness to share more and critically discuss aspects of practice and curiosity of concepts (Loucks-Horsley, 1998). There are online examples that would encourage more participation, for instance, Le Chatellier's principle. Learners need to find data which they will then organize and manipulate so that a conclusion can be reached in groups and evidence be provided to support their conclusion.

5.3.1.3

Learning ecology

This is an environment that illustrates and clarifies conceptual materials that are presented by making the abstract concrete and understandable, for example, evaporation (Chilcoat, 1989). An environment that utilizes technology and Internet in science teaching and demonstrates ways to bring inquiry into science classrooms, scaffolds concepts and illustrate instructional model (Chilcoat, 1989). This environment is consistent with how learners learn. Figure 5.1 below was used to explain aspects such as element, atom, atomic mass – protons, electrons, neutrons using the periodic table. On a click on an element on the periodic table, like Na, all the information that relates to that element would be displayed. Therefore, the model was beneficial to the learners to understand the related concepts and it assisted in scaffolding concepts.

Periodic Table

| Group | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|----------|-------|-------|---------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|-------|---------|-------|---------|-------|
| Period 1 | 1 H | | | | | | | | | | | | | | | | | 2 He |
| 2 | 3 Li | 4 Be | | | | | | | | | | | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne |
| 3 | 11 Na | 12 Mg | | | | | | | | | | | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar |
| 4 | 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co | 28 Ni | 29 Cu | 30 Zn | 31 Ga | 32 Ge | 33 As | 34 Se | 35 Br | 36 Kr |
| 5 | 37 Rb | 38 Sr | 39 Y | 40 Zr | 41 Nb | 42 Mo | 43 Tc | 44 Ru | 45 Rh | 46 Pd | 47 Ag | 48 Cd | 49 In | 50 Sn | 51 Sb | 52 Te | 53 I | 54 Xe |
| 6 | 55 Cs | 56 Ba | 57* La | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir | 78 Pt | 79 Au | 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po | 85 At | 86 Rn |
| 7 | 87 Fr | 88 Ra | 89** Ac | 104 Rf | 105 Db | 106 Sg | 107 Bh | 108 Hs | 109 Mt | 110 Uun | 111 Uuu | 112 Uub | 114 Uuq | | 116 Uuh | | 118 Uuo | |

| | | | | | | | | | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|
| *Lanthanides | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm | 63 Eu | 64 Gd | 65 Tb | 66 Dy | 67 Ho | 68 Er | 69 Tm | 70 Yb | 71 Lu |
| **Actinides | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu | 95 Am | 96 Cm | 97 Bk | 98 Cf | 99 Es | 100 Fm | 101 Md | 102 No | 103 Lr |

: Sodium
 Symbol: Na
 Atomic Number: 11
 Atomic Weight: 22.989770
 Family:
 CASRN: 7440-23-5
 Description: A silvery white metal
 State (25°C): Solid
 Oxidation states: +1
 Valence Electrons:

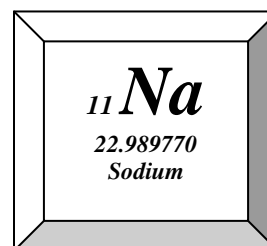


Figure 5.1

The IWB was observed to encourage learners to connect to others, but to a little extent. The learners only connected with other learners within the same class through discussion among learners. E-mails, chat rooms, discussion forums were not used during the observation to connect with one another in different locations. However, learners expressed their love for the board because of its ability to go online while still in class to gather more information and questions, which they considered very helpful and the fact that their work is stored is good. Moreover, three focus group participants described that the boards contribute a lot in helping them explain abstract concepts like stages of chemical reaction, balancing equation, elements of the periodic table and their atomic mass, oxidation state, valence, etc.

Admittedly, all educators indicated their low level of proficiency in ICT skills and instructional approaches that would make them best users of the boards. They were able to form a large group discussion of 26 learners to share how to get the value of the activation of uncatalyzed reaction. To this end, this was seen to be the only approach used together with lecturing during instruction.

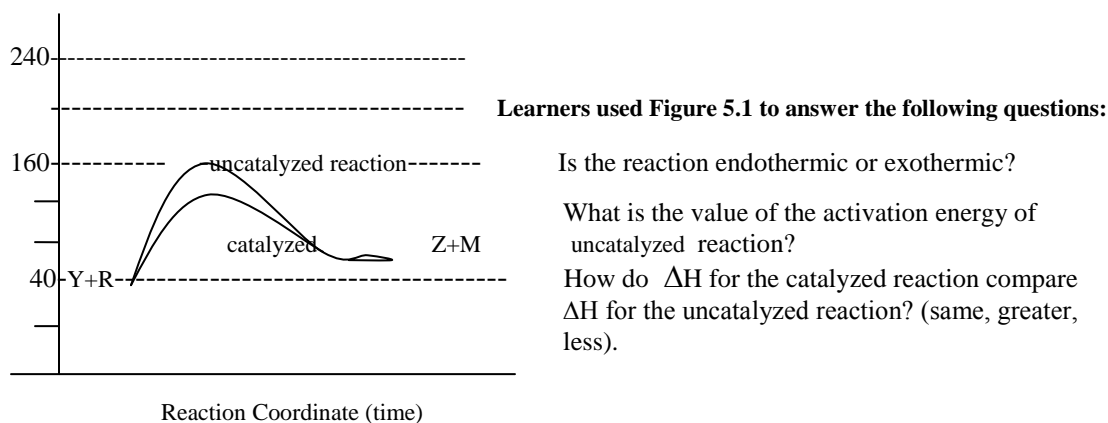


Figure 5.2

This was supported by potential energy diagram or illustration drawn by the teacher (see Figure 5.2) to explain how to get the required value. It became evident that the IWB could enable learners form communities of practice where they share insights and explore learning topics. This was supported by PowerPoint presentation that gave a summary on the rate of chemical reaction. In addition, the use of static graphics such as energy diagrams as in figure 5.3(b), drawings as in figure 5.3(a), dynamic graphs such as

animation assisted in the clarity of process and helped learners to understand the difficult or abstract processes such as uncatalyzed reaction and its reverse.

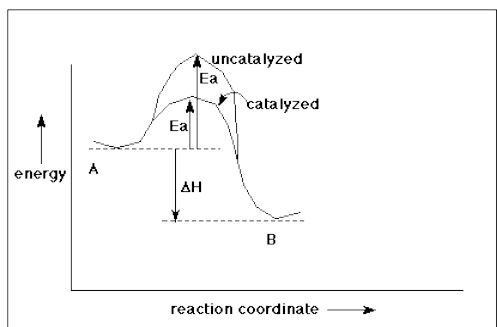


Figure 5.3(a)

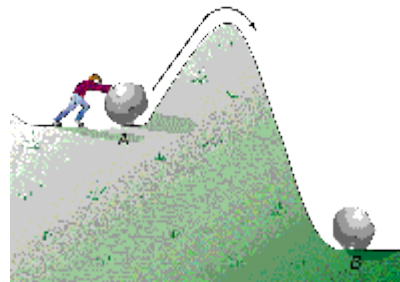


Figure 5.3(b)

5.3.1.4

Address diverse learners needs

This component involves scaffolding learning, considering a variety of learners' learning styles, and catering for individual differences, their interest and personal background (Glover & Miller, 2001). It was only at very rare incidents that individual learners could come up to the board and worked out something as the whole class. It was also not evident how the board could be used to accommodate diverse learners' needs based on their interest and personal background as well as survey learners' interest to allow for student choice. However, the board was used to reinforce concepts considering a variety of learning styles such as visual, auditory, and kinesthetic. Clips were used to explain the process of chemical reaction. At one, point a software package from [.platolearning.co](http://platolearning.co). was used to allow learners visualize how the atoms and molecules move and reorganize themselves as chemicals react. These atomic / molecular simulations were used during the lesson presentation. They helped learners in their understanding of the particulate nature of chemical reaction. Again, the educator used graphics to represent the reaction with arrows, showing their magnitude and direction and how these change.

The use of these multimedia features reinforced concepts and supported the learners to understand concepts. This become evident when learners were able to make use of a variety of activities where they were able to follow and work on them appropriately. However, the activities were from the textbook most of the time; rarely the internet was

used to provide interactive examples. Even though the board was used with the whole class throughout the learning process, not much guidance was rendered to each individual learner. Yet Glover and Miller (2001) are of the opinion that the IWBs have the potential to respond to individual learners' needs, which has not been evident during the observations. Learners indicated that the concepts presented on the board are always left unexplained. Their individual differences are not catered for; one learner reported that the presentation of instructions tend to be very fast for her liking. In addition, it does not accommodate everyone's thinking ability.

5.3.1.5

Authentic learning activities

Authentic learning activities are those activities that technology can make it possible to incorporate inquiry through hands-on and process-oriented activities for the benefit of knowledge construction. Activities that follow the 5-E model (Engage, Explore, Explain, Elaborate, and Evaluate.) (Carin *et al*, (2004). It was evident that the IWB allows learners to solve real-life problems. Models from Plato Science Simulations were used to demonstrate a moving car according to the equations of motion (see figure 5.4). Again, models were also used to show how particles move at random and collide according the Newton's laws (see figure 5.5). The activities used equations that reflected the underlying science. The researcher observed that a model have more possibilities for flexible use because the educator was able to change any parameter that eventually produced a correct outcome. In one instance, the educators used some simulations from Plato Learning Simulations, and diagrammatic presentation to show elements of work and such features were used to clarify the concept of balancing equations.

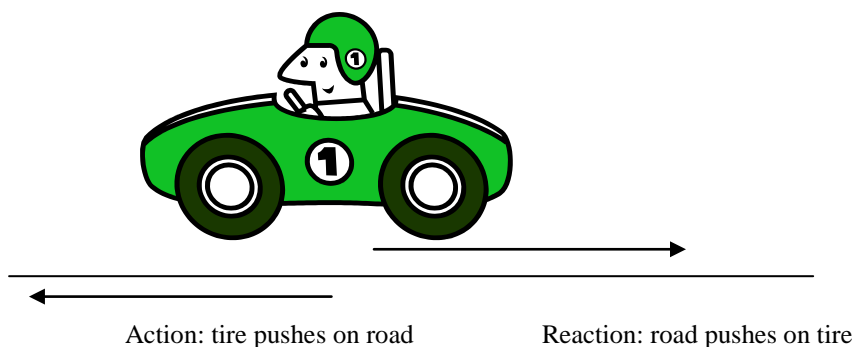


Figure 5.4

A model, as in figure 5.4, was also used to explain the Newton's law of motion. The model was moved back and forth to clarify the concept action and reaction. Learners were able to conceptualize that you cannot pull something unless that something simultaneously pulls back on you.

Additionally, such activities or tasks are said to provide real world relevance and mirror the common practices of the society (Kearney & Schuck, 2007). In the teaching of science, these could be accessible through multimedia simulations, data-logging and projected animations (Hennessy *et al*, 2007). During the observation of instruction, representations of molecules were used (see figure 5.5). Learners saw and manipulated these representations to see how molecules behave under a variety of condition such in a catalyzed reaction or uncatalyzed reaction. Three of the educators are of the opinion that the boards are able to provide authentic learning activities, and on the other hand, learners confirmed that using pictures, models, moving objects and multitude of colours make things clearer. Figure 5.6 was used to illustrate the submicroscopic levels of solid, liquid and gas. A screen from Sunflower Learning was displayed so that learners could see the particles packing together to make solids and liquids and moving freely as gases (as in figure 5.6). Coloured particles helped learners to see particles as they move randomly, collide with each other, and filling a space. Learners could see what could remain invisible through other means.

Simulation of gas kinetics

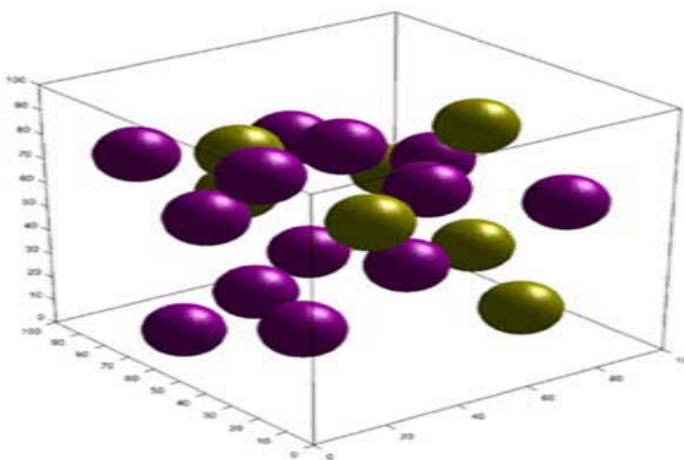
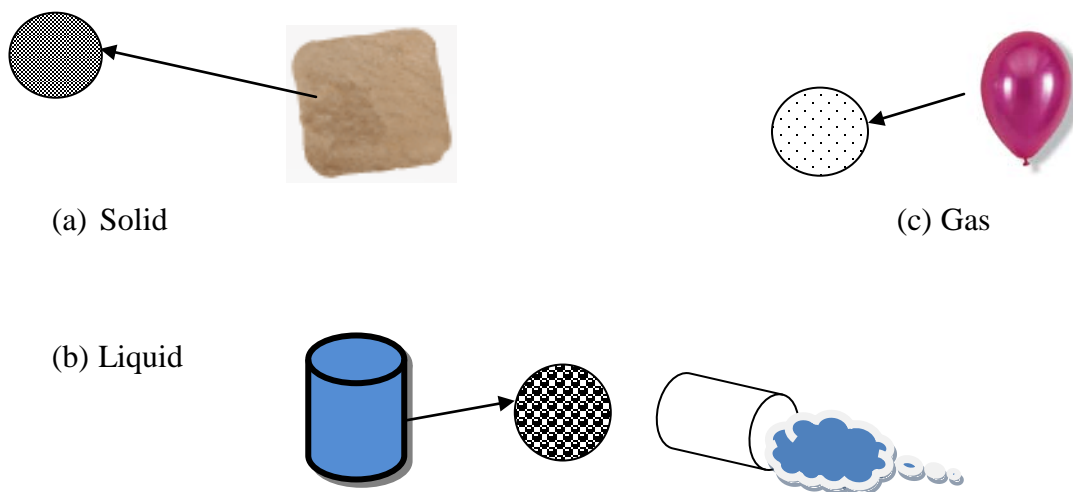


Figure 5.5

Submicroscopic levels in solids, liquids, and gases

*Figure 5.6*

5.3.1.6

Project-based activities

Project-based activities provide a vehicle for learning new information in a context that is meaningful and exposes learners to real problem-oriented cases relevant to their learning outcomes (Damoense, 2003). Project-based activities involve learners in experiences that challenge the current conceptions, provide with experiences that allow them to reconstruct explanations or new concepts, apply new concepts and evaluate them (Schneider, Krajcik, Marx and Soloway, 2002). Similarly, Colley (2005) is also of the opinion that such activities can make science classrooms function like mini- experimental stations, and scientific agencies. Additionally, he suggests that educators need to work with learners to identify projects that they are interested in and create learning environments that allow them to gather resources, plan, implement, evaluate, and report on their projects. Equally, Siemens (2004) argues that decision-making is itself a learning process. He contends that choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality.

During the observations, learners were never engaged in authentic tasks where they worked collaboratively even though it was evident that the educators are aware that the use of the IWB provides activities that are real in most cases and those that may apply to

real-life situations. Damoense (2003) further substantiate that IWBs can provide web-based resources that can enhance project-based activities.

5.3.1.7

Networking

Networking or forming connections or network creation

This component addresses how students learn in the digital age, which involves inquiry that encourages learners to connect their prior knowledge to observations and use their observation as evidence to increase personal scientific knowledge (Carin *et al.*, 2004).

According to the observations conducted, the use of the IWB to encourage independent and networking learning was not evident, though the computer was connected to the internet. The researcher expected to see learners connecting to sources of information; visiting websites to access information; collective use of networked simulations systems. Learners never connected with learners from other parts of the world as well as visiting websites and multiple databases only a few websites were visited only by the educator as concepts were unfolded. In order to teach science for understanding, McFarlane, Hamson, Somekh, Scrimshaw, Harrison and Lewin (2000) identify IWBs as networked technologies that give learners a wide range of resources and access to information potentially greater than a book. This is what Siemens (2004) refers to as forming connections between sources of information. The more frequent websites are visited the more connected a learner can be. On the other hand, Siemens (2004) maintain that learning may reside in non-human appliances such as the IWBs, but it is important to know where to get the right information at the right time so that knowledge continues to develop so that learners remain current in their fields through the connections they have formed.

At the same time, McFarlane *et al* (2000) argue that IWBs puts learners in control of what they are accessing and they can speed ahead if they are more able and as long as information is accessible for all abilities it can be a very positive experience. Similarly, Bybee (1997) suggests that teaching of science for understanding require learners to be active participant who are engaged in asking questions, observing, and inferring, collecting and interpreting data and drawing conclusions. Learners need to find

information everywhere (Siemens, 2004), which they will organize and manipulate so that a conclusion can be reached and evidence is provided (Schwab, 1962).

5.3.2 Summary of findings from observations

| Concepts | Descriptions | evident | less evident | not evident |
|---|---|----------------|---------------------|--------------------|
| Active collaboration | Collective engagement with tasks, learning in groups, peer interaction, sharing of decision-making. | | √ | |
| Working in teams | Small groups, paired learning, discussion with others, solve problems together, small groups of learners working together to achieve a goal. | | √ | |
| Learning ecology / environment | Collaborative learning environment, exploratory learning environment, allows learners complete control, allows active and interactive learning. | | √ | |
| Networking / forming connections | Collective use of networked simulation systems, connecting to sources of information, visiting websites, accessibility of information, sharing ideas with others through e-mail, chat rooms, etc. | | | √ |
| Addressing diverse learners' needs | Scaffolding learning, considering a variety of learning styles, catering for individual differences | | | √ |
| Authentic learning activities | Working in groups with science simulations, learning by doing, discovery learning, exploration, performs real-life meaningful tasks. | | √ | |
| Project-based activities | Perform activities that allow learners gain experience that they will later apply in working situations, define problems, develop strategies, collect and interpret data and evaluate opinions | | | √ |

Table 1

5.3.3

What challenges do science educators face in utilizing the IWB in teaching science?

5.3.3.1 INTERVIEW RESPONSES

The following section presents the responses obtained from the educators on the challenges they face in utilizing the IWB in teaching science.

(i). How were you trained to use the IWB?

Three educators showed that the manufacturer or supplier such as the Promethean had trained them; though they received the training at different level, for instance, one of them was more advanced than the others. While other three indicated that they had no training.

(ii). What experience do you have to use the IWB?

Educators' experiences to using the board vary. Four educators mentioned that they have no experience to using the board, while others were specific about the number of years they have been using the board, one educator claimed that it is about three years and now uses it daily. Another educator mentioned that this is the second year.

(iii). What additional or specialized skills do you think are needed to use the IWB effectively?

Most educators believed that computer literacy is an important skill for them to have in order to feel comfortable and confident in using the board. Though they believed computer literacy is vital to operating the board, they still showed some other skills that are needed such as word-processing skills, file management skills, formatting techniques. Again, one of the educators mentioned the need for a course in a specific subject, for instance, a course in a specific area of concern like teaching science.

(iv). What knowledge and skills do you need in order to use the IWB?

Educators had a strong perception that knowing all the functions is important, such are search engines, useful websites in science, making use of all the functions like general application skills such as creating files, saving them, formatting techniques like inserting graphics and embedding clips during presentation. Two of them indicated that they really have a problem in the above applications as they revealed that making use of websites require some special skills more especially when they are aware that not all search engines and website are relevant to science, therefore need guidance in the selection of relevant sources.

(v). What do you like most about teaching with the IWB?

Educators were vociferous about the benefits and the potential the board affords them. One educator indicated that the board is beneficial for saving information, which can be

e-mailed to absent learners, and for future reference. Another one mentioned that it provides many opportunities for learning; other educators commented that the board is interactive, it makes demonstration of concepts easy, and the class can partake in balancing equations for chemistry. Educators also liked the multimedia feature of the board, which they said it also provides authentic contexts; like using moveable graphics, pictures and images to visualize concepts. It also tends to address different learning styles. Slay, *et al* (2008) and Smith, *et al* (2005) postulate that the flexibility of the IWBs make available a multimedia based approach to planning and presentation of lessons, which eventually reaches a variety of learning styles. Another educator bears out the point that he loves the interactive activities and exercises that are found from the internet.

(vi). What do you like least about teaching with the IWB?

Educators are of the opinion that there is nothing so far they do not like about the IWB except for a few and minor things such as when the power cuts, one become stuck especially when it happens instantly as it usually happens because of the load shedding that prevailed in those days. Another problem arises when pens have to be calibrated and the projector needs servicing. They indicated that these are times when you become frustrated because you need to think quickly in order to get teaching going. One educator commented that the failure to operate the board because of lack of confidence causes frustration. Educators stressed that there are more advantages than disadvantages. They further stated that the board is something challenging; it requires skills, operating skills in particular, not that they may dislike it.

(vii). Can you explain, how does the IWB support different learning styles?

Educators appeared to like the multimedia feature of the board because according to them, it responds to learners different learning styles such as visual, auditory, kinesthetic aspects. Multimedia combines several media to present information. They said it is authentic and provide learners with a real-world environment. They indicated that music and sound clips could be incorporated for auditory learners. Additionally, educators showed that the board can also bring in some visually attractive clips, graphics for visual learners, and also the board can be manipulated by touching, learners are able to touch the screen, thus being kinesthetic and promoting hand-eye coordination. Another

educator emphasized that the board can display large attractive images and pictures as well as text for those who like seeing objects, they become motivated to learn, other learners prefer learning by touching so the board allows such learners to manipulate graphics on it by allowing them to move objects up and down to help them understand. Generally, educators emphasized that the board caters for all different learning styles. Consequently, Slay *et al* (2008) and Smith *et al* (2005) postulate that the flexibility of the IWBs makes available a multimedia based approach to planning and presentation of lessons, which eventually reaches a variety of learning styles.

(viii). Can you explain, how does the use of the IWB support learners to share reflections on each other's activities?

Educators expressed that they believe that with careful planning, the board can be useful to support learners to share their reflections on what they have done. One educator shared that there are useful exercises from the websites and the software where group work is needed; this can be scanned in to share ideas and display them on the board. Again, it helps promote self-assessment. Another educator expressed that there are tasks that normally require learners to work maybe in small groups, so that at the end they get to the board to present their views, which everybody is free to comment on, and some misunderstandings are addressed. One educator stated that actually, learners are able to prepare their tasks and present whatever they have learned and share with other learners in the classroom. Then, from the groups they have formed; have someone to represent the group and then different groups have their own presentation on the similar topic so their input is being shared. However, from the observations, there was no evidence of learners actually working in groups.

(ix). Currently, what are some challenges that you encounter in using the IWB to facilitate teaching and learning?

Educators identified some benefits such as adaptability, IWB resourcefulness and usefulness, its capabilities in learning, provision of authentic learning activities, and multimedia in learning. On the other hand, they also identified negative challenges such as lack of ICT skills, technical problems, availability of software, time constraints, load shedding emerged as a barrier also. Educators shared that multimedia activities in the classroom are exciting and motivating: Multimedia learning is a predominant feature of

the whiteboard since it incorporates sound, visual, spatial elements, and so on. For example, teaching the periodic table becomes interactive and fun for the learners. In addition, experiments that are harmful can be seen graphically using video clips and simulations, which can also help, explain abstract phenomena such as the rate of chemical reaction.

However, two educators complained that from their experience, multimedia activities tend to offer opportunities for learners to be distracted, off-task, and disruptive. Sometimes, learners misbehave because sometimes they appear to be bored, frustrated or misdirected, hence need help in form of techniques that can assist them keep learners on task and engaged.

Educators from Bereng High school shared that the major problem they are having with the boards is that though the school has installed five boards, they are not using them because they do not have software and the boards require a specific code, which they did not know. Furthermore, the software requires a lot of money that the school cannot afford as they are still paying for the boards. One educator specified that they meet a problem with the irrelevant software packages that do not match with the South African curriculum. The issues of availability of software and cost are challenges that they are facing at their school.

(x)(i). How does IWB technology inspire educators to change their pedagogy; Can you explain how this happens?

Educators are aware that they need to change, transform, and transit their pedagogy in order to use the board effectively. They shared that online instructional presentations are far different from the traditional teaching they have been engaged in; therefore, understand that there is a great need for them to change their approaches to teaching. One educator reported that conducting experiments is a critical issue for the use of the board. Another educator indicated that the use of the board urge educators to work as a team in order to share ideas with other educators.

(x)(ii). How does the IWB technology encourage professional development in the use of ICT resources especially SMART Board technology?

All the educators see the need for them to be trained in using the board thoroughly to gain SMART board literacy as one of them puts it. They emphasized that going on training course is very important. They suggested that specialized personnel should hold the training workshops regularly particularly from the education department. One educator mentioned that there are principles that they should follow in the teaching of science like those of the 5-E model (Engage, Explain, Explore, Elaborate, and Evaluate) which they need some knowledge and / or skills to deal with them.

(x)(iii). What issues, if any do you feel need to be resolved for the IWB to be a more effective tool in the classroom?

Educators emphasized that more educators should be trained to use the board prior using it to avoid embarrassment, frustration and to appear to be a loser when this is quite a valuable resource. In addition, educators stressed the need for encouraging the other educators not to be afraid to try to use new things. Furthermore, educators need to be equipped with ICT skills to build their confidence in using the board by adopting the new approaches to using the board because lack in exposure to relevant approaches could lead to their falling back into the traditional methods of teaching with the board. Another issue is of cost, educators suggested that the Department of Education should assist the schools with the cost and maintenance of these ICT resources. There should be enough funds for maintenance of the board, calibration of pens and servicing of equipment such as the projectors. Again, they suggested that there should be enough technical personnel; in this case they made reference to the technicians who will attend to maintaining the equipment so that they do not take a long time without being repaired as it was a case with 'Mamathe High school.

5.3.3.2 Conclusion

The sub-section has presented the findings from the data collected to answer the critical research questions. The data were presented by research questions. The data from the questionnaire for learners and the focused group interview are used to corroborate the data from the semi-structured interviews with educators. In the light of the above reports from participants, it is apparent that educators meet both positive and negative challenges in using the IWB in teaching science. The following sub-section gives interpretation to

the data so that there is clear meaning of the data as well as understanding of what the data portray. The major findings include the following:

- ✓ The findings indicated that educators considered the IWB to be a valuable, resourceful, useful tool to be used in the classroom.
- ✓ Educators viewed the use of the IWB positively, in particular its visual impact, which responds to different learning styles.
- ✓ Educators highlighted the ability of the board to allow them to prepare lessons before hand and save them a highly motivating.
- ✓ Educators perceived that there was a great need for pedagogical shift to include professional development in instructional approaches for the effective use of the IWB.
- ✓ Planning and training should be prerequisite to the use of the IWBs.
- ✓ Both technical and administrative supports are essential for the effective use of the IWBs.
- ✓ Cost, availability and suitability of the software are major factors that need serious attention to best get the potential from the IWB use.

However, there were some elements of interactiveness of the IWB that were not evident enough to portray the potential use of the boards especially in creating authentic learning environments for learning science. Such elements are addressing diverse needs of the learners; forming networks; engagement in project-based activities, and working in teams.

5.4 INTERPRETATION AND DISCUSSION OF THE FINDINGS

This section intended to offer an interpreted view of the data based on the guided analysis using a conceptual framework adapted from the theories of Connectivism and Engagement propounded by Siemens (2004) and Kearsney and Schneiderman (1998) respectively. The framework consists of seven components that dictate how learners learn in the digital era: active collaboration; working in teams; addressing diverse learners' needs, learning ecology; networking or forming connections; authentic learning activities; project-based activities. However, there are other components (as listed in table 2 below) that emerged from the data, which were also accommodated in the framework of analysis. These are further discussed and substantiated in 5.4.2.

5.4.1 SUMMARY OF MAJOR FINDINGS / RESULTS

| Themes | Categories |
|--|---|
| Theme 1: Effectiveness of the IWBs | <ul style="list-style-type: none"> ✓ Multimedia features ✓ Provide large attractive text and images ✓ Easy access to digital resources ✓ Display of information ✓ Support diverse learning styles ✓ Saves information to view later |
| Theme 2: Low level of interactive approaches in the delivery of content | IWBs advocate for interactive pedagogy in the delivery of content: <ul style="list-style-type: none"> ✓ Active collaboration ✓ Working in teams ✓ Addressing diverse learners' needs |
| Theme 3: Capabilities in learning | <ul style="list-style-type: none"> ✓ Networking or forming connections ✓ Authentic learning activities ✓ Project-based activities |
| Theme 4: Exposure to information sources that promote knowledge construction | <ul style="list-style-type: none"> ✓ Authentic learning ecology |
| Theme 5: Lack of planning | <ul style="list-style-type: none"> ✓ Technology planning ✓ Cost ✓ Technical support ✓ Lack of communication |
| Theme 6: Insufficient professional development and training | <ul style="list-style-type: none"> ✓ Educators' training and development ✓ Pedagogical approaches and principles ✓ Low level of educators' ICT skills and knowledge |

Table 2

5.4.2 Discussions of findings

The themes that emerged reflected on benefits and challenges posed by the use of IWBs in teaching science in some public high schools in Durban. The presentation of findings incorporates verbatim quote where applicable and support from the literature to recontextualize the findings.

5.4.2.1 Theme 1: Effectiveness of the IWBs

5.4.2.1.1 Multimedia features

Multimedia in learning refers to auditory and visual methods of presenting information such as sound, graphics, video images / clips that help explain complex phenomena such as chemical reaction (Sand & Frost, 2005). Parallel to the above, multimedia means a “live” presentation in which a group of people seated in a room views images presented on one or more screens and hears music or other sounds presented via speakers (Mayer,

2001). Another example of multimedia is a PowerPoint presentation in which someone presents slides from a computer projected onto a larger screen like that of an IWB and talks about each one. During the observation period, different features of multimedia were used in presented lessons such as in figures 5.1- 5.6). Educators in the interviews discussed others. Even though some of those that were discussed were not observed during the presentation of lessons, Tara shared her appreciation of the feature: *“Interesting! Multimedia learning is a predominant feature of the whiteboard since it incorporates sound, visual, spatial elements, and so on. For example, teaching the periodic table becomes interactive and fun for the learners. Also, experiments that are harmful can be seen graphically through the use of video clips.”* A similar view was also shared by Dolling: *“In physical science, it makes demonstration of concepts like bonding, atomic structure, etc easy. You can also go online and get the class to partake in balancing equation for chemistry, on so on.”* Learners also expressed their appreciation of the IWB. One learner had this to say: *“The fact that it makes things clearer by allowing multitude of colours. I also like that you can see Power-Point on it and can save any work done.”* Another learner also expressed her feeling about the IWB in relation to the multimedia features: *“The use of colours, pictures, moving objects provides a different approach to learning.”* The views identified above are confirmed by the study conducted by Damcott *et al* (2000), the authors support that the use of colour helped learners to understand ideas better. For instance, the learners in their study used different colours to emphasize differences in air pressure. This activity enabled the learners to compare the different weather maps at different intervals. In this regard, Sang and Frost (2005) confirm that multimedia can able learners to answer “what if” questions (Sang & Frost, 2005, p.61). They further expatiate that a simulation can allow learners to alter variables or change configurations so that they can make their own decisions about what to try next, and this can be very empowering for them [learners]. Gage (2005) identified that IWBs provide large attractive text and images that can be moved around or changed. Furthermore, many boards have additional software, which provides a variety of additional graphics such as maps, and a wide range of images. Additionally, Mayer (2005) shares that multimedia features behave similarly to real-world event, therefore promote interactive learning. In addition, one learner indicated that multimedia feature

catches their attention because they get to see actual pictures, videos of what they are learning about.

5.4.2.1.2 Display of information

Another aspect of the IWBs that educators liked is the display of information to the rest of the class. In both individual and focus group interviews, educators were vociferous on this aspect. Tara pointed out: *There are useful exercises from the websites and other software... these can be scanned in to share ideas and display on the board.*” Dolling also indicated: *“it allows highlighting and revealing information that is displayed on the board step by step.”* Similarly, the classes the researcher observed made incredible use of the IWBs to display information in different formats. For instance, text in the form of notes, illustrations, models, pictures, simulations and clips from different information sources such as Plato Learning Simulations, VirtualLab Chem, etc. One learner confirmed: *...”I also like that you can see Power Point on it.* Another learner claimed: *“it shows information in a more interesting manner than the traditional method.”* The researcher is of the view that the IWBs can display information that is difficult to get by other means (Harvey & Purnell, 1995). Sutherland (2004) also highlights that IWBs transform education. He is of the opinion that the use of the IWBs enhances the whole learning process since educators can create and make use of a range of other resources that the board can display. This makes the researcher to understand that the use of the IWBs is exceptional; no other means of delivery is capable so far (Sutherland, 2004). Gage (2005) also pointed out that the IWBs can support the use of other ICT in the classroom by providing a large display.

5.4.2.1.3 Support different learning styles

Educators are adamant about the IWBs to support different learning styles. They raised different opinions in support of this fact. *“Because learners are not the same, they learn differently, audio, visual, can go and work on it...”*. To confirm the issue, one learner said: *“the SMART Board allows me to hear things I need to. I’m a left-behind student which means I learn best when reading or listening, the SMART Board allows me to have these.”* Another learner share the same view: *“The SMART Board uses images + colours*

which help me remember and understand things better.” Glover and Miller (2001) assert that if used effectively, they are capable of transforming learning by creating new learning styles stimulated by interaction with the electronic whiteboards. In the similar vein, Gage (2005) affirms that some learners benefit from being able to touch the board, and physically move objects around it. It is therefore easy to understand Wall *et al* (2005) opinion that IWBs promote hand-eye coordination. Using audio and video files allow voices from outside the classroom to be heard, again refocusing attention. All learners can benefit from the increased opportunities for more auditory learning, more visual learning and more kinesthetic learning. This denotes the new culture of learning – the use of interactive digital media (Tapscott, 1998).

5.4.2.1.4 Ability to save notes

Another advantage of using the board is the ability of the board to save notes. This feature takes up educators. Tara shared: *...”preparing the work and saving it to use the next day is marvelous, and then when the class starts everything is ready.”* The researcher also observed this aspect. Furthermore, learners also indicated that *...” and can save any work done.”* Notes can be e-mailed to learners who were absent, educators further indicated this. Gage (2005) confirms that work can be saved on the IWB for later use and / or printed out. Three participants from the focus group expressed their positive feelings about this feature. They had this to say: *“you can be able to save work, you can prepare, plan prior the lesson, save everything there and when the children are here you’ll be surprised, you just open files and you get the whole information.”* Parallel to this view, Damcott *et al* (2000) identified that the IWBs have the ability to save notes. They observed the instructor saving students’ isobars maps which they later used to compare with the one the instructor downloaded from a website.

5.4.2.2 Theme 2: Low level of interactive approaches in the delivery of content

5.4.2.2.1 Active collaboration

This refers to interaction with others, especially in groups to solve problems that enhance knowledge construction through the addition of visual information and other multimedia features. The researcher assumes that a group of learners with different abilities to share

knowledge and understanding, and think logically can help each other learn effectively (Siemens, 2004; Kearsley & Schneiderman, 1998).

It was evident from the lessons observed that the IWB can allow sharing information and sources of information with learners. Educators searched for information from the Internet and displayed it on the board where it was discussed with the whole class. More lecturing was used between the educators, learners and the use of the IWB rather than interactive instruction. The researcher observed that in many instances, educators would instigate an activity, and then learners would respond then followed by evaluating the response. The process appeared traditional. According to Mehan (1979), this is referred to as IRE interaction – (Initiate, Respond, Evaluate). Another characteristic that the researcher observed is the ability of the board to give assistance to learners by displaying information on the board; displaying illustration, models, pictures and clipart which were used to unfold concepts gradually by shading and revealing concepts as they are discussed to avoid confusion and also to show coherence of processes, for instance, the process of chemical change. The board was able to highlight the processes and reactions in a chemical change as well as visualize abstract reactions such as uncatalyzed reaction and its reverse. In some instance, educators used Power-Point presentations to give a summary of the main points of the lessons taught. In a Grade twelve class, the presentation had been adopted from [.physchem.co](http://physchem.co) website.

However, it was not clearly identified during observations where learners actually collaborated because they were always seated in their normal positions. It was very rare where the researcher saw individuals going to the board to work on a task. It was evident when the learners could not operate the board when some simple applications were required such as erasing the board, and even writing itself. Nevertheless, the researcher was not interested in the operational aspects of the board, but concerned about the use of the board to allow learners in classrooms to be able to solve problems by working together rather than alone (Webb, 1993). Furthermore, in the study conducted by Slay *et al* (2007) it is evident that the IWBs have the potential benefit of allowing South African educators and learners to share information. In this manner, IWB was used as an instructive or informative tool where learners were passive. This is the infusion stage as

Burden (2002) puts it. However, the situation of having one IWB connected to one computer made collaboration impossible even though features such as the e-mail can extend collaborative learning.

The researcher is aware that educators need to consider the way they teach science using the board. As suggested by Online Portal Excellence Gateway (2008) interactive teaching involves the use of the strategies that stimulate feedback from learners. This is important because as learners learn more effectively when they are active agents in their own learning and when they make thinking explicit by words or actions, and when they take ownership of ideas and information. It is in this context that learners benefit from seeing other learners demonstrate and explain their thinking and model how they arrive at their solution. Admittedly, educators, both in individual and focus groups interviews, affirmed that they really lack appropriate strategies when using the IWBs.

Scholars such as Kennewell, Tanner, Jones and Beauchamp (2007) and Wall, Higgins and Smith (2005), assert that the use of the board will encourage interactive teaching and be a useful tool for promoting interactive whole class teaching, but only if it is used effectively. Similarly, Averill (2006) identified that the use of the boards also create an active and engaged class with increased learner participation and better time on task returns, which translate into saving the teacher much time needed and effort to accomplish classroom and directed curriculum goals.

5.4.2.2.2 Working in teams

Siemens (2004) considers the element of working in teams to be to participate in collaborative work groups e.g. using blogs, wikis, and discussion forums to share information. Parallel to this, Foot *et al* (1994) are of the opinion that working in teams suggests small groups, paired learning, solving problems together, and discussing with others. This encourages willingness to share and critically discuss aspects of practice and curiosity of concepts in a learning environment (Loucks-Horsley, 1998). The researcher observed that the component of working in teams was not evident from lessons. Educators shared that because of the recent use of the technology in the school, they have not reached the point where they could let learners engage in such applications of using

discussion forums, blogs among learners since they are still struggling with some presentation skills themselves. Some learners also confirmed that they have never used the board in small groups or in pairs either. However, they [educators] are aware and appreciated the flexibility, usefulness and adaptability of the board. This is a challenge to educators to change their pedagogy and opt for that, which allows interactivity. Research literature shows that IWBs potentially offer opportunities for collective knowledge building in teaching science (Hennessy, *et al.*, 2007). Similarly, Foot *et al* (1994) caution that small groups of learners are useful because they allow learners to work together to achieve a common goal.

5.4.2.3 Theme 3: Capabilities in learning

5.4.2.3.1 Networking or forming connections or network creation

This refers to how learners learn in the digital age, which involves learners connected to everyone and everything. These can be enabled by technology: email, discussion forums, and websites, search engines, plug-ins, file-uploading (Kearsley, 2000). Networked learning focuses on the connections between learners, learners and educators, and between learners and the information as well as resources (technological artefacts) used in their learning.

The researcher observed that educators do not make use of the board to encourage independent learning and networked learning, whereby learners would connect with other learners from other parts of the world. This could be possible using e-mails, discussion forums, blogs, and wikis. These are the features that can extend collaboration, especially e-mails (O'Leary, 2006). However, the only aspect that was used by the teacher was to e-mail some work to learners who were absent that day, particularly when there was a homework to do. This was only applicable to those learners who have computers that are connected to the Internet at their homes; about three-quarters of the learners had Internet-connected computers at their homes. Even though networking or forming connections was not evident during observation session; but learners made mention of this valuable aspect. One of them had this to say: *“The ability to be able to go online while still in class so to gather more information and questions is very helpful...”* Visiting websites using some search engines such Google was evident though it was only teacher-centred;

learners never had the opportunity to explore or surf the Web nor any databases; although some learners mentioned that, they like the capability of the IWB to go online to get information. IWBs promote interactivity by integrating digital information into teaching; presenting and brainstorming, thereby enhance the communication medium, which can bring improvements in learning (Averill, 2006). Learners need to find data that they will then organize and manipulate, so that a conclusion can be reached and evidence provided so that they are able to learn science with understanding (Schwab, 1962). Thus for Siemens (2004) the capability of learners to distinguish between important and unimportant information is vital to afford learners to make informed decisions. Similarly, Kearsley (2000) asserts that learners need to explore and share information to promote knowledge construction (donate component). Unless educators adapt to recent pedagogical skills considering the technology [IWBs], then it will be just a waste of money, time and energy to install this type of technology regardless its usefulness in teaching.

5.4.2.3.2 Authentic learning activities

These are activities that technology can make it possible to incorporate inquiry through hands-on and process-oriented activities for the benefit of knowledge construction, this means activities that encourage learners to seek knowledge; activities that follow the 5-E model (Engage, Explain, Explore, Elaborate, and Evaluate) (Carin *et al*, 2004). In view of the fact that the science terminology is usually new to learners, authentic activities will better off be advantageous in conceptualizing science concepts and visualizing difficult - to - understand concepts.

Sang and Frost (2005) posit that there are many sites available that can provide useful images. For example, Classroom Clipart contains hundreds of scientifically based images, which can be used for educational purposes. Google Image Search also has a list of indexed images. From the observation of lessons, the board use did not seem to incorporate inquiry through hands-on activities, as it seemed not applicable to the topic at hand. Again, educators disclosed from their interviews that they have never indulged in project-orientated activities using the IWB rather they conduct experiments in the laboratory only.

In addition, Hennessy *et al* (2007) suggest that virtual experiments can be instantly accessed through using multimedia simulations, projected animations and data logging. Furthermore, they identified that such tools can encourage and support prediction and to demonstrate scientific concepts and physical processes thereby proliferate concepts/ border cross between scientific and informal knowledge. Three of the focus group participants ascertained that the use of the multimedia features help them to present new information, to model new concepts and process and explain new and abstract ideas.

5.4.2.3.3 Project-based activities

These involve activities that concern learners in experiences that challenge the current conceptions, provide with experiences that allow them to reconstruct explanations or new concepts, apply new concepts and evaluate them (Schneider, Krajcik, Marx & Soloway 2002). Project –based activities were not evident in the presentations of lessons. Similarly, Colley (2005) is also of the opinion that such activities can make science classrooms function like mini- experimental places, and scientific agencies. Additionally, he suggests that educators need to work with learners to identify projects that they are interested in and create learning environments that allow them to gather resources, plan, implement, evaluate, and report on their projects. Equally, Siemens (2004) argues that decision-making is itself a learning process. He contends that choosing what to learn and the meaning of incoming information is due to the actual changes that emanate from the technology.

5.4.2.4 Theme 4: Exposure to information sources/ knowledge construction

5.4.2.4.1 Authentic learning ecology

This environment is consistent with how learners learn. Furthermore, it allows access to resources that are current and from real-world applications (Schuck & Kearsney, 2007). Such resources illustrate and clarify conceptual materials presented by making the abstract concrete and understandable, for example, evaporation (Chilcoat, 1989). An environment that utilizes technology and Internet in science teaching and demonstrates ways to bring inquiry into science classrooms, scaffolds concepts and illustrate instructional model (Chilcoat, *ibid*). On the other hand, such environment involve multimedia environments which are learning spaces that use a combination of teaching

and learning resources such as the web, video, posters, overhead projectors, PowerPoint presentation, CD ROMS, interactive electronic whiteboards, hypermedia to enhance teaching and learning (Mayer, 2001) and also able to bring rich media into the classroom (Schuck & Kearsney, 2007). Such environments allow for cognitive apprenticeship, active collaboration, critical thinking, problem-solving skills, authentic learning, and cooperative learning (Mayer, 2005).

From the researcher's observation, it was apparent that the educators could not provide an authentic learning environment as identified above and that offer motivation, strategies and self-monitoring skills to control their own learning by effective exploration (Foot, Howe, Anderson, Tolmie & Warden, 1994). Furthermore, based on the observed practice of the IWB, the researcher could not see where and how the IWB could enable learners to connect to each other, to organize themselves and to form discussion groups.

In this regard, Leask and Pachler (2005) caution that IWB can support teachers in developing and providing a stimulus for discussion, for example, from an image, piece of text, video clips or the teacher could pose a complex question by displaying it on the IWB. In addition, the IWB can enable educators to ask 'what if' questions when reviewing a model, simulation or scenario on the IWB and following it with a discussion to allow learners or a group of learners to test their ideas on the IWB (Leask & Pachler, 2005). From the researcher's observation, learners could hardly use the board, rather they would do exercises from their textbooks and then the teacher would do the work on the board. Some learners had this to say: ...” *the teacher does all the work, all you need to do is sit and listen.*” However, the teacher would still interact with the learners by posing some questions and ideas, which seemed to stimulate a whole-class discussion, probe them until they reached the correct answer by consensus. Studies conducted by Smith (2003) found that few teachers make good use of the facilities to enable the range of interaction that is possible and that can benefit learning. Furthermore, the current practice is against the internet-based culture of today (Tapscott, 1998) which is so explorative, allows freedom to choose, promotes independence in terms of computer use, innovative hence learners do not feel challenged when educators revert to their traditional mode of instruction.

What this implies is that educators should seek and use more powerful ways of working with the IWBs especially those that will include learners in the teaching of science such as projected Web-based and multimedia resources whose projection, manipulation and annotation features serve to facilitate visualization of abstract knowledge (Smith, 2003).

5.4.2.5 Theme 5: Lack of planning

5.4.2.5.1 Technology planning

There were problems that participants shared on the use of the IWB, particularly in Bereng High school. They explained that the boards are there at school but are not using them, as they should. They are used as ordinary whiteboards. The reasons they disclosed were that they are unable to use the boards because they cannot operate them because they do not have access to the pin or security code. Another reason was shared by John¹, one educator from Bereng High school *“In order to access the pin; the school needs to spend a hundred thousand rands which is quite impossible at the moment because we are still paying for the boards”* Another reason was shared by ²Carthy *“we are running up and down to get software packages... and cheaper ones for that matter, that is why we are not using the boards...companies sell products that do not work with the type of boards fitted in the school, eh! We did not know that there isn't software that came with the boards we thought it is there already”*. What these mean is that the school has no direction to follow for the installation of the boards in the school. In this matter, Harvey and Purnell (1995, p.5) caution: “a vision of technology in support of learning is essential.” This means needs have to be identified. Questions to be addressed could include “what do we need in education, and how can technology contribute?” (Harvey & Purnell, 1995, p.6).

Planning is critical for the successful implementation of technology in schools. According to Cradler (1997), in order to effectively target technology to support teaching and learning, it is necessary to engage in planning at all levels of education. This could be

¹ For the sake of anonymity, a fictitious name has been used as assured in the informed consent.

² A pseudonym for the sake of non-traceability as assured in the consent form

applicable at, for instance, the department of education, district level, and school and classroom level. Recent findings from research posit that in most instances, teachers were often not involved in decisions about technology applications (Cradler, 1997). Nevertheless, this is not the case with the educators in the participating schools, though their involvement was not clearly articulated. Their engagement was not fruitful because they lack knowledge about the purchase of the boards. In addition, the study conducted by Cradler (1997) showed that technology has a positive impact on teaching and learning when teachers and principals worked together to plan the use of technology in the classroom. Hence, there is a need for the technology plan for the school. This should clearly spell out the rationale for the technology and related resources such as availability of software packages to include the issue of cost and suitability of the software. One educator, Portia³ complained: *“Most of the software are international and very expensive, they are mainly British...and do not work for us. I believe that these boards can function best with the locally produced software based on the local curriculum”*. This comment implies that there is a need for locally produced software packages that will best spell out and be relevant to the curriculum content.

5.4.2.5.2 Cost

Another issue that emerged from the study is the cost factor. This has also been made mention of in several instances where major investments have been made and in some cases IWBs are rarely used to their full potential or not used at all. This is the case with one High school that participated in the study – Bereng High school. John, one educator from this school shared that: *“the school is still in debt with the five installed IWBs, but what hurts is that we need to get some software which is also expensive...it is a shock to have the school to pay more than a hundred thousand bucks to get the software, we are still struggling to identify any thing cheaper but relevant to the curriculum.”* Additionally, Carthy explained: *“it is even painful to discover lately that the boards do not have software that comes with them, we thought everything is complete once the boards are put up.”* Besides the issue of cost, it shows that neither adequate planning nor consultation have been considered in the initiative to purchase and install the IWBs in

³ Portia; not real name to ensure confidentiality of the participant

this school. The IWBs appeared to be cheaper than purchasing 30 computers for 30 learners to be used in the classroom, rather one board that can cater for those 30 learners. Recently, the price of IWB has drastically dropped, but they still affect the schools' budget (Leask & Pachler, 2005). International governments such as the UK, Australia, are investing some significant amount of money into this area (Leask & Pachler, 2005). Interactive whiteboards use special tools in order to function effectively. They use only special pens not mere whiteboard markers, which need some maintenance. The filters need to be checked and cleaned every month hence funds are needed. The concern on this issue arises when authorities continue to spend money on this equipment without considering what is fundamental prior its use.

Consequently, schools need to have a clear budget, which stipulate where funds will be obtained from to cater for the cost and maintenance of the IWBs. These should be preceded by thorough needs identification that relates to the installation and maintenance of the IWBs. However, Glover and Miller (2001c) and Levy (2002) proved that IWBs are difficult to maintain and, as a result, present difficulties when they are out of order or when an educator without skills to use one was faced with one problem in the classroom. The current situation in South Africa is problematic because there are no full time educators to manage the ICT facilities and to champion the use of the ICT in the schools as per the Department of Education (2004). In the light of the problems these boards pose, South Africa as a developing country needs a thorough planning in implementation of these IWBs in schools.

5.4.2.5.3 Technical support

Educators indicated that suitable technical help is essential to support the use of the boards in schools. They proposed that schools should have qualified technicians to respond to the maintenance requirement of the boards rather than waiting for someone from far away like Johannesburg. They said that it takes time to get things back to normal. For instance, during the data collection period, one board in Mamathe High school was out of order and the educator who uses the board stated that it has been time that the board has not been working. The school had been waiting for someone who could not even tell when he may come to fix the board, and this causes inconveniency in the

process of teaching and learning. In this regard, one learner confirms, “*as at times, teacher saves work there and if there’s a problem, a whole lesson is lost, making us be behind schedule.*” Another learner complained: “*I agree because whenever the board won’t work or the power goes out, having to revert to normal board throws you off.*” Additionally, educators need to know where to resort to if they come across a problem. Glover and Miller (2002) suggest that there should be someone committed to help educators through the problem, that is, someone leading the project and taking responsibility for troubleshooting should be considered as a high priority. Nevertheless, Leask and Pachler (2005) caution that any use of ICT is characterized by a risk that problems may arise. For instance, the board can sometimes fail to function due to the driver, which enables the computer to recognize input from the board, or could be a technical problem with the board itself. A projector may fail because the bulb has been blown. This can be promoted by not cleaning the filters. The school technician should be responsible for such services, and other problems. For the reasons identified above, schools need to be optimistic in their planning to cater for such problems more especially when the whole technology planning and implementation process still remain the individual schools’ initiative here in South Africa especially those schools which use such high technology devices.

Another support is human-related. This means there should be sufficient efforts to support educators with the board, such as ICT training workshops or courses to afford educators’ competence and literacy in general ICT skills. To substantiate the above theme, Portia said, “*There should be more teachers trained to use it. Boards should not be imposed to us without enough preparation because like myself at times I feel so frustrated that I feel I am wasting my time and feel to resort back to my normal teaching.*” In the study conducted by Slay *et al* (2008), in the Eastern Cape, educators were prepared before they could use the board to ensure their confidence and acquisition of related skills. Therefore, training and support are integral to the implementation process and should not be overlooked or ignored.

This implies that the National Department of Education is challenged to urge training institutions to incorporate a component on ICT literacy within the initial teacher training

because it is evident that IWBs have attracted so many educators and institutions. During the researcher's initial teacher training, chalkboard technique or work was a compulsory component in the professional studies. Assuming as the researcher may, this practice was seen as important in the delivery of content and therefore, needed mastery. Chalkboard in those days was the only presentation and delivery tool. This implies that similarly educators should acquire IWB literacy prior to using IWBs. In view of the fact that the IWB installation is increasing in schools; any related ICT literacy course should be infused in higher institutions' initial teacher training courses. As a result, preparations need to be made in advance. This suggests very strongly that sideline with the process of transforming education in South Africa through ICTs; the National Department of Education should consider training at the same time with furnishing schools with the ICT suites like computers as it is taking place now. This challenges the implementation strategy of the e-Education policy. The implementation is at its second phase currently. The expectation is that by 2010; about 50% of educators should have been trained in basic ICT integration into teaching and learning; educators should have access to ICT technical support training; to mention a few. This means research that informs the process is important. Since technology has some drawbacks as reiterated by Leask and Pachler (2005), Harvey and Purnell (1995) caution that meaningful use of technology requires a lot of support.

5.4.2.5.4 Lack of communication

There were two instances when one morning one educator found that the projector was missing. When trying to find out, she was told that it has been taken away for service. This was rather unpleasant because she had prepared and saved her lessons on the board the previous day only to find that lately that she cannot access the information. This had not been communicated on time so that she seeks alternative ways in time for learning to take place. The school executives or any responsible structures should ensure a supportive and collegial atmosphere to ensure good communication throughout the school (Kearney & Schuck, 2007). The school technology plan should stipulate clearly the frequencies at which the equipment needs to be serviced and how that aspect should be communicated.

5.4.2.6 Theme 6: Insufficient professional development and training

5.4.2.6.1 Educators' training and development

Most participants indicated that there is the need for professional development and pedagogical shift. From the emerging literature, different scholars caution that educators who intend to use or use the IWBs with confidence need to be highly committed in sorting out efforts for training and independent exploration (Glover & Miller, 2001; Bell, 2000; Damcott, Landato & Marsh, 2000). Alternatively, the researcher posit that the skills needed to be deployed with the IWBs are equally important like those used traditionally with the chalkboard whereby chalkboard use had been a component element in the professional studies to ensure that student teachers have acquired necessary skills before going out into the field. Slay *et al* (2008) also suggest in-service ICT programs to alleviate the problem.

Following are some of the comments educators made in this regard:

Tara: *“Using the board, according to what I have observed since I used it, requires one to grow, I mean to change your style of teaching, develop your own style of using the board mmm! Also going on training courses is very important. Yes, it does, you know we need to acquire some skills as professionals, we need to develop our profession, we need skills in order to operate, we need to manage files, find skills like word-processing, so that we can be able to use the SMART Board effectively.”*

Irene: *“we need to adopt learner-centred approaches in the true sense of it; at the moment I am the one using the board when in actual fact, the learners also need to operate the board; since I am not confident enough myself, it is hard to lead them use the board; so training is important and it should be frequent in order to build our confidence in using this board.”*

Dolling: *“Teachers who use the board should first be made aware and understand that there is a need for a shift from where we are, where we think we are going to where we engage learners in their own education. What I am saying here is the change in approach to teaching and learning. We also need to be confident in using the board by adopting the new approaches to using it because if we lack exposure in the relevant approaches we are likely to fall back into the traditional methods of teaching with the board.”*

However, most educators indicated that manufacturers of the whiteboards offered some training as part of their professional development. This shows that the training was not enough because they indicated that they were trained once when the boards were installed in the schools for the first time. A member of staff at Mamathe High school, Dolling

suggested that “... *We need training and not a once off training but it should be continuous.*” Another staff member has this to say, “*Educators should be confident in using the board before actually using it. It is true that with practice one becomes a better user, but I think equipping teachers with the basic ICT skills can be appreciated.*” In order to respond to these challenges, Glover and Miller (2001) outlined some basic guidelines for good practice and outcomes of engaging classroom interaction and participation with IWBs.

During the data collection period, one of the staff members at Mamathe High school, Tara, indicated that she is to attend an advanced course on the use of the IWB. However, it was not discussed as to how she shares the information when she comes back. This makes the researcher to conclude that there is no sharing of information amongst educators; there was no need for such a saying “*no training, I play and learn by myself.*” Therefore, this suggests that there should be staff development days as Schuck and Kearney (2007) suggest. Such trainings can be conducted by advanced teachers within the school or could be offered by regional staff members whereby special arrangements could be made for such an exercise to take place. Another way could be to have colleagues demonstrate the use of the IWB to colleagues (Schuck & Kearney, 2007). In the similar vein, Stein (2005) also found sharing to be an integral part of the implementation process. Additionally, educators need to know where to resort to if they come across a problem. Glover and Miller (2002) suggest that there should be someone committed to help educators through the problem, that is, someone leading the project and taking responsibility for troubleshooting should be considered as a high priority.

Some educators are technophobic; therefore, such activities as staff development days can help alleviate these fears (Schuck & Kearney, 2007). One educator has this to say in support of the above view: “...*encourage teachers not to be “afraid” to try new things in the classroom,*”... “*Yes, it encourages professional development because eh! You see teachers need to be trained in using the board thoroughly to gain SMART board literacy. Oh Yes! Smart board literacy is when teachers are able to use the board effectively.*” In terms of professional development, Harvey and Purnell (1995) share several views concerning staff training: educators need a situation in which they could learn from both

their achievements and mistakes; they need sustained staff development, not short-term programs; they need teacher-controlled programs; they also need programs that would advance them intellectually and professionally. They further outlined the guiding standard in the use of IWBs. They are “Three C’s” – comfort, confidence, and creativity (p.8). They postulate that in the first year educators simply become comfortable with the new technology, the second, they develop the confidence to use it, and in the third year and later, educators are expected to become creative in using the technology, such as Internet, CD-ROMs, video images, sound and multimedia.

This implies that currently, professional development is conceived and delivered as “one-shot seminar,” “an afternoon with an expert” (Harvey & Purnell (1995, p.1), thus Dolling complained... “*We need training and not a once off training but it should be continuous.*” Similarly, Tara too declared ...“*the training took place in 2006 in one afternoon... This year, 2008 I went on the advanced training course, also one afternoon where they [representatives of the manufacturing company] introduced new concepts and technologies.*” This shows a low professional development. Accordingly, it is apparent that educators are vociferous that the preparation of educators to confident use of IWBs is underprovided. Therefore, something needs to be done in order to respond to the emerging schools’ transformation. In this respect, the researcher recalled that during the initial teacher training he / she underwent as a teacher trainee in the early eighties; one of the courses offered was professional studies, which included a component of chalkboard management which was compulsory. Chalkboard in those days was the only presentation and delivery tool used in schools. The researcher assumes that the practice was seen important in the delivery of content. This bears to the point that similarly, educators prior using the IWBs should acquire IWB literacy. The strongly suggests that it should be integrated in the higher institution initial teacher education and training. Again, on the correct supposition, currently, basic professional development has not been put in place in South Africa. The researcher perceives professional development very shallow (Harvey & Purnell, 1995). Initial teacher training institutions do not offer ICT across the curriculum, only a few student teachers especially those who may choose to specialize in Educational Technology get some training. This bear out the point that those educators

already in the field get shallow or no training. Therefore, a sustained staff development is essential (Harvey & Purnell, 1995).

5.4.2.6.2 Pedagogical shift / challenge

Educators showed the need to change, shift or transform their teaching styles or approaches. Schenk (2007) emphasizes that integrating technology into the classroom can influence the way lessons are prepared and delivered. Therefore, educators need to divorce themselves from their traditional teaching methods, adopt, and adapt to recent pedagogical approaches, taking into consideration the technology side of learners' education. Beauchamp and Parkinson (2005) also assert that as educators develop their ICT skills, they also need to accept changes in their role and in the interaction with learners – this adjustment to coach; observer and facilitator afford learners a great responsibility for their own learning. During the observation of lessons, educators were inclined towards using discussion and questioning methods. This confirms the ideas from individual and focus group interviews as well as learners that educators need to change their pedagogical approaches in as far as using the board is concerned. One learner had this to say: *“the teacher does all the work, all you need to do is sit and listen, trying to learn certain skills will be rather pointless.”* Another learner also shared this: *“...you have to be very quick to understand.”* The use of the IWBs advocates for interactive pedagogical approaches especially in teaching science.

The following sample of responses support the above-identified view:

Dolling: *“Teachers who use the board should first be made aware and understand that there is a need for a shift from where we are, where we think we are going to where we engage learners in their own education. What I am saying here is the change in approach to teaching and learning.”*

Tara: *“We also need to be confident in using the board by adopting the new approaches to using it because if we lack exposure in the relevant approaches we are likely to fall back into the traditional methods of teaching with the board.”*

Irene: *“we need to shift from there and get to the point whereby learners are given chance to find information and be responsible for their own learning.”*

Tara: *“I believe online instructional presentation is far different from the traditional teaching we have been engaged in therefore I understand that there is a need to change our approaches to teaching Hm! Engaging learners online requires a particular strategy, for instance, selection of authentic learning tasks which are relevant and*

interesting to learners, preparing structured lessons like having hyperlinks to different activities allowing differentiation and quick access to a variety of resources.”

Dolling: “This calls for different approaches to teaching eh! such as whole class teaching, working in small teams, yah! I also think independent learning is still ok! I really feel that the use of the IWB challenges one to change the styles of teaching, mm! The approach to teaching.”

Glover and Miller (2001) provide evidence on the need for educators to change their teaching technique. However, they do not go into details about what these changes may be. Glover *et al* (2005), however, revealed different pedagogic phases at three levels, namely: supported didactic, interactive and enhanced interactive to promote learning. On the other hand, Lewin *et al* (2003) postulate that pedagogy is no longer merely a process of teacher-student interaction, but a complex process of interaction between educator, learner, peers, family and technology. This is true because there are computers at schools and at home today and some parents can be able to guide their children at home. Similarly, Hargreaves (1997) asserts that there is an infinite variety of multiple forms of teaching and learning so that educators can turn the “learning society” or “lifelong education” a reality (p.11). Glover and Miller (2001) identified that the main factors that will affect the use of the board, one in particular is the training of educators in the use of the board in their subject, in this regard, science, and ensure good access to them to build their confidence. Hennessy *et al* (2007) outlined the pedagogical principles in teaching science such as Predict, observe, and explain; Tell, explore and check, and Analyse, explore, plan, implement and verify. In all these principles, Hennessy *et al* (2007) stress that multimedia simulations and animations can assist learners in exploring and testing out their ideas about the natural world in comparison with the theoretical world of science through direct manipulation of abstract representations of concrete objects and phenomena.

5.4.2.6.3 Low level of educators’ ICT skills and knowledge

Educators reported that they lack necessary skills to operate the board effectively. This is confirmed by the observations the researcher conducted. The use of the IWBs is actually a teacher-centred didactic pedagogy, which needs adjustment (Hennessy *et al.*, 2007). They identified numerous skills that they lack. They identified the following skills which

they considered important in operating the board: general application skills, creating files and saving them, formatting techniques, for example, inserting graphics, clipart, etc during presentations, using different search engines and the ability to select relevant sites for teaching science, surfing the Internet and following hyperlinks. In support of educators' views, Leask and Pachler (2005) identified the ICT skills and how they can be demonstrated in science teaching:

- ✓ Finding things out using graphic packages, internet searching e.g. genetic information;
- ✓ Developing ideas by modeling experiments / simulations;
- ✓ Making things happen by modeling experiments, simulations to respond to 'what if' questions;
- ✓ Exchanging and sharing information by communicating investigation, web / multimedia authoring and;
- ✓ Receiving, modifying and evaluating consequences of their own reasoning through visuals.

In the similar vein, Hennessy *et al* (2007) postulate that simulation offer idealized, lively and visual representations of physical phenomena and experiments which would be dangerous, costly or otherwise not feasible in a school laboratory. Again, using simulation is deemed to support science learning through encouraging learners to pose and investigate exploratory 'What if' questions and bringing in less chaotic data (Hennessy *et al.*, 2007). Data logging make routine in recording and handling experimental data using sensing equipment, which offers immediate feedback, and alleviate laborious data collection and graph production (Hennessy *et al*, 2007). They further share that immediate feedback from dynamic graph production enables actions to be monitored and adjusted; yet, demonstration remains the common mode of use.

Lack of ICT literacy and ICT competency are frequently identified by educators in the literature and have become evident in this particular study. Educators from the two schools commented that one can become "frustrated," "stressed," "a fool" if you can fail to operate the board especially in front of the class. Therefore, Hall and Higgins (2005) caution that if educators do not have sufficient ICT skills can result in poor use of the

IWBs. The findings from this study confirms this as Irene commented: *“In terms of operating the board, you know this ICT business can drive you mad sometimes, files can just miss or appear fragmented when you know you have saved it as a whole.”* Another educator, Dolling has this to say in response to the theme: *“From my experience working with the board is very crucial, therefore it is very important to equip [familiarize] teachers with the board prior using it because one can be frustrated and appear to be a loser when this is quite a valuable resource.”* Similarly, Tara shares her experience too: *“I think teachers need to be encouraged not to be “afraid”... to try to use the new things in the classroom.”* Concisely, the low level of ICT knowledge in educators has been found to be one of the most notable challenges to use the interactive electronic whiteboards in education (Sharma, 2003). Emphatically, knowledge of ICT skills is evident when educators regularly practice ICT literacy skills they have acquired rather than waiting to apply them when the need arises. This will lead them to forget hence loose confidence (Watson, 2001).

5.4.3 KEY FINDINGS OF THE STUDY

The section below gives a summary of the key findings.

- ✓ The effectiveness of the IWBs in teaching
- ✓ Educators viewed the use of the IWB positively, in particular its visual impact and the multimedia features;
- ✓ Educators highlighted the ability of the board to allow them to prepare lessons before hand and save them as highly motivating and;
- ✓ Educators indicated the ability of the board to support different learning styles.
- ✓ Low level of interactive approaches in the delivery of content.
- ✓ Capabilities in learning in terms of networking or forming connections, provision of authentic learning activities and project-based activities.
- ✓ Exposure to information sources to promote knowledge construction. This refers to interactive learning ecology.
- ✓ Insufficient professional development and training in educators on the use of the IWBs and low level of educators’ ICT skills and knowledge.
- ✓ Pedagogical approaches and principles and;

- ✓ Lack of planning - This was seen as a prerequisite to the installation, implementation and use of the IWBs;
- ✓ Both technical and administrative supports are essential for the effective use of the IWBs and; cost, availability and suitability of the software are major factors that need serious attention to best get the potential from the IWB use.

Based on the findings of this study, the following recommendations are put forth:

- ✓ Technology planning – The National Department of Education should initiate the need for technology planning in schools. Districts should spearhead the process. School development planning should be seen as a priority. The focus should be on the inclusion of maintenance plan, consultation strategies, and collaborative efforts, to mention a few.
- ✓ Training / professional development - the use of IWBs in teaching science should be considered as part of classroom technology. The Department of Education and other administrative structures should ensure that training is provided to educators prior the actual use of the boards. The acquisition of ICT skills should be seen as a prerequisite to the use of the board and the awareness of pedagogical principles should be considered.
- ✓ Reflective practice - A framework for reflective practice should be drawn to initiate educators to reflect on their practice timeously, employing strategies such as self-monitoring model, clinical supervision and triangulation.
- ✓ Pedagogy shift - educators should be introduced to interactive approaches relevant to teaching science using the IWBs.

Further exploration is needed to find out if IWBs really support scientific inquiry that could result in understanding science under some of the following aspects: instructional approaches relevant to the teaching science, pedagogical principles of teaching science, how IWBs support and improve learners' achievement in learning science, and support scientific inquiry.

5.4.4 CONCLUSION

This study has revealed that the use of the IWBs is still at its infancy and educators are not familiar with the boards. However, educators have identified the usefulness of the IWBs in teaching which involve the multimedia features that support learning, support of different learning styles, access to digital resources and the ability of the IWBs to save notes. Some discrepancies need to be attended to so that the boards are effective. From

the observations only visual learners benefit from the use of the boards while auditory and tactile learners are still left behind. Another view is that the use of the board as observed currently is still inclined towards traditional teaching approaches whereby educators still teach or lecture in the true sense of the word instead of facilitating teaching and learning especially when the boards support such aspects. These inadequacies could be associated with lack of training that could be associated with professional development and pedagogical shift. Following is the issue of cost and availability of software, which relates directly to lack of planning.

The following chapter reiterates the whole study. It summarizes the major features in the study, to include the introductory chapter, the significance of the study; major issues from the literature reviewed, the framework that guided the study, the methodology and research design adopted for collecting data for this study; major findings and interpretation of the findings as well as a summary of themes that emerged for the data. Finally, recommendations will be drawn and conclusion presented.

CHAPTER SIX

RECOMMENDATIONS AND CONCLUSION

6.1 INTRODUCTION

The interactive whiteboards are considered vital in the learning environment. Most educators consider the boards to be essential presentation and organizational tools. This small study aimed at identifying those practices that educators engage in as they use the IWBs in teaching the processes and activities of science. From observation, instruction-utilizing IWBs do not reflect effective learner-centred teaching of science. Educators use the IWBs in an authoritative way; they tend to dominate the lesson presentation. Although educators used whole class teaching, learners have not been actively involved in their own learning, opportunities were not created for them to be responsible for their learning by, for instance, searching for information to tackle some tasks, work on the board to illustrate some scientific processes, and so on. To ensure active collaboration and participation, paired work or small groups could also be used to work on scientific activities on the board. Leask and Pachler (2005) are of the opinion that the IWBs by nature require that educators allow learners a greater measure of independence. This can be made possible if educators are able to create authentic learning environments as suggested by Siemens (2004), Kearsley and Schneiderman (1998).

One of the major findings of the study reveals that currently, educators mainly theorize the use of the IWBs more than the actual practice. This chapter reiterates the whole study by highlighting the methodology the study adopted; the significance of the study, major findings and proposes future directions in the form of recommendations.

6.2 METHODOLOGY

The study investigated the use of the IWBs in the teaching of science in two public high schools in the Durban Metropolis. The study was guided by the following questions:

1. How do science educators utilize the IWBs in order to provide authentic learning environments in teaching science in some public high schools?
2. What are the challenges facing educators in utilizing the IWBs in teaching science in some public high schools?

The study adopted a case study methodology involving two public high schools in the Durban metropolis. It was qualitative in nature because it investigated educators' perceptions, experiences, attitudes, opinions to using the IWBs in teaching science through semi-structured individual interviews, focus groups, classroom observations and an open-ended questionnaire for learners as a way of corroborating the data from individual interviews. Only six participants took part in the study.

The findings emerged from the data collection as explained above. The analysis of data followed a guided analysis. However, initially a conceptual framework derived from the two theories that informed the study was used, and then other themes that emerged as the data were analyzed were accommodated into the framework. The tool of analysis consisted of the following components: active collaboration; working in teams, learning ecology; addressing diverse learners' needs, authentic learning activities, project-based activities, and networking. Other themes that emerged from the data were lack of planning, professional development, pedagogy change / shift, cost, technical support, and lack of communication. Educators have developed some love for the IWBs, though there are still some critical issues that need to be addressed so that the boards are used effectively. Nevertheless, to some extent, the current practice does not actually portray what educators had shared in the interviews. This was corroborated by the observations the researcher engaged in and from the learners' open-ended questionnaire.

6.3 SIGNIFICANCE OF THE STUDY

The use of this technology is just at its initial stage in South Africa. Very few studies have been undertaken recently on the use of the IWBs in education, but with no focus on a particular subject as done in this study. The focus of the study was on the utility of the board in the teaching of science. The choice for this subject has been influenced by its nature, it is more practical with other aspects hazardous to conduct in normal laboratories and is characterized by abstract phenomena that are difficult to explain or show through other means. According to the literature, with the use of the IWBs such processes are possible through simulations, data logging and projected animations (Hennessy *et al*, 2007). The study considered the ways learners are to learn as dictated by the theories of learning in the digital era that are connectivism and engagement. These theories of

learning relate with Tapscott's (1998) shift of interactive learning, which compares how learning used to take place in the past as compared to this time, when the world is highly influence by technology. The use of the IWBs should create an authentic learning environment that is versatile, adaptable, resourceful and flexible. For instance, the use of multimedia presentations should be seen to accommodate a range of learning styles and motivate learners to participate in learning tasks (Leask & Pachler, 2005). It considered the challenges that educators face in using IWBs such as pedagogy, professional development, negative issues like technical problems, and in general some likes and dislikes of the IWBs. Educators seem to be excited about the new technology, thereby ignore some other important issues such as planning, professional development and training, awareness of pedagogical principles, and technical support that could make them [educators] effective users of this technology in teaching science in South Africa.

6.4 SUMMARY OF MAJOR FINDINGS OF THE STUDY

6.4.1 The Effectiveness of the IWBs.

This appeared to be the major benefit of the IWBs use in the learning environment. Educators seemed to be overwhelmed by the benefits the IWBs offer in teaching and learning. They identified a myriad of benefits such as its multimedia features that are authentic and provide learners with real-world environment. Multimedia features also support different learning styles that promote hand-eye coordination in kinesthetic learners who also appreciate video and animations, and can touch and move things on the board. Visual learners can enjoy the colours, graphics, pictures, graphs, mind-maps. Auditory learners can be stimulated by audio and video files that can be used to supplement classroom discussion. The IWBs can also share information as well as digital sources of information, which can be displayed on the board. Furthermore, the capability of the board to save notes during and after presentation attracted educators a great deal.

6.4.2 Low level of interactive approaches in the delivery of content.

In principle, educators are aware of the benefits of IWBs in teaching and learning environments, but they fail to adhere to those principles in practice. The use of the IWBs calls for interactive approaches in the delivery of content. Such approaches include active

collaboration and working in teams. However, educators seemed to be lacking in these approaches. The dominant approach that was used in most lessons was large group or whole-class discussion. Learners could hardly work in small groups, paired learning, solve problems together, discuss with other learners. Interactive approaches require learners to work together to construct knowledge and acquire skills (Mayer, 2001; Wall *et al* (2005).

6.4.3 Capabilities in learning.

The use of the IWBs can allow learners to connect between other learners, learners to educators, and between learners and the information as well as resources in their learning (McFarlane *et al*, 2000). Forming connections by visiting different sources of information has not been evident. Only educators had access to the sources on information such as websites, search engines, etc. However, some learners mentioned the capability of the IWBs to go online to get information. This aspect was not evident during observations. Siemens (2004) cautions that learners in the digital era can learn best if they are exposed to different sources of information. These could include non-human appliances such as computers. The exposure could help learners to distinguish between important and unimportant information so that they are able to make informed decisions. Learners in this era have ample access to computers either at home or at school (Tapscott, 1998). This means that they are capable of getting information from the Internet from peers around the world without restriction and this could promote interactivity. Computers to today's generation have become a second nature. Furthermore, one of the benefits of the IWBs that educators mentioned is the multimedia features that the IWBs provide to present information, to model new concepts, and to explain abstract concepts. The IWBs also provided interactive activities and exercises from the Internet that helped in demonstrating concepts with easy. Project-based activities were not evident in this study. Colley (2005) suggests that if such activities are considered; they can make science classrooms function like mini-experimental places and scientific agencies.

6.4.4 Exposure to information sources that promote knowledge construction.

Learning using the IWBs needs to take place in interactive environments in which features in the environment behave similarly to real-world events (Mayer, 2005). There

seemed to be lack of interactivity within the classrooms. Educators could not provide such multimedia, interactive environments that could allow for cognitive apprenticeship, active collaboration, critical thinking, problem-solving skills, authentic learning, and cooperative learning. Multimedia presentations accommodate a range of learning styles, and motivate learners to participate in learning tasks (Leask & Pachler, 2005). Such environments should also be seen to engage learners in interactive activities and exercises. This component seemed lacking. Therefore, educators need to pay attention to the ways they deliver content materials to learners; more especially when the IWBs can access and bring a variety of resources into the classroom (Schunk & Kearsney, 2007).

6.4.5 Lack of planning.

One of the two schools that participated in the study had problems with the implementation of the IWBs in their school. For instance, IWBs were installed but not working. According to educators, this was due to no software because of unaffordable cost. These discrepancies could be related to lack of technology planning. The school did not have a technology plan. Again, it was no clear as to how the two schools render technical support to their educators; as a result, support seemed insufficient. This also included lack of communication between the authorities and the educators who use the IWBs

6.4.6 Insufficient professional development and training.

The only way the lessons were delivered was through discussion, questioning and lecturing. No interaction was observed except when learners worked as a whole-class. One learner would lead a discussion from the board and all learners would contribute. This mode of teaching indicated that there is lack of pedagogical approaches in educators for the effective use of the board. Educators also showed lack of ICT skills to use the IWBs effectively. Collaborative efforts need to be encouraged to urge educators to share ideas. Professional development and training need to be considered in a more intensive manner to include pre-service and in-service training.

6.5 RECOMMENDATIONS

Based on the above findings of the study; following are the recommendations:

6.5.1 Need for technology planning

The National Department of Education should initiate the need for technology planning in schools. Districts should spearhead the process. The inclusion of the IWBs in the education system lately can be related to the improvement or development that school authorities considered important for effective teaching. Therefore, school development planning should be seen as a priority. A technology plan is one initiative that schools could adopt in order to guide the implementation process. Needs should be identified and clearly articulated and how they are going to be met. This is a shared sense of direction in order to manage the tasks of development and change. The problems of cost, availability of software as it became evident in the study; professional development and training could be overcome through thorough planning.

6.5.1.1 Need for collaborative efforts

Kent (2004) points out that the leadership of schools and involvement of all stakeholders are important in the effective use of the IWBs. Support and encouragement for those who use the IWBs is essential because currently not all educators use the board. Additionally, support is needed to develop educators' ability to exploit the potential of IWBs in relation to the curriculum. In the similar vein, Winzenreid (2006) undertook a study whose conclusion cautions that the implementation of the IWBs entail or involve or is a collective effort of the whole school and affects school policies, educators, parents, as well as the culture of the school.

6.5.1.2 Need for consultation

It is important for schools that plan to purchase and install these IWBs to engage in some sort of survey by visiting schools who have these technology; basically to give guidance in terms of purchase, installation and implementation.

6.6 Need for training / professional development

Teacher education training at higher education institutions should consider the use of IWBs in teaching as part of classroom technology. Courses should emphasize appropriate strategies that afford new student teachers with opportunities to do science, in addition to learning facts and concepts of science. From this particular study and others conducted, it is obvious that the IWBs will be the only presentation tool used in schools in few years to come given the rate at which they are being installed. The Department of Education and other administrative structures should ensure that training is provided to educators prior the actual use of the boards. Intensive training in terms of pre-service and in-service should concentrate on acquisition of ICT skills as a prerequisite to the use of the board. As revealed by the study, skills and confidence are vital to the effective use of the IWBs. Furthermore, educators should be trained specifically for using IWBs in their specific subjects. ICT literacy is important, hence continuous training for new ideas, new sources of information, new software, and new techniques to learn and practice. Training courses should cover basic issues such as:

- ✓ Overview of the Internet and its uses in teaching and learning;
- ✓ Using a browser to navigate the Web;
- ✓ Saving material from the Internet (images, sounds, movies);
- ✓ Using search techniques to locate educational resources on the Internet;
- ✓ Using portals such as Scoilnet to locate educational resources and;
- ✓ Classroom management.

Source: [://www.ncte.ie/](http://www.ncte.ie/) or [://www.ncte.ie/](http://www.ncte.ie/)

6.6.1 Need for pedagogy shift

It has been evident from the study's findings that educators lack in approaches to teaching science using the IWBs. Educators resorted to one strategy of whole class teaching. As it may be appropriate, some other strategies can also be useful or could complement the whole class teaching at some point. Paired work and small groups working at the board are recommended. Educators should be able to identify appropriate science pedagogy such as asking questions, observing and inferring, collecting and

interpreting data, and drawing conclusions (Bybee, 1997). In general, the use of the IWBs calls for interactive approaches to teaching which this technology can afford.

6.6.1.1 Awareness of pedagogical principles

In teaching science using the IWBs, educators need to be aware of some pedagogical principles to make science teaching using the boards meaningful. Hennessy *et al* (2007) suggest the following principles vital to teaching science:

- ✓ Predict, observe, and explain (POE);
- ✓ Tell, explore, and check;
- ✓ Analyse, explore, plan, implement and verify and;
- ✓ 5-E model (Engage, Explore, Explain, Elaborate, and Evaluate).

Furthermore, educators need to be helped to explain concepts following strategies such as concept proliferation, border crossing, and conceptual change that are relevant to science teaching. One of the aspects of learning in the digital age is the instruction that considers learners' diverse needs, interest and their background knowledge or prior experiences upon which educators should build on learners' knowledge. So the IWBs should be seen to cater for such processes.

6.6.2 Need for reflective practice

If after three years of using the board educators have not changed their styles of teaching it means something is wrong. A framework for reflective practice should be drawn to initiate educators to reflect on their practice timeously. This initiative could provide many opportunities for educators to talk with others, to seek agreement on standards, to observe one another and most importantly read relevant materials that can contribute to their knowledge. The use of the IWBs requires a research-based teaching particularly in science that could include self-monitoring model, clinical supervision and triangulation.

6.7 Need for further research

Most of the studies have been conducted in schools where the use of IWBs has been very new to both educators and learners. This means the impact is not evident therefore further research is needed to assess the impact more especially when the IWBs are being

implemented at an alarming rate in schools especially in South Africa. Furthermore, evaluation is needed on the relevant applications for IWBs in the teaching of science or in the science curriculum. For example, there is a need to consider how best various features can be deployed to create an interactive learning environment and promote greater interactivity. Furthermore, further research is needed when there is a considerable coverage of the IWBs so that the impact could be more evident. Planning and professional development are also integral to the implementation of the IWBs in educational institutions to avoid embarrassment in the end and waste of funds.

Further exploration is needed in instructional approaches that educators use with the IWBs in teaching science. Additionally, research is needed to find out how educators use the IWBs in teaching science to support the pedagogical principles of learning science. Again, further research could be conducted to give insight into how do IWBs in the teaching of science promote the quality of teaching science and improve learners' achievement in learning science, and how IWBs really support scientific inquiry.

6.8 CONCLUSION

By conducting this investigation, the study was able to identify and understand the challenges educators meet in using the IWBs in teaching and learning environments; particularly in science instruction. The data were collected from two public high schools in the Durban metropolis. The two schools use different brands of the IWBs. Mamathe High school uses the e-Beam and the Promethean ACTIVBoard, while Bereng High schools uses the interactive whiteboards. Six science educators participated in the study. The study followed a qualitative case study approach that used observations, semi-structured individual interviews, focus group interviews and open-ended questionnaires. These instruments (see appendices I, II, III, and IV) were used to collect data that answered the following research questions that guided the study:

1. How do science educators utilize the IWBs in order to provide authentic learning environments in teaching science in some public high schools?
2. What challenges do educators face in utilizing the IWBs in teaching science in some public high schools?

The data were analyzed following a guided analysis that revealed possible themes and categories that supported them. This small case study, furthermore, revealed both positive and negative challenges. The positive challenges that educators identified were the effectiveness of the IWBs in terms of providing learners with real-world environment, authentic multimedia features that support different learning styles, the capability of the IWBs to save notes, connecting to digital sources of information, display of information that promote exposure to information sources that enhance knowledge construction. The negative challenges that educators identified were their low level of interactive approaches in the delivery of content, insufficient professional development and training, lack of ICT literacy and skills, and lack of planning which includes issues of technology planning, technical support, cost and maintenance requirements. This study has also revealed general trends affecting effective implementation and use of the IWBs in science instruction in some high schools in South Africa.

Based on the findings from the literature, this particular study looked into how the identified issues from the literature prevail in South African schools. The study investigated the effectiveness of the IWBs in learning environments in the public high schools in the Durban metropolis in South Africa, issues of professional development and training, pedagogical change / shift, ICT literacy, cost and maintenance requirements, technical problems. The category of challenges that have a negative influence on the use of the IWBs in teaching science in South African classrooms provides a framework from which such challenges should be analyzed further and addressed.

This study had some limitations that need to be acknowledged. Firstly, the use of IWBs in education in South Africa is still new and educators appear to be not familiar with the use of this technology. A second limitation is that the literature on the use of IWBs in science instruction is so limited that in-depth analysis was not possible. The researcher had to adopt some information such as methodologies and findings used in other subjects especially mathematics. A third limitation relates to the sample size. The sample population was restricted because not all schools use the IWBs, and schools which have IWBs in Durban refused to grant permission to use them as research sites. The sample size limited the scope of the study. The researcher conducted limited interviews and

observations with the participants because of some problems especially with one school where IWBs were not in use. A fourth limitation was time factor. The researcher was able to carry out the study after a long struggle to get schools to conduct this research. As a result, the time in which the study was undertaken was limited.

This small case study has brought insights into the use of the IWBs in teaching science. Both benefits and challenges were revealed. Given the view that the boards are valuable, the fact that there are still some pitfalls to attend to (see recommendations) may reduce the likelihood to recommend this type of technology now. Furthermore, the challenge of using the IWBs in teaching science is too great while the support is insufficient, then learning is unlikely to take place effectively.

The investigation was a small-scale study with a case study approach. The findings from this study will add to the limited body of literature concerning the use of the IWBs in teaching science. The information from this study could provide a focus for planning in teacher training institutions with regard to pre-service teacher preparation and in-service professional development in the use of IWBs in teaching and learning environments in South Africa. In general, it is only through the teacher training institutions that awareness of pedagogical approaches and principles in educators can be carried out. The researcher hopes that the findings of this study could provide the opportunity for debate on measures that will aim at improving the use of the IWBs in teaching, particularly science in South Africa.

The insights provided by this study, if considered, may influence and address the goals of the e-Education policy that says “every South African learner in the general and further education and training bands will be ICT capable by 2013” (Department of Education, 2004). This means that all the institutions should have incorporated the ICT policy. Therefore, the researcher hopes that the recommendations of the study will contribute in the process of transforming learning and teaching through ICT. If the recommendations are implemented, they will go a long way to the achievement of the e-Education White Paper. In addition, the recommendations from this study may also inspire and intensify the professional development and training in initial teacher education programs in South Africa in integrating Educational Technology in higher institutions.

It is the responsibility of the National Department of Education to convene information seminars where recommendations from studies like this one could be disseminated. The Department of Education should organize a range of specialized forums or workshops that focus on the use of the specific technologies such as the IWBs in specific subject areas. Furthermore, the National Department of Education, in collaboration with the initial teacher training institutions should ensure that such institutions produce ICT literate educators. This will be in response to the ICT government policy. This will also adhere to the ambitions and aspirations of the society. In terms of capacity building, the Department of Education should provide ICT pre-service teacher preparation programs and in-service training programs for educators, as suggested in the recommendations.

Should the recommendations from this study be considered, learners would have increased opportunities for life long learning, social skills, improved inventive thinking skills such as creativity, problem solving, higher-order thinking skills and sound reasoning, effective communication, and competent, creative and confident learners who will achieve in the global community as reiterated in the ICT policy.

BIBLIOGRAPHY

- Alberta's Commission on Learning (2003). *Every Child Learns, Every Child Succeeds*. Retrieved May 25, 2009, from [://education.alberta.ca/media/413413/commissionreport](http://education.alberta.ca/media/413413/commissionreport).
- Al-Habaan, A. H. H. (2008). Attitudes and skills of Omani teachers of social studies to the use of computers in instruction. *International Journal of Education and Development using ICT*, 4, (4).
- Anderson, T., & Elloumi, F. (2004). *Theory and Practice of Online Learning*. Canada: Athabasca University.
- Anglin, G. J. (Eds.). (1995). *Instructional Technology: Past, Present, and Future*. (Ed.). Englewood, Colo: Libraries Unlimited, Inc.
- Anton, A.S. (2006, 03 Feb). Teaching and Learning come alive with SMART Board. *Anton Community Newspaper, Inc*. Retrieved April 22, 2008, from [://www.antonnews.com/gardencitylife/2006/02/03/news/26](http://www.antonnews.com/gardencitylife/2006/02/03/news/26).
- Averill, D. (2006). Making the leap to interactive whiteboards. *T.H.E Journal*. Retrieved September 10, 2008, from [://www.thejournal.com/the/newsletter/smartclassroom/archives/?aid=](http://www.thejournal.com/the/newsletter/smartclassroom/archives/?aid=)
- Beauchamp, G., & Parkinson, J. (2005). Beyond the 'wow' factor: developing the interactivity with the interactive whiteboard. *School Science Review*, 86 (316), 97-104.
- Bell, J. (1994). *Doing your research project. A guide to first time researchers in education and social science*. Stratford: Oxford University Press.
- Bell, J. (1999). *Doing your research project* (Ed.). Milton Keynes: Open University Press.
- Bell, M.A. (1998). *Teachers' Perception Regarding the Use of the Interactive Electronic Whiteboards in Instruction*. Retrieved July 10, 2007, from [://smarkids.org/research/paper6](http://smarkids.org/research/paper6).
- Bell, M.A. (2002). *Why use an interactive whiteboard*. Retrieved July 12, 2007, from [://teacehrs.net/gazette/JAN02/mabel](http://teacehrs.net/gazette/JAN02/mabel).
- Bertrand, I., & Hughes, P. (2005). *Media Research Methods*. New York: Palgrave Macmillan.
- Boehrer, J. (1990). Teaching with Cases: Learning to Question. *New direction for Teaching and Learning*, 42, 41-57.
- Braham, G. (2006). *How to Survive and Succeed with an Interactive Whiteboard*. Cambridge: LDA.

Brna, P., & Aspin, R. (1997). Collaboration in a Virtual World: Support for conceptual learning? In Proceedings of the IFIP WG 3.3 working conference “human-computer interaction and educational tools” (pp.113-123).

British Communication and Technology Agency. (Becta) (2003). *What the Research Says about Interactive Whiteboards*, Coventry: Becta. Retrieved November 29, 2007, from [://www.becta.org.uk/page-documents/research/wtrs-whiteboards](http://www.becta.org.uk/page-documents/research/wtrs-whiteboards).

British Communication and Technology Agency. (Becta) (2004). *Embedding ICT @ Secondary: Use of interactive whiteboards in Science*. Coventry: Becta. Retrieved February 23, 2008, from [://publications.becta.org.uk/display.cfm?resID=25835&page=](http://publications.becta.org.uk/display.cfm?resID=25835&page=).

British Communication and Technology Agency. (Becta) (2004). *A review of the research literature on barriers to the uptake of ICT by teachers*. Coventry: Becta. Retrieved May 15, 2009, from [://www.bects.org.uk/pagedocuments/research/barriers](http://www.bects.org.uk/pagedocuments/research/barriers).

British Communication and Technology Agency. (Becta) (2006). *Getting the most from your interactive whiteboard: A guide for primary schools*. Coventry: Becta. Retrieved March 01, 2008, from [://publications.becta.org.uk/display.cfm?resID=25835&page=](http://publications.becta.org.uk/display.cfm?resID=25835&page=).

Burden, K. (2002, 21 June). *Learning from bottom up – the contribution of school based practice and research in the effective use of interactive whiteboards for the FE/HE sector*. Discussion paper presented at LSDA, Making an Impact Regional Conference. The Earth Centre, Doncaster. Retrieved 31 March, 2008, from [://www.lsda.org.uk/files/llda/regions/8-Bio-KBurden](http://www.lsda.org.uk/files/llda/regions/8-Bio-KBurden).

Bybee, R.W. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Carin, A.A., Bass, J.E., Contant, T.L. (2004). *Teaching Science as Inquiry*. (Ed.). London: Prentice Hall.

Chilcoat, G.W. (1989). Instructional behaviours for clear presentation in the classroom. *Instructional Science*, 18, 289-314.

Chong, N.S.T., & Sakauchi, M. (2000). *Back to the basics: a first class chalkboard and more*. Proceedings of the 2000 ACM Symposium on Applied Computing pp.131-136. Retrieved 12 March, 2008, from [://www.artemis.utdc.vuw.ac.nz:8000/vqwiki/jsp/wiki.jsp?Chongo00-](http://www.artemis.utdc.vuw.ac.nz:8000/vqwiki/jsp/wiki.jsp?Chongo00-)

Clark, R.E. (1984). Reconsidering Research on Learning from Media. *Review of Educational Research*, 53 (4), 445-459.

Clyde, L.A. (2004). Electronic whiteboards. *Information Technology* 32 (2). Retrieved June 15, 2008, from [://www.teacherlibrarian.com/tltoolkit/info-tech/info-tech-30-2](http://www.teacherlibrarian.com/tltoolkit/info-tech/info-tech-30-2).

Coe, D. E. (1991). Levels of ethnographic inquiry. *Qualitative Studies in Education*, 4, 313-331.

Cohen, L., Manion, C., & Morrison, K. (2007). *Research Methods in Education*. (Ed.). London: Routledge.

Colley, K.E. (2005). *Project-Based Science Instruction: Teaching Science for Understanding*. Retrieved August 10, 2008, from [://radicalpedagogy.icaap.org/content/issue7-2/colley](http://radicalpedagogy.icaap.org/content/issue7-2/colley) .

Collis, B. (1996). *Tele – Learning in a digital world*. International Thomson Computer Press. Retrieved May 31, 2008, from [://www.to.utwente.nl/user/collins/home](http://www.to.utwente.nl/user/collins/home) .

Cook, J.A., & Fonow, M.M. (1990). Knowledge and women's interests: issues of epistemology and methodology in feminist sociological research. In J.M. Nielsen (Eds.). *Feminist Research Methods: Exemplary Readings in the Social Sciences* (pp 69- 91). Boulder, CO: Westview Press.

Cradler, J. (1997). *Implementing Technology in Education: Recent Findings from Research and Evaluation Studies*. San Francisco, CA: Far West Laboratory. Retrieved July 22, 2008, from [://www.fwl.org.techpolicy/recapproach](http://www.fwl.org.techpolicy/recapproach).

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design: Choosing Among the Five Traditions*. Thousand Oaks, CA: Sage.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (Ed.). Thousand Oaks, CA: Sage.

Creswell, J.W. (2005). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (Ed.). Upper Saddle River, NJ: Pearson.

Crotty, M. (1998). *Foundations of social research: Meaning and perspective in the research process*. London: Sage.

Cunningham, A. (2002). Quality field experiences: A keystone in teacher preparation for the digital age. *Journal of Computing in Teacher Education*, 1 (2), 31-32.

Damcott, D., Landatto, J., & Marsh, C. (2000). *The use of the SMART Board interactive whiteboard in Physical Science*. Retrieved May 07, 2008, from [://smarterkids.org/research/paper3](http://smarterkids.org/research/paper3) .

Damoense, M.Y. (2003). Online Learning: Implications for effective learning for higher education in higher education. *Australian Journal of Educational Technology*, 19 (1), 25-45. Retrieved July 07, 2008, from [://www.asclite.org.au/ajet/ajet19/damoense](http://www.asclite.org.au/ajet/ajet19/damoense) .

Department of Education and Training (2004). *White paper on e-Education: Transforming learning and teaching through Information and Communication Technologies*. Pretoria: Department of Education.

Denzin, N.K., & Lincoln, Y.S. (1994). Introduction: entering the field of qualitative research. In N.K. Denzin and Y.S Lincoln (Eds.), *Handbook of Qualitative Research* (pp.1-17). Thousand Oaks, CA: Sage.

Denzin, N.K., & Lincoln, Y.S. (2003). Introduction: The discipline and practice of qualitative research. In N.K. Denzin and Y.S Lincoln (Eds.), *The landscape of qualitative research: theories and issues* (pp.1-45). Thousand Oaks, CA: Sage.

Diem, R. (1999). Editor's notes. *Social Studies and the Young Learner*, 2 (1), 2.

Dreachslin, J. (1999). Focus groups as a quality improvement technique: A case example from health administration education. *Quality Assurance in Education*, 7 (4), 224-232.

Eckstein, H. (2002). Case study and theory in political science. In R. Gomm, M. Hammersley, & P. Foster (Eds.), *Case Study Method: Key Issues, Key Texts* (pp.119 – 163). London: Sage.

Engler, D. (1972). Instructional Technology and the Curriculum. In F.J. Pula & D.J.Goff (Eds.). *Technology in Education: Challenge and change* (pp.23-42). Worthington, OH: Charles A. Jones.

European Schoolnet (2006). *The ICT Impact Report: A Review of studies of ICT impact on schools in Europe*. Retrieved May 17, 2009, from [://insight.eun.org/shared/data/pdf/impact-study](http://insight.eun.org/shared/data/pdf/impact-study).

Feagin, J., Orum, A., & Sjoberg, G. (Eds.). (1991). *A case for case study*. Chapel Hill, NC: University of North Carolina Publishers.

Finn, J.D. (1960). Technology and the instructional process. *Audiovisual Communication Review*, 8 (1), 9-10.

Foot, H. C., Howe, C. J., Anderson, A., Tolmie, A. K., & Warden, D.A (1994). *Group and Interactive Learning*. Southampton, Boston: Computational Mechanics Publications.

Gage, J. (2005). *How to Use an Interactive Whiteboard really effectively in your Secondary Classroom*. London: David Fulton Publishers.

Glover, D. & Miller, D. (2001). Running with Technology: The pedagogic impact of the large-scale introduction of interactive whiteboards in one secondary school. *Journal of Information Technology for Teacher Education*, 10 (3).257-276.

Glover, D., & Miller, D. (2002). The interactive whiteboard as a force for pedagogic change: the experience of five elementary schools in an English education authority. *Information Technology in Childhood Education*, Norfolk, Vermont, AACE.

Glover, D., Miller, D., Averis, D., & Door, V. (2005). The interactive whiteboard: a literature review. *Technology, Pedagogy and Education*, 14 (2), 55-170.

Guba, E. G., & Lincoln, Y. S. (1981). *Effective Evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches*. San Francisco, CA: Jossey-Bass.

Hall, I., & Higgins, S. (2005). Primary school students' perception of interactive whiteboards. *Journal of Computer Assisted Learning*, 21 (2), 102-117.

Hargreaves, D. (1997). A road to the learning society. *School Leadership and Management*, 17 (1), 9-21.

Hartley, J. (2007). Teaching, learning and new technology: a review for teachers. *British Journal of Educational Technology*, 38 (1), 42-62.

Hartley, J., & Davies, I. K. (1978). *Contributions to an Educational Technology*. London: Kogan Page Limited.

Harvey, J., & Purnell, S. (1995). *Technology and teacher Professional Development*. Report prepared for the Office of Educational Technology, US Department of Education. Santa Monica, CA: Rand Corporation. Retrieved November 01, 2008, from [://eric.ed.gov/ERICDocs/data.ericdocs2sql/content-storage-01/0000019b/80/14/75/4e](http://eric.ed.gov/ERICDocs/data.ericdocs2sql/content-storage-01/0000019b/80/14/75/4e).

Heinich, R., Molenda, M., Russell, J.D., & Smaldino, S.E. (1999). *Instructional Media and Technologies for Learning*. Upper Saddle River, NJ: Macmillan.

Hennessy, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, R., la Velle, L., Mcfarlane, A., Ruthven, K., & Winterbottom, M. (2007). Pedagogical approaches for technology-integrated science teaching. *Computers & Education*, 48, (1), 137-152.

Henning, E. (2004). *Finding your way in qualitative research*. Pretoria: Van Schaik.

Howie, S.J., Muller, A., & Patterson, A. (2005). *Information and Communication Technologies in South African Secondary Schools*. Cape Town: HSRC.

Kearsley, G. (2000). Developments in Learning. In H.H Adelsberger., B. Collis & J.M Pawlowski (Eds.), *Handbook on Information Technologies for Education and Training* (pp.333-341). New York: Springer.

Kearsley, G., & Schneiderman, B. (1998). Engagement theory: A framework for technology-based teaching and learning. *Journal of Distance Education*, 38 (5), 20-23. Retrieved June 16, 2007, from [://home.sprynet.com/~gkearsley/en-gage](http://home.sprynet.com/~gkearsley/en-gage).

Kearsley, G., & Schneiderman, B. (1999). *Engagement theory*. Retrieved June 16, 2007, from [://home.sprynet.com/~gkearsley/engage](http://home.sprynet.com/~gkearsley/engage).

Keller, J. (2007). *TechLearning*. Retrieved September 26, 2007, from [://www.techlearning.com/shared/printableArticle.php?articleID=](http://www.techlearning.com/shared/printableArticle.php?articleID=)

Kennedy, C. (2008). *Technology aids teaching – Lifestyle*. Retrieved June 01, 2008, from [://www2.smarttech](http://www2.smarttech).

Kennewell, S., Tanner, H., Jones, S., & Beauchamp, G. (2007). Analyzing the use of interactive technology to implement interactive teaching. *Journal of Computer Assisted Learning*, 24. Retrieved September 01, 2008, from [://www3.interscience.wiley.com.qe2a-proxy.mun.ca/cgi-bin/fulltext/118838483/](http://www3.interscience.wiley.com.qe2a-proxy.mun.ca/cgi-bin/fulltext/118838483/)

Kent, P. (2004). E-teaching and interactive whiteboards. The Richardson experience. *The Practicing Administrator*, 26 (1), 14-16.

Kerlinger, F.N. (1986). *Foundations of Behavioural Research*. (Ed.). New York: Holt, Rinehart and Winston.

Kerr, B. (2007). *Which radical discontinuity?* Retrieved July 30, 2008, from [://billkerr2.blogspot.com/2007/02/which-radical-discontinuity](http://billkerr2.blogspot.com/2007/02/which-radical-discontinuity).

Khoza, S.B. (2001). *The Outcomes of students studying a computer literacy course at Unischool*. Unpublished master's thesis, University of Durban-Westville, Durban, KwaZulu-Natal.

Knodel, J.D. (2006). *SMART Board in the classroom: The influence of interactive boards in Education*. Retrieved May 10, 2008, from [://tiger.towson.edu/users/sunger2/smart-boards-in-the-classroom.htm-24k](http://tiger.towson.edu/users/sunger2/smart-boards-in-the-classroom.htm-24k).

Knowlton, N. (2006). *Guide on the Side*. Retrieved June 10, 2008, from [://www2.smarttech](http://www2.smarttech).

Knowlton, N. (2007). *SMART product improves students' performance and teachers' lives*. Retrieved June 01, 2008, from [://www2.smarttech](http://www2.smarttech).

Kramarski, B., & Gutman, M. (2006). How can self-regulated learning be supported in mathematics learning environment? *Journal of Computer-Assisted Learning*, 22, 24-46.

Krauss, S.E. (2005). Research Paradigms and Meaning Making: A Primer. *The Qualitative Report*, 10 (4), 758 – 770. Retrieved September 10, 2007, from [://www.nova.edu/ssss/QR/QR10-4/krauss](http://www.nova.edu/ssss/QR/QR10-4/krauss).

Krefting, L. (1991). Rigour in qualitative research: the assessment of trustworthiness. *The American Journal of Occupational Therapy* 45 (3), 214-222.

Kvale, S. (1996). *Interviews: An introduction to Qualitative Research Interviewing*. Thousand Oaks, California: Sage.

Lankshear, C., & Knobel, M. (2004). *A Handbook for Teacher Research: from design to implementation*. England: Open University Press.

Lauer, P.A. (2006). *An Educational Research Primer: How to Understand, Evaluate, and Use it*. San Francisco, CA: Jossey-Bass.

Leask, M., & Pachler, N. (2005). *Learning to Teach Using ICT in the Secondary School: A companion to school experience*. (Ed.). London: Routledge.

Levy, P. (2002). *Interactive Whiteboards in Learning and Teaching in Two Sheffield Schools: A Developmental Study*. Department of Information Studies, University of Sheffield.

Lewin, C., Mayers, D., & Somekh, B. (2003). Broadening access to the curriculum through using technology to link home and school: a critical analysis of reforms intended to improve students' educational attainment. *The Curriculum Journal*, 14 (1), 23-53.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. Beverly Hills, CA: Sage.

Lundall, P., & Howell, C. (2000). *Computers in Schools: A national survey of information technology in South African schools*. Cape Town: Education Policy Unit of the University of the Western Cape.

MacQueen, K.M. (2002). Introduction: Enriching Facts and Figures. *Network*, 22 (2).

Maree, K. (2007). (Eds). *First Steps in research*. Pretoria: Van Schaik.

Mayer, R.E. (1996). Learners as Information Processors: Legacies and Limitations of Educational Psychology Second Metaphor. *Educational Psychologist*, 31, (4), 151-161.

Mayer, R.E. (2001). *Multimedia Learning*. New York: Cambridge University Press.

Mayer, R.E. (2005). *The Cambridge Handbook of Multimedia Learning*. London: Cambridge University Press.

McFarlane, A., Hamson, C., Somekh, B., Scrimshaw, P., Harrison, A., & Lewin, C. (2000). *Establishing the Relationship between Networked Technology and Attainment: Preliminary Study*, Coventry: Becta. Retrieved August 16, 2008, from [://www.becta.org.uk/research/reports/docs/impact2-prelim1](http://www.becta.org.uk/research/reports/docs/impact2-prelim1).

- McNeese, M.N. (2006). *Evaluation of SMART Multimedia Classrooms: Impact on Student Face-to-Face Participation and E-Learning*. Retrieved March 31, 2008, from <://smarkids.org/research/pdf/McNeese-SB%20Evaluation.>
- Mehan, H. (1979). *Learning lessons: Social organization for the classroom*. Cambridge, MA: Harvard University Press.
- Merriam, S.B. (1998). *Qualitative Research and Case Study Applications in Education*. San Francisco, CA: Jossey-Bass.
- Merriam, S.B. (2001). *Qualitative Research and Case Study Application in Education*. San Francisco, CA: Jossey-Bass.
- Miles, M.B., & Huberman, A.M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. (Ed.). Thousand Oaks: Sage.
- Mishler, E.G (1986). *Research interviewing: context and narrative*. Cambridge, MA: Harvard University Press.
- Moggan, T. (2006, March 1). Taking the bored out of boards. *The Telegraph*. Retrieved May 16, 2009, from <://www.tom-moggach.com/edu-tel-boards.>
- Mohammed, K.A., & Ottmann, T. (2005). *Controlling the Electronic Whiteboard's Writing Surface with Cluttered Toolboxes: Shifting the Focus Back to Content Delivery*. Retrieved April 07, 2008, from <://ad.informatik.unifreiburg.de/mitarbeiter/khaireel/authorscopy/2005/-eLearn.>
- Morgan, D. (1996). Focus groups. *Annual Review of Sociology*, 22, 129-152.
- Mouton, J., & Marais, H.C. (1990). *Basic concepts in the methodology of social sciences*. Pretoria: Human Sciences Research Council.
- Neumann, W.L. (2000). *Social research methods: qualitative and quantitative approaches*. Boston: Allyn & Bacon.
- Nieuwenhuis, J. (2007). Analyzing Qualitative Data. In Maree, K. (Eds). *First Steps in research* (pp.99-115). Pretoria: Van Schaik.
- O'Leary, R. (2006, April). Teacher, what is a Blackboard? *In Touch*, pp.30-31.
- O'Neil, H.E., & Perez, R.S. (Eds.). (2003). *Technology applications in education*. Mahwah, NJ: Erlbaum.
- Online Portal Excellence Gateway (2008). *Working with Electronic Whiteboards*. Retrieved September 09, 2008, from <://excellence.qia.org.uk/page.aspx?0=ferl.aclearn.page>.

Pandor, N. (2004). White Paper on e-Education: Transforming Teaching and Learning through Information and Communications Technology (ICT). Pretoria: Department of Education.

Parker, I. (1994). Qualitative research. In P. Banister, E. Burman, I. Parker & C. Tindall. (Eds.), *Qualitative methods in psychology: A research guide*. (pp. 121-141). Buckingham, UK: Open University Press.

Partridge, S. (2004). *Teacher and Technology: the interactive whiteboard*. Austin: University of Texas. Retrieved September 30, 2007, from <://smarttech>.

Patru, M. (2002). Information and Communications Technologies in Teacher Education: A Planning Guide. (UNESCO) France: Division of Higher Education.

Patton, M.Q. (1990). *Qualitative evaluation and research methods*. (Ed.). Newbury Park: Sage.

Percival, F., & Ellington, H. (1984). *A Handbook of Educational Technology*. New York: Nicols Publishing.

Percival, F., Ellington, H., & Race, P. (1993). *Handbook of Educational Technology*. (Ed.). London: Kogan Page.

Perrin, D.G. (2005). Connectivism: A Learning Theory for the Digital Age. *International Journal of Instructional Technology and Distance Learning*. Retrieved July 20, 2008, from <://www.itdl.org/Journal/Jan-05/article01>.

Reiser, R.A., & Demsey, R.J. (2006). *Trends and issues in instructional design and technology*. (Ed.). Upper Saddle, NJ: Merrill Prentice Hall.

Robinson, S. (2000). Maths classes for the century. *Media and Methods*, 36 (4), 10-11.

Rudd, T. (2007). *Interactive whiteboards in the classroom*. Retrieved April 25, 2008, from <://www.futurelab.org.uk/events/listing/whiteboards/>.

Sang, D., & Frost, D. (2005). *Teaching Secondary Science using ICT*. London: Hodder Murray.

Schenk , B.L.(2007). *Technology in the Classroom: The Interactive Whiteboard*. Retrieved May 31, 2008, from <://brittany%20Schenk%20Thesis>.

Scheurich, J.J. (1995). A postmodernist critique of research interviewing. *International Journal of Qualitative Studies*, 8, pp.239-252.

Schneider, R.M., Krajcik, J., Marx, R.W., & Soloway, E. (2002). Performace of students in project-based Science Classrooms on a National measure of Science Achievement. *Journal of Research in Science teaching*, 39, (5), 410-422.

Schuck, S., & Kearney, M. (2007). *Exploring pedagogy with interactive whiteboards*. Retrieved September 08, 2008, from [://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb](http://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb).

Schwab, J. (1962). The teaching of science as inquiry. In J. Schwab and P. Brandwein. (Eds.). *The teaching of Science* (pp.1-103). Cambridge, MA: Harvard University Press.

Seale, C. (2002). Quality Issues in Qualitative Inquiry. *Qualitative Social Work* 1(1), 97–110.

Sharma, R.C. (2003). Barriers in using technology for education in developing countries. In Proceedings of the International Conference on Information: Research and Education.

Siemens, G. (2004). *Connectivism: A Learning Theory for the Digital Age*. Retrieved July 09, 2007, from [://www.itdl.org/Journal/Jan-05/article01](http://www.itdl.org/Journal/Jan-05/article01).

Siemens, G. (2005). *Connectivism: Learning as Network Creation*. Retrieved August 04, 2007, from [://www.learningcircuits.org/2005/nov2005/siemens](http://www.learningcircuits.org/2005/nov2005/siemens).

Siemens, G. (2007). *Century Learning: Connectivism: Learning Conceptualized through the lens*. Retrieved July 30, 2008, from [://21stcenturylearning.typepad.com/blog/2007/02/george-siemens](http://21stcenturylearning.typepad.com/blog/2007/02/george-siemens).

Slay, J. (1997). *The use of the Internet in creating as effective learning environment*. Proceedings of the Third Australian World Wide Web Conference, 5-9 July, Southern Cross University, Australia. Retrieved August 05, 2008, from [://ausweb.scu.edu.au/aw97/papers/slay/index](http://ausweb.scu.edu.au/aw97/papers/slay/index).

Slay, H., Sieborger, I., & Hodgkinson-Williams, C. (2007). The use of ‘smart’ pens in South African teaching and learning environments. *South African Computer Journal*, 40, 83-94.

Slay, H., Sieborger, I., & Hodgkinson-Williams, C. (2008). Interactive Whiteboards: Real beauty or just “lipstick”. *Computers & Education Journal*, 51 (3), 1321-1341.

Slay, H., Sieborger, I., & Hodgkinson-Williams, C. (2008). The use of Interactive Whiteboards to support the creation, capture and sharing of knowledge in South African schools. In IFIP International Federation for Information Processing, Volume 281, M. Kendall & B. Samways, *Learning to live in the knowledge society* (pp. 19-26). Boston: Springer.

SMART Technologies, Inc, (2005). *Gloucester cit public schools: Case study*. Retrieved April 25, 2008, from <://education.smarttech.> .

SMART Technologies, Inc, (2007). *Study links interactive whiteboards to improve student performance*. Retrieved April 25, 2008, from <://www2.smarttech.> .

Smith, A. (2003). *Interactive Whiteboards Evaluation*. Miranda Net Community Focus on Research and Dissemination. Retrieved October 15, 2007, from <://www.mirandanet.ac.uk/pubs/SMARTBoard.>

Smith, H., Higgins, S., Wall, K., & Miller, J. (2005). *Interactive whiteboards: Boon or bandwagon? A critical review of literature*. *Journal of Computer Assisted Learning*. Retrieved September 11, 2008, from <://www3.interscience.wiley.com.qe2a-proxy.mun.ca/cgi-bin/fulltext/118652048/>

Stake, R. (1995). *The art of case research*. Newbury Park, CA: Sage.

Stanfield, J.H.I. (1993). Methodological Reflections: An Introduction. In J.H. Stanfield (Eds.), *Race and Ethnicity in Research Methods* (pp.3-15). Newbury Park, CA: Sage.

Steed, A. (2002). *Use of an interactive whiteboard*. Retrieved September 20, 2008, from <://www.teachernet.gov.uk/professionaldevelopment.opportunities/brps/search/index.cfm?report=>

Stein, G. (2005). *Pedagogy, practice & ICT: What skills, training and professional development are needed to support the effective use of interactive whiteboards in the primary classroom?* Retrieved April 7, 2008, from <://client.canterbury.ac.uk/research/papers/georgina-stein/interactive-whiteboards-primary.> .

Stokes, D., & Bergin, R. (2006). Methodology or 'methodolatry'? An evaluation of focus groups and in-depth interviews. *Qualitative Market Research: An International Journal*, 9 (1), 26-37.

Sutherland, R. (2004). Designs for learning: ICT and knowledge in the classroom. *Computers and Education*, 43, 5-16.

Tapscott, D. (1998). *Growing Up Digital: The Rise of the Net Generation*. New York: McGraw-Hill. Retrieved May 15, 2009, from <://www.growingupdigital.> .

Terre Blanche, M., & Durrhein, K. (2006). *Research in Practice: Applied methods for the social*

Thomas, R.M., & Kobayashi, N. (Eds). (1987). *Educational Technology – Its creation, development and cross-cultural transfer*. Oxford: Pergamon Books Ltd.

Venkataiah, N. (1996). *Educational Technology*. New Delhi: APH Publishing Corporation.

Verhagen, P. (2006). *Connectivism: a new learning theory?* In E-learning Themaside. Retrieved July 28, 2008, from [://elearning.surf.nl/elearning.english/3793](http://elearning.surf.nl/elearning.english/3793).

Walker, R. (1985). An introduction to applied qualitative research. In R. Walker (Eds.) pp.3-26. *Applied Qualitative Research*. Gower, 3-26.

Wall, K., Higgins, S., & Smith, H. (2005). The visual helps me understand the complicated things: pupils views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology*, 36 (5). 851-867.

Watson, D. M. (2001). Pedagogy before technology: rethinking the relationship between ICT and teaching. *Education and Information Technologies*, 6 (4), 251-266.

Watson, D., & Downes, T. (2000). *Communication and Networking in Education: Learning in a networked Society*. London: Springer.

Webb, N.M. (1993). Collaborative group versus individual assessment in mathematics: processes and outcomes. *Educational Assessment*, 1, (2), 131-152.

Weimer, M.J. (2001). *The influence of technology such as SMART Board Interactive Whiteboard on student motivation in the classroom*. Retrieved May 27, 2008, from [://www.smarterkids.org/research/paper7](http://www.smarterkids.org/research/paper7).

Wilson, V. (1997). Focus groups: A useful qualitative method for educational research. *British Educational Research Journal*, 23 (2), 209-224.

Wilson, K.R., Wallin, J.S., & Reiser, C. (2003). Social stratification and the digital divide. *Social Science Computer Review*, 21 (2), 133-143.

Winzenreid, A. (2006). *Interactive whiteboards: for better or for worse?* Paper presented at the ACEC 2006 conference, Cairns, Queensland, 2-4 October 2006. Retrieved April 23, 2008, from [://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb](http://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb).

Wood, R., & Ashfield, J. (2008). The use of the interactive whiteboard for creative teaching and learning in literacy and mathematics: A case study. *British Journal of Educational Technology*, 39 (1), 84-96.

Yin, R. K. (1994). *Case study research: Design and Methods*. (Ed.). Beverly Hills, CA: Sage.

Yin, R.K. (2003). *Case Study Research: Design and Methods*. (Ed.). Thousand Oaks, CA: Sage.

Yvette, J.G. (2003). Low Threshold Pre-service Multimedia Digital Portfolio Preparation as “Product of learning” That Equality Meets Multimedia Accreditation standards. Hawaii. World Conference on educational multimedia, hypermedia and telecommunications.

BIBLIOGRAPHY

- Anderson, T., & Elloumi, F. (2004). *Theory and Practice of Online Learning*. Canada: Athabasca University.
- Anglin, G. J. (Eds.). (1995). *Instructional Technology: Past, Present, and Future*. (Ed.). Englewood, Colo: Libraries Unlimited, Inc.
- Anton, A.S. (2006, 03 Feb). Teaching and Learning come alive with SMART Board. *Anton Community Newspaper, Inc.* Retrieved 22 April, 2008, from [://www.antonnews.com/gardencitylife/2006/02/03/news/26](http://www.antonnews.com/gardencitylife/2006/02/03/news/26).
- Averill, D. (2006). Making the leap to interactive whiteboards. *T.H.E Journal*. Retrieved 10 September, 2008, from [://www.thejournal.com/the/newsletter/smartclassroom/archives/?aid=](http://www.thejournal.com/the/newsletter/smartclassroom/archives/?aid=)
- Beauchamp, G., & Parkinson, J. (2005). Beyond the ‘wow’ factor: developing the interactivity with the interactive whiteboard. *School Science Review*, 86 (316), 97-104.
- Bell, J. (1994). *Doing your research project. A guide to first time researchers in education and social science*. Stratford: Oxford University Press.
- Bell, J. (1999). *Doing your research project* (Ed.). Milton Keynes: Open University Press.
- Bell, M.A. (1998). Teachers’ Perception Regarding the Use of the Interactive Electronic Whiteboards in Instruction. Retrieved 10 July, 2007, from [://smarkids.org/research/paper6](http://smarkids.org/research/paper6).
- Bell, M.A. (2002). Why use an interactive whiteboard. Retrieved 12 July, 2007, from [://teacehrs.net/gazette/JAN02/mabel](http://teacehrs.net/gazette/JAN02/mabel).
- Bertrand, I., & Hughes, P. (2005). *Media Research Methods*. New York: Palgrave Macmillan.
- Boehrer, J. (1990). Teaching with Cases: Learning to Question. *New direction for Teaching and Learning*, 42, 41-57.
- Braham, G. (2006). *How to Survive and Succeed with an Interactive Whiteboard*. Cambridge: LDA.

British Communication and Technology Agency. (Becta) (2003). What the Research Says about Interactive Whiteboards, Coventry: Becta. Retrieved 29 November, 2007, from [://www.becta.org.uk/page-documents/research/wtrs-whiteboards](http://www.becta.org.uk/page-documents/research/wtrs-whiteboards).

British Communication and Technology Agency. (Becta) (2004). Embedding ICT @ Secondary: Use of interactive whiteboards in Science. Coventry: Becta. Retrieved 23 February, 2008, from [://publications.becta.org.uk/display.cfm?resID=25835&page=](http://publications.becta.org.uk/display.cfm?resID=25835&page=).

British Communication and Technology Agency. (Becta) (2006). Getting the most from your interactive whiteboard: A guide for primary schools. Coventry: Becta. Retrieved 01 March, 2008, from [://publications.becta.org.uk/display.cfm?resID=25835&page=](http://publications.becta.org.uk/display.cfm?resID=25835&page=).

Burden, K. (2002, 21 June). Learning from bottom up – the contribution of school based practice and research in the effective use of interactive whiteboards for the FE/HE sector. Discussion paper presented at LSDA, Making an Impact Regional Conference. The Earth Centre, Doncaster. Retrieved 31 March, 2008, from [://www.lsda.org.uk/files/llda/regions/8-Bio-KBurden](http://www.lsda.org.uk/files/llda/regions/8-Bio-KBurden).

Bybee, R.W. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Carin, A.A., Bass, J.E., Contant, T.L. (2004). *Teaching Science as Inquiry*. (Ed.). London: Prentice Hall.

Chilcoat, G.W. (1989). Instructional behaviours for clear presentation in the classroom. *Instructional Science*, 18, 289-314.

Chong, N.S.T., & Sakauchi, M. (2000). Back to the basics: a first class chalkboard and more. Proceedings of the 2000 ACM Symposium on Applied Computing pp.131-136. Retrieved 12 March, 2008, from [://www.artemis.utdc.vuw.ac.nz:8000/vqwiki/jsp/wiki.jsp?Chongo00-](http://www.artemis.utdc.vuw.ac.nz:8000/vqwiki/jsp/wiki.jsp?Chongo00-)

Clark, R.E. (1984). Reconsidering Research on Learning from Media. *Review of Educational Research*, 53 (4), 445-459.

Clyde, L.A. (2004). Electronic whiteboards. *Information Technology* 32 (2). Retrieved 15 June, 2008, from [://www.teacherlibrarian.com/tltoolkit/info-tech/info-tech-30-2](http://www.teacherlibrarian.com/tltoolkit/info-tech/info-tech-30-2).

Coe, D. E. (1991). Levels of ethnographic inquiry. *Qualitative Studies in Education*, 4, 313-331.

Cohen, L., Manion, C., & Morrison, K. (2007). *Research Methods in Education*. (Ed.). London: Routledge.

Colley, K.E. (2005). Project-Based Science Instruction: Teaching Science for Understanding. Retrieved 10 August, 2008, from [://radicalpedagogy.icaap.org/content/issue7-2/colley](http://radicalpedagogy.icaap.org/content/issue7-2/colley) .

Collis, B. (1996). Tele – Learning in a digital world. International Thomson Computer Press. Retrieved 31 May, 2008, from [://www.to.utwente.nl/user/collins/home](http://www.to.utwente.nl/user/collins/home) .

Cook, J.A., & Fonow, M.M. (1990). Knowledge and women's interests: issues of epistemology and methodology in feminist sociological research. In J.M. Nielsen (Eds.). *Feminist Research Methods: Exemplary Readings in the Social Sciences* (pp 69- 91). Boulder, CO: Westview Press.

Cradler, J. (1997). Implementing Technology in Education: Recent Findings from Research and Evaluation Studies. San Francisco, CA: Far West Laboratory. Retrieved 22 July, 2008, from [://www.fwl.org.techpolicy/recapproach](http://www.fwl.org.techpolicy/recapproach).

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design: Choosing Among the Five Traditions*. Thousand Oaks, CA: Sage.

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (Ed.). Thousand Oaks, CA: Sage.

Creswell, J.W. (2005). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (Ed.). Upper Saddle River, NJ: Pearson.

Crotty, M. (1998). *Foundations of social research: Meaning and perspective in the research process*. London: Sage.

Cunningham, A. (2002). Quality field experiences: A keystone in teacher preparation for the digital age. *Journal of Computing in Teacher Education*, 1 (2), 31-32.

Damcott, D., Landatto, J., & Marsh, C. (2000). The use of the SMARTBoard interactive whiteboard in Physical Science. Retrieved 07 May, 2008, from [://smarterkids.org/research/paper3](http://smarterkids.org/research/paper3) .

Denzin, N.K., & Lincoln, Y.S. (1994). Introduction: entering the field of qualitative research. In N.K. Denzin and Y.S Lincoln (Eds.), *Handbook of Qualitative Research* (pp.1-17). Thousand Oaks, CA: Sage.

Denzin, N.K., & Lincoln, Y.S. (2003). Introduction: The discipline and practice of qualitative research. In N.K. Denzin and Y.S Lincoln (Eds.), *The landscape of qualitative research: theories and issues* (pp.1-45). Thousand Oaks, CA: Sage.

Diem, R. (1999). Editor's notes. *Social Studies and the Young Learner*, 2 (1), 2.

Dreachslin, J. (1999). Focus groups as a quality improvement technique: A case example from health administration education. *Quality Assurance in Education*, 7 (4), 224-232.

Eckstein, H. (2002). Case study and theory in political science. In R. Gomm, M. Hammersley, & P. Foster (Eds.), *Case Study Method: Key Issues, Key Texts* (pp.119 – 163). London: Sage.

Engler, D. (1972). Instructional Technology and the Curriculum. In *Technology in Education: Challenge and change* (eds.). F.J. Pula & J.D. Finn (pp.??). Worthington, OH: Charles A. Jones.

Feagin, J., Orum, A., & Sjoberg, G. (Eds.). (1991). *A case for case study*. Chapel Hill, NC: University of North Carolina Publishers.

Finn, J.D. (1960). Technology and the instructional process. *Audiovisual Communication Review*, 8 (1), 9-10.

Foot, H.C., Howe,C.J., Anderson,A., Tolmie, A.K., & Warden, D.A (1994). *Group and Interactive Learning*. Southampton, Boston: Computational Mechanics Publications.

Gage, J. (2006). *How to Use an Interactive Whiteboard really effectively in your Secondary Classroom*. London: David Fulton Publishers.

Glover, D. & Miller, D. (2001). Running with Technology: The pedagogic impact of the large-scale introduction of interactive whiteboards in one secondary school. *Journal of Information Technology for Teacher Education*, 10 (3).257-276.

Glover, D., & Miller, D. (2002). The interactive whiteboard as a force for pedagogic change: the experience of five elementary schools in an English education authority. *Information Technology in Childhood Education*, Norfolk, Vermont, AACE.

Glover, D., Miller, D., Averis, D., & Door, V. (2005). The interactive whiteboard: a literature review. *Technology, Pedagogy and Education*, 14 (2), 55-170.

Guba, E.G., & Lincoln, Y.S. (1981). *Effective Evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches*. San Francisco, CA: Jossey-Bass.

Hall, I., & Higgins, S. (2005). Primary school students' perception of interactive whiteboards. *Journal of Computer Assisted Learning*, 21 (2), pp.102-117.

Hargreaves, D. (1997). A road to the learning society. *School Leadership and Management*, 17 (1), 9-21.

Hartley, J. (2007). Teaching, learning and new technology: a review for teachers. *British Journal of Educational Technology*, 38 (1), 42-62.

Hartley, J., & Davies, I. K. (1978). *Contributions to an Educational Technology*. London: Kogan Page Limited.

Harvey, J., & Purnell, S. (1995). Technology and teacher Professional Development. Report prepared for the Office of Educational Technology, US Department of Education. Santa Monica, CA: Rand Corporation. Retrieved 01 November, 2008, from <://eric.ed.gov/ERICDocs/data.ericdocs2sql/content-storage-01/0000019b/80/14/75/4e>.

Heinich, R., Molenda, M., Russell, J.D., & Smaldino, S.E. (1999). *Instructional Media and Technologies for Learning*. Upper Saddle River, NJ: Macmillan.

Hennessy, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, R., la Velle, L., Mcfarlane, A., Ruthven, K., & Winterbottom, M. (2007). Pedagogical approaches for technology-integrated science teaching. *Computers & Education*, 48, (1), 137-152.

Henning, E. (2004). *Finding your way in qualitative research*. Pretoria: Van Schaik.

Kearsley, G. (2000). Developments in Learning. In H.H Adelsberger., B. Collis & J.M Pawlowski (Eds.), *Handbook on Information Technologies for Education and Training* (pp.333-341). New York: Springer.

Kearsley, G., & Schneiderman, B. (1998). Engagement theory: A framework for technology-based teaching and learning. *Journal of Distance Education*, 38 (5), 20-23. Retrieved 16 June, 2007, from <://home.sprynet.com/~gkearsley/en-gage>.

Kearsley, G., & Schneiderman, B. (1999). Engagement theory. Retrieved 16 June, 2007, from <://home.sprynet.com/~gkearsley/engage>.

Keller, J. (2007). TechLearning. Retrieved 26 September, 2007, from <://www.techlearning.com/shared/printableArticle.php?articleID=>

Kennedy, C. (2008). Technology aids teaching –Lifestyle

Kennewell, S., Tanner, H., Jones, S., & Beauchamp, G. (2007). Analysing the use of interactive technology to implement interactive teaching. *Journal of Computer Assisted Learning*, 24. Retrieved 01 September, 2008, from <://www3.interscience.wiley.com.qe2a-proxy.mun.ca/cgi-bin/fulltext/118838483/>

Kent, P. (2004). E-teaching and interactive whiteboards. The Richardson experience. *The Practicing Administrator*, 26 (1), 14-16.

Kerlinger, F.N. (1986). *Foundations of Behavioural Research*. (Ed.). New York: Holt, Rinehart and Winston.

Kerr, B. (2007). Which radical discontinuity? Retrieved 30 July, 2008, from <://billkerr2.blogspot.com/2007/02/which-radical-discontinuity>.

Knodel, J.D. (2006). SMART Board in the classroom: The influence of interactive boards in Education. Retrieved 10 May, 2008, from [://tiger.towson.edu/users/sunger2/smart-boards-in-the-classroom.htm-24k-](http://tiger.towson.edu/users/sunger2/smart-boards-in-the-classroom.htm-24k-).

Knowlton, N. (2007). SMART product improves students' performance and teachers' lives. Retrieved 01 June, 2008, from [://www2.smarttech.](http://www2.smarttech.)

Kramarski, B., & Gutman, M. (2006). How can self-regulated learning be supported in mathematics learning environment? *Journal of Computer-Assisted Learning*, 22, 24-46.

Krauss, S.E. (2005). Research Paradigms and Meaning Making: A Primer. *The Qualitative Report*, 10 (4), 758 – 770. Retrieved 10 September, 2007, from [://www.nova.edu/ssss/QR/QR10-4/krauss](http://www.nova.edu/ssss/QR/QR10-4/krauss).

Krefting, L. (1991). Rigour in qualitative research: the assessment of trustworthiness. *The American Journal of Occupational Therapy* 45 (3), 214-222.

Kvale, S. (1996). *Interviews: An introduction to Qualitative Research Interviewing*. Thousand Oaks, California: Sage.

Lankshear, C., & Knobel, M. (2004). *A Handbook for Teacher Research: from design to implementation*. England: Open University Press.

Lauer, P.A. (2006). *An Educational Research Primer: How to Understand, Evaluate, and Use it*. San Francisco, CA: Jossey-Bass.

Leask, M., & Pachler, N. (2005). *Learning to Teach Using ICT in the Secondary School: A companion to school experience*. (Ed.). London: Routledge.

Levy, P. (2002). *Interactive Whiteboards in Learning and Teaching in Two Sheffield Schools: A Developmental Study*. Department of Information Studies, University of Sheffield.

Lewin, C., Mavers, D., & Somekh, B. (2003). Broadening access to the curriculum through using technology to link home and school: a critical analysis of reforms intended to improve students' educational attainment. *The Curriculum Journal*, 14 (1), 23-53.

Lincoln, Y. S. and Guba, E. G. (1985) *Naturalistic Inquiry*. Beverly Hills, CA: Sage.

MacQueen, K.M. (2002). Introduction: Enriching Facts and Figures. *Network*, 22 (2).

Maree, K. (2007). (Eds). *First Steps in research*. Pretoria: Van Schaik.

Mayer, R.E. (1996). Learners as Information Processors: Legacies and Limitations of Educational Psychology Second Metaphor. *Educational Psychologist*, 31, (4), 151-161.

Mayer, R.E. (2001). *Multimedia Learning*. New York: Cambridge University Press.

Mayer, R.E. (2005). *The Cambridge Handbook of Multimedia Learning*. London: Cambridge University Press.

McFarlane, A., Hamson, C., Somekh, B., Scrimshaw, P., Harrison, A., & Lewin, C. (2000). Establishing the Relationship between Networked Technology and Attainment: Preliminary Study, Coventry: Becta. Retrieved 16 August, 2008, from [://www.becta.org.uk/research/reports/docs/impact2-prelim1](http://www.becta.org.uk/research/reports/docs/impact2-prelim1).

McNeese, M.N. (2006). Evaluation of SMART Multimedia Classrooms: Impact on Student Face-to-Face Participation and E-Learning. Retrieved 31 March, 2008, from [://smarkids.org/research/pdf/McNeese-SB%20Evaluation](http://smarkids.org/research/pdf/McNeese-SB%20Evaluation).

Mehan, H. (1979). *Learning lessons: Social organization for the classroom*. Cambridge, MA: Harvard University Press.

Merriam, S.B. (1998). *Qualitative Research and Case Study Applications in Education*. San Francisco, CA: Jossey-Bass.

Merriam, S.B. (2001). *Qualitative Research and Case Study Application in Education*. San Francisco, CA: Jossey-Bass.

Miles, M.B., & Huberman, A.M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. (Ed.). Thousand Oaks: Sage.

Mishler, E.G (1986). *Research interviewing: context and narrative*. Cambridge, MA: Harvard University Press.

Mohammed, K.A., & Ottmann, T. (2005). Controlling the Electronic Whiteboard's Writing Surface with Cluttered Toolboxes: Shifting the Focus Back to Content Delivery. Retrieved 07 April, 2008, from [://ad.informatik.unifreiburg.de/mitarbeiter/khaireel/authorscopy/2005/-eLearn](http://ad.informatik.unifreiburg.de/mitarbeiter/khaireel/authorscopy/2005/-eLearn).

Morgan, D. (1996). Focus groups. *Annual Review of Sociology*, 22, 129-152.

Mouton, J. & Marais, H.C. (1990). *Basic concepts in the methodology of social sciences*. Pretoria: Human Sciences Research Council.

National Advisory Committee on Creative and Cultural Education (NACCCE), (1999). *All our futures: creativity, culture, and education*. London, UK: DfES.

Neumann, W.L. (2000). *Social research methods: qualitative and quantitative approaches*. Boston: Allyn & Bacon.

Nieuwenhuis, J. (2007). Analyzing Qualitative Data. In Maree, K. (Eds). *First Steps in research* (pp.99-115). Pretoria: Van Schaik .

O'Leary, R. (2006, April). Teacher, what is a Blackboard? *In Touch*, pp.30-31.

O'Neil, H.E., & Perez, R.S. (Eds.). (2003). *Technology applications in education*. Mahwah, NJ: Erlbaum.

Online Portal Excellence Gateway (2008). Working with Electronic Whiteboards. Retrieved 09 September, 2008, from [://excellence.qia.org.uk/page.aspx?0=ferl.aclearn.page](http://excellence.qia.org.uk/page.aspx?0=ferl.aclearn.page).

Pandor, N. (2004). White Paper on e-Education: Transforming Teaching and Learning through Information and Communications Technology (ICT). Pretoria: Department of Education.

Parker, I. (1994). Qualitative research. In P. Banister, E. Burman, I. Parker & C. Tindall. (Eds.), *Qualitative methods in psychology: A research guide*. (pp. 121-141). Buckingham, UK: Open University Press.

Partridge, S. (2004). Teacher and Technology: the interactive whiteboard. Austin: University of Texas. Retrieved 30 September, 2007, from [://smarttech](http://smarttech).

Patru, M. (2002). Information and Communications Technologies in Teacher Education: A Planning Guide. (UNESCO) France: Division of Higher Education.

Patton, M.Q. (1990). *Qualitative evaluation and research methods*. (Ed.). Newbury Park: Sage.

Percival, F., & Ellington, H. (1984). *A Handbook of Educational Technology*. New York: Nicols Publishing.

Percival, F., Ellington, H., & Race, P. (1993). *Handbook of Educational Technology*. (Ed.). London: Kogan Page.

Perrin, D.G. (2005). Connectivism: A Learning Theory for the Digital Age. *International Journal of Instructional Technology and Distance Learning*. Retrieved 20 July, 2008, from [://www.itdl.org/Journal/Jan-05/article01](http://www.itdl.org/Journal/Jan-05/article01).

Reiser, R.A., & Demsey, R.J. (2006). *Trends and issues in instructional design and technology*. (Ed.). Upper Saddle, NJ: Merrill Prentice Hall.

Robinson, S. (2000). Maths classes for the century. *Media and Methods*, 36 (4), 10-11.

Rudd, T. (2007). Interactive whiteboards in the classroom. Retrieved 25 April, 2008, from [://www.futurelab.org.uk/events/listing/whiteboards/](http://www.futurelab.org.uk/events/listing/whiteboards/).

Sang, D., & Frost, D. (2005). *Teaching Secondary Science using ICT*. London: Hodder Murray.

- Schenk , B.L.(2007). Technology in the Classroom: The Interactive Whiteboard. Retrieved 31 May, 2008, from [://brittany%20Schenk%20Thesis](http://brittany%20Schenk%20Thesis).
- Scheurich, J.J. (1995). A postmodernist critique of research interviewing. *International Journal of Qualitative Studies*, 8, pp.239-252.
- Schneider, R.M., Krajcik, J., Marx, R.W., & Soloway, E. (2002). Performace of students in project-based Sceince Classrooms on a National measure of Science Achievement. *Journal of Research in Science teaching*, 39, (5), 410-422.
- Schuck, S., & Kearney, M. (2007). Exploring pedagogy with interactive whiteboards. Retrieved 08 Sepetember, 2008, from [://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb](http://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb).
- Schwab, J. (1962). The teaching of science as inquiry. In J. Schwab and P. Brandwein. (Eds.). *The teaching of Science* (pp.1-103). Cambridge, MA: Harvard University Press.
- Seale, C. (2002). Quality Issues in Qualitative Inquiry. *Qualitative Social Work* 1(1), 97–110.
- Sharma, R.C. (2003). Barriers in using technology for education in developing countries. In Proceedings of the International Conference on Information: Research and Education.
- Siemens, G. (2004). Connectivism: A Learning Theory for the Digital Age. Retrieved 09 July, 2007, from [://www.itdl.org/Journal/Jan-05/article01](http://www.itdl.org/Journal/Jan-05/article01).
- Siemens, G. (2005). Connectivism: Learning as Network Creation. Retrieved 04 August, 2007, from [://www.learningcircuits.org/2005/nov2005/siemens](http://www.learningcircuits.org/2005/nov2005/siemens).
- Siemens, G. (2007). Century Learning: Connectivism: Learning Conceptualized through the lens. Retrieved 30 July, 2008, from [://21stcenturylearning.typepad.com/blog/2007/02/george-siemens](http://21stcenturylearning.typepad.com/blog/2007/02/george-siemens).
- Slay, H., Sieborger, I., & Hodgkinson-Williams, C. (2007). The use of ‘smart’ pens in South African teaching and learning environments. *South African Computer Journal*, 40, 83-94.
- Slay, H., Sieborger, I., & Hodgkinson-Williams, C. (2008). Interactive Whiteboards: Real beauty or just “lipstick”. *Computers & Education Journal*, 51 (3), 1321-1341.
- Slay, H., Sieborger, I., & Hodgkinson-Williams, C. (2008). The use of Interactive Whiteboards to support the creation, capture and sharing of knowledge in South African schools. In IFIP International Federation for Information Processing, Volume 281, M. Kendall & B Samways, *Learning to live in the knowledge society* (pp. 19-26). Boston: Springer.

SMART Technologies, Inc, (2005). Gloucester cit public schools: Case study. Retrieved 25 April, 2008, from <://education.smarttech.>

SMART Technologies, Inc, (2007). Study links interactive whiteboards to improve student performance. Retrieved 25 April, 2008, from <://www2.smarttech.>

Smith, A. (2003). Interactive Whiteboards Evaluation. MirandaNet Community Focus on Research and Dissemination. Retrieved 15 October, 2007, from <://www.mirandanet.ac.uk/pubs/SMARTBoard.>

Smith, H., Higgins, S., Wall, K., & Miller, J. (2005). Interactive whiteboards: Boon or bandwagon? A critical review of literature. *Journal of Computer Assisted Learning*. Retrieved 11 September, 2008, from <://www3.interscience.wiley.com.qe2a-proxy.mun.ca/cgi-bin/fulltext/118652048/>

Stanfield, J.H. II. (1993). Methodological Reflections: An Introduction. In J.H. Stanfield (Eds.), *Race and Ethnicity in Research Methods* (pp.3-15). Newbury Park, CA: Sage.

Steed, A. (2002). Use of an interactive whiteboard. Retrieved 20 September, 2008, from <://www.teachernet.gov.uk/professionaldevelopment.opportunities/brps/search/index.cfm?report=>

Stein, G. (2005). Pedagogy, practice & ICT: What skills, training and professional development are needed to support the effective use of interactive whiteboards in the primary classroom? Retrieved 7 April, 2008, from <://client.canterbury.ac.uk/research/papers/georgina-stein/interactive-whiteboards-primary.>

Stokes, D., & Bergin, R. (2006). Methodology or ‘methodolatry’? An evaluation of focus groups and in-depth interviews. *Qualitative Market Research: An International Journal*, 9 (1), 26-37.

Sutherland, R. (2004). Designs for learning: ICT and knowledge in the classroom. *Computers and Education*, 43, 5-16.

Terre Blanche, M., & Durrhein, K. (2006). *Research in Practice: Applied methods for the social*

Thomas, R.M., & Kobayashi, N. (Eds). (1987). *Educational Technology – Its creation, development and cross-cultural transfer*. Oxford: Pergamon Books Ltd.

Venkataiah, N. (1996). *Educational Technology*. New Delhi: APH Publishing Corporation.

Verhagen, P. (2006). Connectivism: a new learning theory? In E-learning Themasite. Retrieved 28 July, 2008, from <://elearning.surf.nl/elearning.english/3793.>

Walker, R. (1985). An introduction to applied qualitative research. In R. Walker (Eds.) pp.3-26. *Applied Qualitative Research. Gower*, 3-26.

Wall, K., Higgins, S., & Smith, H. (2005). The visual helps me understand the complicated things: pupils views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology*, 36 (5). pp. 851-867.

Watson, D. (2001). Pedagogy before technology: rethinking the relationship between ICT and teaching. *Education and Information Technologies*, 6 (4), pp. 251-266.

Watson, D., & Downes, T. (2000). *Communication and Networking in Education: Learning in a networked Society*. London: Springer.

Webb, N.M. (1993). Collaborative group versus individual assessment in mathematics: processes and outcomes. *Educational Assessment*, 1, (2), 131-152.

Weimer, M.J. (2001). The influence of technology such as SMART Board Interactive Whiteboard on student motivation in the classroom. Retrieved 27 May, 2008, from [://www.smarterkids.org/research/paper7](http://www.smarterkids.org/research/paper7).

Wilson, V. (1997). Focus groups: A useful qualitative method for educational research. *British Educational Research Journal*, 23 (2), 209-224.

Winzenreid, A. (2006). Interactive whiteboards: for better or for worse? Paper presented at the ACEC 2006 conference, Cairns, Queensland, 2-4 October, 2006. Retrieved 23 April, 2008, from [://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb](http://www.ed-dev.uts.edu.au/teachered/research/iwbproject/pdfs/iwbreportweb).

Wood, R., & Ashfield, J. (2008). The use of the interactive whiteboard for creative teaching and learning in literacy and mathematics: A case study. *British Journal of Educational Technology*, 39 (1), 84-96.

Yin, R. K. (1994). *Case study research: Design and Methods*. (Ed.). Beverly Hills, CA: Sage.

Yin, R.K. (2003). *Case Study Research: Design and Methods*. (Ed.). Thousand Oaks, CA: Sage.

Yvette, J.G. (2003). Low Threshold Pre-service Multimedia Digital Portfolio Preparation as a "Product of learning" That Equality Meets Multimedia Accreditation standards. Hawaii. World Conference on educational multimedia, hypermedia and telecommunications.