UNDERSTANDING AND USES OF CONCEPT MAPPING IN TEACHING NATURAL SCIENCE: CASES OF TWO PRIMARY SCHOOLS IN WINDHOEK, KHOMAS REGION

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF EDUCATION

(SCIENCE EDUCATION)

OF

THE UNIVERSITY OF NAMIBIA

BY

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APRIL 2015

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APPROVAL PAGE

This research has been examined and is approved as meeting the required standards for partial fulfilment of the requirements of the degree of Master of Education.

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DECLARATION

I, Jafet Shikongo Uugwanga, hereby declare that "**Understanding and uses of concept mapping in teaching Natural Science: cases of two primary schools in Windhoek, Khomas Region"** is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

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DEDICATION

First and foremost, this thesis is dedicated to my mother, Taimi Kaapangelwa Shamena-Iipinge and my late father, Junias Shapaka-Kasamane Uugwanga (may his soul rest in peace). They have sacrificed their lives for my education although they didn't get formal education; they have been very enthusiastic about my education. They have positively shaped my life and made me who I am today. Thank you very much *Meme gwaShamena* and *Tate Kasamane* for being my mentors and for giving me an opportunity to realise my life dreams and ambitions.

Secondly, I dedicate this thesis to my wife, Klaudia Ndeshipanda Iimene and my son, Ndeshipanda Kagadhinwa Uugwanga for their unwavering love, kindness, patience, understanding and support, as well as for the good and bad times that I ripped-off from them during my entire study period.

Thirdly, I dedicate this thesis to all the teachers who live and teach in rural schools in Namibia and the rest of the world. Your commitment and dedication to live and travel long distances, often in harsh and unsafe conditions to serve and make a difference in the lives of thousands of children are highly acknowledged and saluted.

"…MAY OUR HEAVENLY FATHER KEEP BLESSING THE WORK OF OUR TRUE MOTHERS, FATHERS AND TEACHERS…"

ACKNOWLEDGEMENTS

If it were not for their remarkable and valuable contributions, I would not have been able to complete this study and it is, therefore, my privilege and honour to take this opportunity to express my sincere thanks and appreciation to:

The Almighty God for giving me wisdom, strength, knowledge and His grace and spirit to complete the study.

My supervisor, Dr. Hedwig Utjungirua Kandjeo-Marenga, for her incredible and infinite perseverance and support, her professional guidance and advice, her being an approachable and dedicated mentor, her sympathy, kindness and constructive criticism for which all made the study a success.

The Ministry of Education that funded my study under Namibia Government Scholarship and Training Programme (NGSTP), the Permanent Secretary as well as the Khomas Directorate of Education, for granting me permission to conduct the study in schools in the Khomas Educational Region.

The principals, for giving me the opportunity, freedom and support to conduct the study as well as the teachers and learners, for their whole-hearted consent and valuable contributions.

All my colleagues and friends who supported and encouraged me, made a huge difference in many ways to my study.

Ms. Martha Amupolo, for being a humble mother and always taking care of me, especially, during the hectic times of my study. Your generosity and tirelessness is greatly appreciated.

My family, especially my parents, my wife, Klaudia Ndeshipanda Iimene, and my brothers Junias Hiskia 'Shamavi' and Ismael Shoopala Uugwanga. Thank you for your love, care, support and motivation. This kept the candle burning.

"*A sacrifice to be real, it must cost, must hurt, and must empty ourselves. The fruit of silence is prayer; the fruit of prayer is faith; the fruit of faith is love; the fruit of love is service; and the fruit of service is peace.*"

Mother Teresa of Calcutta (1910 - 1997)

"The love and peace be with you all"!!

ABSTRACT

The purpose of the study was to investigate the Grade six Natural Science teachers' understanding of concept mapping. The study also investigated learners' understanding of science concepts on "matter and its properties" taught through the use of concept mapping as compared to traditional lecture method. The study was conducted with two science teachers who taught Natural Science to Grade six, thirty-three learners at Alpha Primary School and thirty-seven learners at Omega Primary School in the Khomas Educational Region, Namibia. Mixed research methods were used.

A semi-structured interview schedule and a video recorder were used to collect data from teachers. The researcher was an active participant in the collection of data and a video recorder was also used to capture his own instructions. A pre- and post-tests were conducted in order to find out the difference in learners' understanding of "matter and its properties" when taught through concept mapping as compared to traditional lecture method. Each test had 22 items. All learners were given the same pre-test, followed by an intervention (treatment) and then a post-test was administered.

Learners at Alpha Primary School were taught through the traditional lecture method while those at Omega Primary School were taught through the concept mapping method. The scores on both tests were analysed to see if there are statistically significant difference between learners' understanding of "matter and its properties" taught through the concept mapping and those taught through the traditional lecture methods. It was found that learners taught through concept mapping out-performed

those who were taught through the traditional lecture at statistically significant difference of alpha 0.05. That means that the overall critical value of 1.998 is significant (t-tests = -4.574 and -2.830, at $p < 0.05$). As the critical value of 1.998 obtained for the degree of freedom (df) = 63, p = .000. The calculated t-value is higher than the critical value, therefore, the Null hypothesis is rejected and the results are significant at $p = 0.05$. The study also found that both science teachers have vague ideas about what the concept mapping strategy was hence they did not even use the strategy in their instructions.

TABLE OF CONTENTS

Approval page i

Declaration ii

Dedication iii

Acknowledgements iv

Abstract vi

List of tables xiii

List of figures xiv

Acronyms xv

CHAPTER ONE: INTRODUCTION 1

1.1 Introduction 1

1.2 Background of the study 1

1.3 Research problem 7

1.4 Research questions 9

1.5 Hypothesis of the study 10

1.6 Significance of the study 10

1.7 Limitations of the study 11

1.8 Delimitations of the study 12

1.9 Definition of terms as used in this study 13

1.10 Research synopsis 14

CHAPTER TWO: LITERATURE REVIEW 16

2.1 Introduction 16

2.2 Theoretical framework 16

2.2.1 Ausebel's Assimilation Theory of cognitive learning 17

2.2.2 Conceptual change framework 19

2.2.3 ED^{3}U Model for teaching science for conceptual change 22

2.3 Science teaching for conceptual understanding 28

2.4 Uses and importance of a concept mapping in science teaching 31

2.5 Science pedagogy in relation to scientific concepts 32

2.6 Exposing learners to scientific concepts 33

2.7 Teaching science concepts for conceptual understanding 34

2.8 Conclusions 36

CHAPTER THREE: METHODOLOGY 38

3.1 Introduction 38

3.2 Research design 38

3.3 Population and sample 43

3.3.1 Schools' profiles 44

3.3.1.1 Alpha Primary School 44

3.3.1.2 Omega Primary School 45

3.3.1.3 Middle-Class Primary School 46

3.3.2 Teachers' profiles 47

3.3.2.1 Teacher 1: Mr Golden 48

3.3.2.2 Teacher 2: Mr Silveren 48

3.3.2.3 Teacher 3: Ms Bronzen 49

3.4 Sampling procedure 50

3.5 Research instruments 51

3.5.1 Pre- and post-tests...51

3.5.2 Interviews 56

3.5.3 A video recorder 57

3.5.4 Treatment 58

3.6 Data collection procedure 58

3.7 Data analysis..60

3.7.1 Pre- and post-tests...60

3.7.2 Interviews 60

3.8 Research ethics 61

3.9 Conclusions 62

CHAPTER FOUR: RESULTS AND DISCUSSION...63

4.1 Introduction 63

4.2 Research question one...63

4.3 Research question two 73

4.4 Difference in pre-test and post-test mean of scores...78

4.4.1 Mean scores for learners exposed to the traditional lecture method 78

4.4.2 Mean scores for multiple choice items for the traditional lecture group 78

4.4.3 Mean scores for structured questions for the traditional lecture group.................82

4.4.4 Mean scores for multiple choice items for the concept mapping group 90

4.4.5 Mean scores for the structured questions concept mapping group... 95

4.5 Conclusions 100

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS..102

5.1 Introduction 102

5.2 Summary 102

5.2.1 Research question one.. 102

5.2.2 Research question two 103

5.3 Recommendations... 104

5.3.1 Research question one.. 104

5.3.2 Research question two 106

5.4 Conclusions 106

5.5 Summary 107

REFERENCES 108

APPENDICES 125

Appendix 1: A granted permission letter from the University of Namibia to carry out a research 125

Appendix 2: A letter requesting permission from the permanent secretary (Ministry of Education) 126

Appendix 3: A letter requesting permission from the director of education (Khomas Region)... 127

Appendix 4: A follow-up letter requesting permission from the director of education (Khomas Region) 128

Appendix 5: An approval letter from the permanent secretary (Ministry of Education)129

Appendix 6: An approval letter from the director of education (Khomas Region) 130

Appendix 7: A letter requesting permission from the school principals 131

Appendix 8: A letter requesting permission from the teachers (consent form)...........132

Appendix 9: A letter requesting permission from the learners (consent form) 134

Appendix 10: Pre-test items on “matter and its properties” 136

Appendix 11: Post-test items on “matter and its properties”......................................142

Appendix 12: An individual interview schedule for teachers.....................................148

LIST OF TABLES

Table 1: Scheme of work for twelve days spent during data collection........................52

Table 2: Pre- and post-test items spread across the concepts (A) 55

Table 3: Pre- and post-test results of traditional lecture group 75

Table 4: Pre- and post-test results of concept mapping group 75

Table 5: Pre- and post-test items spread across the concepts (B) 90

LIST OF FIGURES

Figure 2.1: The ED^3U Model of teaching science for conceptual change.....................23

Figure 3.1: Alpha Primary School as seen from outside 44

Figure 3.2: Omega Primary School as seen from outside 45

Figure 3.3: Middle-Class Primary School as seen from outside..................................47

Figure 4.1: Learners' mean scores for each multiple choice item of traditional lecture group 79

Figure 4.2: Mean difference of improvement between pre- and post-test results (A) ...80

Figure 4.3: Mean difference of slight decrease between pre- and post-test results 81

Figure 4.4: Learners' mean scores of science concepts taught through traditional lecture method 83

Figure 4.5: Science concepts presented using traditional lecture strategies..................84

Figure 4.6: Learners' performance on ice concept on pre- and post-tests.....................88

Figure 4.7: Learners' performance on freezing concept on pre- and post-tests.............89

Figure 4.8: Learners' mean scores for each multiple choice item of concept mapping group 91

Figure 4.9: Mean difference of improvement between pre- and post-test results (B)....92

Figure 4.10: Learners' mean scores of science concepts taught through concept mapping method..95

ACRONYMS

AAT	Ausubel's Assimilation Theory
ACE	Advanced Certificate in Education
BETD	Basic Education Teachers Diploma
CA	Continuous Assessment
HODs	Heads of Department
LCE	Learner Centred Education
M	Mean scores
NAEP	National Assessment of Educational Progress
NAMCOL	Namibia College of Open Learning
NGSTP	Namibia Government Scholarship and Training Programme
NIED	National Institute for Educational Development
NSATs	National Standardise Achievement Tests
UNAM	University of Namibia
WCE	Windhoek College of Education
ZPD	Zone of Proximal Development

CHAPTER ONE
INTRODUCTION

1.1 Introduction

This chapter introduces the study on the understanding and uses of concept mapping in teaching Natural Science. The background of the study, research problem, research questions, hypothesis, significance, limitations, delimitations and operational definition of terms used in the present study are described in his chapter.

1.2 Background of the study

The difficulty of teaching and learning in science is not unique to African countries but manifests itself in Western countries too, such as the United States of America (Ottevanger, van den Akker, & de Feiter, 2007). In Namibia, most teachers seem to focus on using the lecture methods of teaching rather than new and innovative methods of teaching (Amoonga & Kasanda, 2011; Kapenda, Kandjeo-Marenga, & Kasanda, 2002).

Kasanda (2005) conducted a study on problems that prevent effective development of the teaching of mathematics and science education in Namibia and Zambia in primary and secondary school levels. He found that teachers concentrated on teaching rules more than employing innovative teaching strategies in teaching science content. Amoonga and Kasanda (2011) also found that teachers in Namibian schools prefer to use the lecture method. The lecture method is not only used by Namibian teachers, but globally (Mwakapenda, 2006; Safdar, Hussain, Shah, & Rifat, 2012). Lubben, Kasanda, Gaoseb, Kandjeo-Marenga, Kapenda, and Campbell (2005) also found that the lecture method was preferred by many teachers since many teachers think that the lecture strategy could contribute to rote learning and, thus, high retention of subject content by most learners and consequently high performance in examinations. Therefore, there is a need to practice innovative teaching strategies such as "concept mapping" in teaching and learning science concepts rather than the lecture method in order to nurture learners' scientific skills and understanding.

Concept mapping is a teaching and learning tool that was derived from Ausubel's learning theory which is used to help learners explain and generate individual understanding about certain concepts (Novak, 1990, Novak & Canas, 2008). According to Prediger (2008), cross-links or relationships between concepts in different domains of the concept map, for example, events or objects help learners to understand relationships amongst given concepts.

The process of teaching and learning by using concept mapping, gives learners a structured space in which to reflect upon a specific theme and topic, that is "matter and its properties" (Elizabeth, 2013) and to scientifically clarify their ideas on that theme and topic. According to Vitale and Romance (1992) mastery of core science concepts could assist learners to improve in understanding and learning science. Elizabeth (2013) notes that concept mapping teaching strategy gives learners a clear understanding on how science concepts are inter-linked when learning through concept mapping rather than given the traditional lecture.

In addition, the concept map is a "graphical representation of the relationship among terms" (Vanides, Yin, Tomita, & Ruiz-Primo, 2005, p. 27). This means that specific concepts in concept mapping are connected together by arrows labelled with short phrases that describe the relationship between the two connected concepts. These connected concepts could be read as a sentence to describe the connection and relationship between these concepts. Studies (Canas & Novak, 2009; Vanides et al., 2005) define concept mapping as a graphical tool for organising and representing science concepts. In other words, learners tend to learn and perceive science concepts from concept maps in a visual manner that enables them to organise, remember, represent and recognise scientific concepts reasonably well. Ebenezer and Conner cited in Safdar, Hussain, Shah and Rifat (2012) state that a concept map is a "semantic network showing the relationships among concepts in a hierarchical fashion" (p. 57). When concepts are written in a hierarchical approach, learners tend to remember them easily than when written in text format and that concepts in semantic network help learners and teachers to organise their thoughts and ideas in an orderly way.

Generally, teachers tend to use the concept mapping strategy in teaching science concepts for different reasons. Some teachers tend to use it in order to determine the nature of learners' existing ideas on what they already know and what they need to be taught (Asan, 2007). Other teachers use concept maps in order to provide learners with opportunities to operate at all six levels of Bloom's educational objectives of cognitive domain (Safdar et al., 2012). Thus, allowing learners to engage with subject matter at all the levels of the cognitive domain. For example, Vanides, Yin, Tomita, and Ruiz-Primo (2005) conducted a study on using concept maps in the science classroom. They found that the concept mapping teaching strategy provides learners with opportunities to:

- discover the connections between the science concepts;
- organise their thoughts in making sense of the science concepts;
- visualise the relationships between key concepts in a systematic way in learning science concepts;
- reflect on what they have learned in constructing meaning; and
- show their understanding of science concepts by illustrating what they have learned in visual concept map (p. 28).

It is, for the above reasons that teachers tend to use the concept mapping strategy in order to allow learners to discover the connections between the science concepts first and in so doing be able to understand the science concepts manner which is easy (Mwakapenda & Adler, 2003). For example, it becomes important for learners to connect and link concepts by using new linking words such as “formed by”, “can be changed to”, “taken up by”, “released from” in order to construct new understanding about the science concepts learners are taught (Asan, 2007). Moreover, such an exercise is used to determine the nature of learners’ existing knowledge and the acquisition of the taught concepts.

In addition, concept mapping strategy could be used in assessing learners’ understanding of what have been taught (Mwakapenda, 2004). In other word, learners’ understandings of science concepts could be assessed by examining the connections learners make in producing a concept map of what was taught. For instance, learners could make connections and links about science "matter" by using other related concepts such as sublimation, condensation, energy released, melting, freezing, liquid and boiling in order to indicate how these concepts are related to each other. By connecting and linking concepts, studies (Mwakapenda, 2003; Brinkmann, 1999) show that concept mapping could help learners to understand science concepts in an easy way within a short period of time and meaningful manner.

Concept mapping strategy seems to have many positive contributions to learners' thinking capacities, problem solving skills, academic achievements, understanding of content, knowledge and attitudes toward science and the development of appropriate thinking skills (Asan, 2007; Brinkmann, 1999; Mwakapenda, 2003; Mwakapenda & Adler, 2003; Vanides et al., 2005). According to Chiou (2008) concept mapping enhances learning effectively and it is effective "for learning and understanding the structure and inter-relations of the curriculum content" (p. 383). Candan, Türkmen and Cardak (2006) point out that concept mapping is an effective tool as it "reveals the misconceptions, and it is effective to teach scientific concepts" (p. 29). Furthermore, the strategy facilitates learners' independent learning and thinking and it reduces the barriers and promotes learners' interests in learning science concepts (Asan, 2007; Candan, Türkmen, & Cardak, 2006; Chiou, 2008). Concept mapping could also be used in documenting the hierarchical relationships as described by learners before, during, and after learning experiences in classrooms (Wehry, Algina, Hunter, & Monroe-Ossi, 2007) as well as to assess what learners know about science concepts (Asan, 2007; Prediger, 2008).

Despite the positive contributions listed above, the use of the concept mapping strategy seems to have challenges too. Learners seem to experience many challenges when they are not properly introduced to how to use and/or presented science concepts in a concept map hierarchy. Mwakapenda (2004) stated that learners may experience some challenges even if they were taught specific concepts, for example, some learners may not have understood the content well enough in order to be able to communicate the knowledge gained. In this case, he argued that the concept mapping strategy might prevent learners to meaningfully learn. Give learners an opportunity to understand science concepts as well as to critically and freely reflect on relationships between science concepts or ideas (p. 33).

Chiou (2008) conducted a study on the effect of the concept mapping strategy on the Taiwan University students' learning, achievements and interests and found that nearly half of the students could not quickly adapt to the concept mapping strategy. Furthermore, he indicated that a lack of familiarity with concept mapping technique could be frustrating and that the training of learners to use the concept mapping learning strategy can be tiresome and time-consuming.

Several studies have been conducted in the Namibian context in the field of science education on characteristics of practical work in science classrooms; post colonialism and globalisation in science education; the role of everyday contexts in learner-centred teaching; and the use of constructivism in teaching mathematics for understanding (Amoonga & Kasanda, 2011; Kapenda et al., 2002; Kasanda, 2005; Lubben, Kasanda, Gaoseb, Kandjeo-Marenga, Kapenda, & Campbell, 2005). Thus far, no study seems to have been conducted in Namibia on the uses of innovative teaching strategies such the concept mapping strategy in teaching science.

1.3 Research problem

Concept mapping is one of the new innovation teaching strategies in teaching science subjects in schools. Although some studies (Amoonga & Kasanda, 2011; Asan, 2007; Lubben et al, 2005; Mwakapenda, 2006) consider the concept mapping teaching strategy to be an effective teaching strategy, not many teachers seem to be equipped in using this strategy during instruction (Crawford, 2007; Grosser, 2007).

Moreover, concept mapping is seen to be an effective teaching strategy in science education due to its contribution to developing learners' thinking capacities, problem solving skills, promoting learners' understanding of content knowledge (Novak, 2008; Trochim, 2006). Concept mapping strategy seems to have several purposes for learners such as:

- assisting leaners to brainstorm and generate new ideas;
- encouraging learners to discover new concepts and the propositions that connect science concepts;
- allowing learners to clearly communicate science ideas, thoughts and information;
- assisting leaners to integrate new science concepts with old or acquired concepts; and
- enabling learners to gain enhanced knowledge of any topic and assess the information (http://www.inspiration.com/visual-learning/concept-mapping).

One of the fundamental aims in the use of concept mapping is to foster meaningful learning as compared to rote learning. Ausubel, cited in Canas (2003) described three conditions that seem to be important in increasing learners' performance in school science, in particular, to the Namibian learners who are prone to rote learning. Firstly, concept mapping need to be conceptually clear and be presented with language and examples relatable to the learners' prior knowledge. Secondly, learners must possess relevant prior knowledge and lastly, learners must be motivated in order to choose to learn meaningfully (http://www.ihmc.us/users/acanas/Publications/ConceptMapLitReview/).

In Namibia, the application of concept mapping in teaching is still a new teaching strategy and teachers are not well equipped to use it (Amoonga & Kasanda, 2011; Kapenda et al., 2002; Lubben et al., 2005). Therefore, Namibian science teachers seem to experience some problems, particularly in classrooms. It is also a new teaching strategy and teachers are not familiar with it. It seems to take time for teachers to shift from their usual lecture method to the concept mapping strategy and this shift might frustrate teachers. If teachers are frustrated, then, they might not motivate learners for deeper and meaningful learning to take place. It is also possible that teachers may also find it difficult to get information on how to use concept mapping as compared to the text-rich lecture teaching strategy. In addition, training teachers on how to use the concept mapping strategy might be seen as tedious and time-consuming by many lecturers and, thus, and many teachers may not be willing to adopt the concept mapping strategy (Chiou, 2008).

Another factor that seems to influence teachers not to apply concept mapping is the teacher-learner ratio (Black, 2005). In overcrowded classrooms, teachers do not pay attention to each learner to oversee the usefulness of concept mapping. Another problem might be the language barriers amongst teachers and learners (Jarvis & Pell, 2005). Teachers and learners might find some linking words, phrases and prepositions used on the concept map as unfamiliar, too complicated and difficult to use as they themselves seem to struggle to understand science concepts.

Therefore, this study is twofold and aims to (i) investigate the Grade six Natural Science teachers' understanding and use of concept mapping; (ii) examine the usefulness of concept mapping by assessing learners' understanding of the concept of "matter and its properties" taught through the concept mapping method as compared to the traditional lecture method.

1.4 Research questions

The purpose of the study was to investigate the Grade six Natural Science teachers' understanding of concept mapping and use of the concept mapping strategy in relation to the lecture strategy in teaching science content. Therefore, the following are the main research questions of the study:

1. How do Grade six Natural Science teachers understand and use concept mapping?

2. Is there a significant difference in learners' understanding of "matter and its properties" taught through concept mapping as compared to traditional lecture strategy?

1.5 Hypothesis of the study

The following is the hypothesis for the current study:

There is no statistically significant difference in learners' understanding of "matter and its properties" taught through concept mapping and those taught through traditional lecture.

1.6 Significance of the study

The importance of this study was to find the usability of a teaching tool 'concept mapping' that could be used to enhance learners' conceptual understanding of science concepts. Some science concepts on 'matter and its properties' that the study focused on are: evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy. The researcher was curious in trying to find out the usefulness of concept mapping as a tool that could help learners to understand the relationship between the various scientific concepts in relation to the lecture method. Also, the study could serve as a guiding tool and an eye-opener to other science teachers and curriculum planners by informing them that concept mapping could contribute positively if it is used appropriately in teaching learners.

Moreover, this study may also be useful in different ways. Firstly, the study might bridge the gap in the contemporary literature and transform the notion of instructional practice from rote learning to meaningful learning. The study might, thus, provide some information in trying to discover challenges associated with innovative strategies of teaching as compared to traditional lecture teaching strategy in teaching science and by so doing serve as reference material for further studies. Secondly, the study may lead to discovering some misconceptions or alternative concepts in learners' understanding of science concepts such as evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy. Thirdly, the study could be useful to educators in training student-teachers on what to avoid and what to apply in using the concept mapping strategy during instruction. Fourthly, this study might consequently enhance a deeper understanding of the subject content if such a tool is used appropriately. Finally, the study may directly inform other researcher about the benefits and weaknesses of concept mapping strategy when teaching science.

1.7 Limitations of the study

Limitations are possible weaknesses and shortcomings that the researcher identified during the research study (Pajares, 2007). The limitations for this study were: Firstly, the study focused only on few government primary schools in the Khomas Educational Region. Therefore, the outcomes of the study are not generalizable to larger primary school teachers and learners' understandings of science concepts because of the small sample that was used for data gathering. In the same breath, the researcher would want to say that the success of the method lies in how the teachers use the concept mapping and these might differ from one school to another and from one educational region to another.

Secondly, a sample size of two schools and two teachers seem be too small and if a larger sample is used, it might have delivered different results. Thirdly, the targeted science teachers were too nervous as they seemed to be deliberately provided information that they thought the researcher wanted to hear and by so doing unknowingly they did not provide useful information as to how they assessed themselves on how they understood the concept mapping strategy. Fourthly, analysis of the recorded video was not an easy task to carry out but it was possible by developing an appropriate analysis scheme for lesson presentations during the piloting sessions. Fifthly, analysing own teaching was challenging as one was likely tempted to look at the video recorded data with biased eyes (Kinchin, Streatfield, & Hay, 2010). In order to avoid bias, the researcher developed an analysis tool that was used by two experienced educators and then it was corrected before analysing the videos content.

1.8 Delimitations of the study

The study targeted only three government primary schools in the Khomas Educational Region. These schools were studied in terms of performance, locations and resources and there were no difference in their settings as to avoid discrepancy. Only two Grade six Natural Science teachers and their learners were included in the study in order to minimize the number of case study sites. The study deliberately focused only on the understanding and uses of concept mapping strategy on “matter and its properties” and wanted to have in-depth information relating to the practices of the concept mapping teaching strategy rather than focusing on many schools.

1.9 Definitions of terms as used in this study

Concept mapping refers to a diagrammatic representation of what is in order to show meaningful relationships between concepts. Arrows and linking words are used in the form of propositions (Stoica, Moraru, & Miron, 2011).

Conceptual understanding refers to the ability to transfer and to understand ideas which are based on facts, laws, principles and basic scientific concepts such as energy, matter, solubility and photosynthesis, and tools used in the process of a scientific investigation (Mbano, 2004).

Science refers to the study of facts, principles and theories that describe the world around us. It is also described as a set of processes by which people systematically acquire and refine knowledge (Merki, 1993; Snively & Corsiglia, 2001)

Science teaching refers to the systematic process of presenting science facts, skills, concepts, ideas and techniques to the learners (Brown, 2009; Duit & Treagus, 1998).

Scientific concepts refer to mental representations of a single concept, for example, water, weight, electricity, chemical change and matter (Department of Education, 2006).

Traditional lecture refers to the practice when teachers provide the subject content to the learners with the help of a textbook, and then learners have to learn it (Marsh, Ontero, & Shikongo, 2002).

1.10 Research Synopsis

In **Chapter One**, the background of the study, research problem, research questions, hypothesis, significance, limitations, and delimitations of the study and definitions of terms are described.

In **Chapter Two**, the following subtitles: theoretical framework including models of science teaching for conceptual change, science teaching for conceptual change, the meaning of concept mapping with its uses and importance, science pedagogy in relation to scientific concepts, learners' exposure to scientific concepts, teaching science for conceptual understanding will be covered.

In **Chapter Three**, the following subtitles are described: research design, population and sample, the profiles of the schools, profiles of the teachers, sampling procedure, research instruments, data collection procedure, data analysis and research ethics.

In **Chapter Four**, the results are presented, interpreted and discussed under the following subtitles: research question one and two.

In **Chapter Five**, summary, conclusion and recommendations are described under the following subtitles: the summary, conclusions and the recommendations will be given based on the two research questions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature conducted locally and internationally on the focus and purpose of the current study. The literature review also presents a critical discussion of the uses and classroom practices of the concept mapping teaching strategy in enhancing learners' conceptual understanding in science teaching. The main points for discussion are the theoretical framework of Ausubel's Assimilation Theory (AAT) of cognitive and meaningful learning; Conceptual Change Framework (CCF) and ED^3U models for conceptual understanding, science teaching for conceptual change; science teaching for conceptual change, uses and importance of concept mapping; science pedagogy in relation to scientific concepts, importance of exposing learners to scientific concepts and teaching science concepts for conceptual understanding.

2.2 Theoretical framework

The theoretical framework is derived from Ausubel's Assimilation Theory (AAT) of cognitive learning, the Conceptual Change Framework (CCF) in making meaning, and the ED^3U Model, teaching science for conceptual change.

2.2.1 Ausubel's Assimilation Theory of cognitive learning

The theory emphasises how learners gain conceptual understanding and how concepts are structured in the minds of leaners. According to Ausubel, learning relies on what is already known, that is, what is referred to as prior knowledge. In other words, knowledge construction starts with what learners are observing and recognising as events and objects as concepts that are already established in their minds. According to Ausubel's theory of learning, learners learn by constructing a network of science concepts and by adding new scientific concepts to prior learnt concepts.

In addition, Ausubel's theory of learning focuses on reception and meaningful learning rather than rote learning (Novak, 2011). Novak (2011) argues that understanding concepts, principles and ideas are best achieved through deductive reasoning rather than rote learning. Furthermore, assimilation theory of cognitive learning emphasises meaningful learning as well as provision of opportunities to learners in order to enhance meaningful learning by relating new knowledge (science concepts) to relevant science concepts that are already known to learners. For example, new information is gained from well-planned class activities and the knowledge levels of the learners expand in order to accommodate the gained information (Cantú, Farines, & Angotti, 2004).

The assimilation theory of cognitive learning also involves recognition or what Ausubel refer to as "reception" of the links or connection between concepts. Ausubel (1962) believes that knowledge is hierarchically organised and that new knowledge would be meaningful if it could be anchored to what is already known (Novak and Canas (2008). In the current study, in order to teach meaningfully and for the learners to learn meaningfully, concept mapping is used as a tool for creative productions of science concepts. The researcher as well as the teacher provided learners with well organised and relevant structures of knowledge. The researcher also used a tool (concept mapping) to illustrate how science concepts were linked in order to enhance learners' understanding of the "matter and its properties".

One of the powerful uses of concept mapping is evaluation of learnt information (Novak & Canas, 2008; Novak, 2011). It is, thus, encouraging learners to continuously use concept mapping as an evaluation tool to assess their understanding of the learnt science concepts which is in accordance with conceptual change framework. The concept mapping strategy involve three conditions that satisfy the assimilation theory of cognitive learning, namely: (i) strategy used in concept mapping as an organiser to link concepts to one another, (ii) processing new science concepts with existing concepts and (iii) a comparative organiser in activating existing structures to integrate new science concepts with acquired science concepts in cognitive structures (Ausubel, 1962). In addition, the concept mapping strategy acts as an expository organiser – when new science concepts are familiar to learners they relate to what they already know easily.

In the same vein, Ausubel's assimilation theory of cognitive learning also relates to the conceptual change framework. The conceptual change framework is considered in the next subsection.

2.2.2 Conceptual change framework

Conceptual change framework is defined as a learning approach that changes existing conceptions such as ideas, beliefs (Davis, 2001; Wood, 2011). According to Duit and Treagust (2010), conceptual change framework tries to explain how learners learn in a meaningful way. Duit and Treagust (2010) describe two types of conceptual change, namely: (i) "the weak knowledge restructuring, assimilation or conceptual capture" and (ii) "the strong/radical knowledge restructuring, accommodation or conceptual exchange" (p. 672). Concept mapping is seen as a tool that can provide opportunities to learners in order to acquire science concepts in a meaningful manner. Concept mapping approach encourages and guides learners to take an active role in re-organizing their ideas, thoughts and knowledge about science concepts (Mbano, 2004; Wood, 2011).

The use of concept mapping strategy requires a supportive and conducive classroom environment in which learners feel comfortable in expressing and discussing their scientific ideas with the teacher (Ozdemir & Clark, 2007). In other words, the teacher as a facilitator needs to prepare learners for emotional commitment in order to allow then to integrate new knowledge with existing knowledge as explained in Ausubel's assimilation theory of cognitive learning above. Thus, learners are required to acquire knowledge through active participation through the process of sharing ideas.

Science teachers are encouraged to develop and adapt effective teaching and learning strategies so that the new knowledge could be integrated into learners' existing cognitive structures (Davis, 2003; Prediger, 2008). Teaching science for conceptual change offers opportunities to teachers to guide learners towards meaningful learning by:

- considering learners' prior knowledge and experience;
- identifying learners' common misconceptions;
- planning activities through which learners shift from less accurate to more accurate understanding of science concepts; and
- guiding learners in order to modify or create a place of newly constructed knowledge within their conceptual understanding (Hewson, 1992, p. 43).

One way to do that is to develop and adapt teaching strategies that could provide learners with intelligible, plausible, and fruitful learning opportunities and activities. According to Hewson and Hewson (1984), ***intelligible*** opportunities, learners are provided with learning opportunities of concepts which are familiar to them. Thus, they know the meaning of these concepts and how these concepts make sense in their everyday life. ***Plausibility*** comes in when provided opportunities and activities are interesting yet challenging to learners. However, learners do believe in their potential and that these are true in their own nature. Usually learners tend to weigh the meaningfulness of such new knowledge and they might decide whether such learnt concepts can offer a better explanation than the existing concepts or not. Lastly, ***fruitfulness*** comes in when learners start to reason as to how these learnt concepts could be incorporated in their understanding, and whether such concepts could be useful in explain phenomena in a broader context.

In addition, teaching for conceptual change provides teachers with opportunities to guide learners through a five-phased, interative process of shifting from the naïve towards a more advanced scientific understanding. According to Shope (2006), the following processes are involved in guiding learners for meaningful learning to take place:

- diagnosis strategies that form a true teacher-learner interaction in order to identify learners' personal conceptions of science concepts;
- mentoring individual learners' progress in restructuring their existing knowledge in order to accommodate new science ideas;
- scaffolding strategies are provided in order to guide;
- challenges ideas;
- move learners through scientific inquiry experiences, in proximal leaps, towards new scientific conceptual understanding; and
- engage learners in a real learning experience that initiates them into the way scientists think about science and do science through mentoring strategies (http://theaste.org/pubs/proceedings/2006proceedings/ Shope_1% 201 %20.htm).

Such process of teaching approach will involve confronting learners with new science concepts concerning particular concepts and through that allow learners to reconstruct their prior knowledge. It becomes necessary as new knowledge becomes old mismatched knowledge (Prediger, 2008).

2.2.3 *ED^3U Model for teaching science for conceptual change*

The ED^3U model focuses on teaching science for conceptual change by developing the learners' zone proximal development. It becomes important for teachers to create opportunities in order to allow their learners to participate in active inquiry activities (Shope, 2006). In such teaching and learning environment, it is expected from a teacher to diagnose the nature of the learners' personal conceptions (Chapman, 2001; Shope, 2006). Thus, exploration of the phenomenon, generation of questions, make or propose explanations, design and carry out investigations as well as arrange participatory discourses are important aspects that actively involve learners in order to grasp scientific concepts meaningfully. Figure 2.1 below shows the ED^3U Model for teaching science for conceptual change that focuses on the following concepts: explore, diagnose, design, discuss and use.

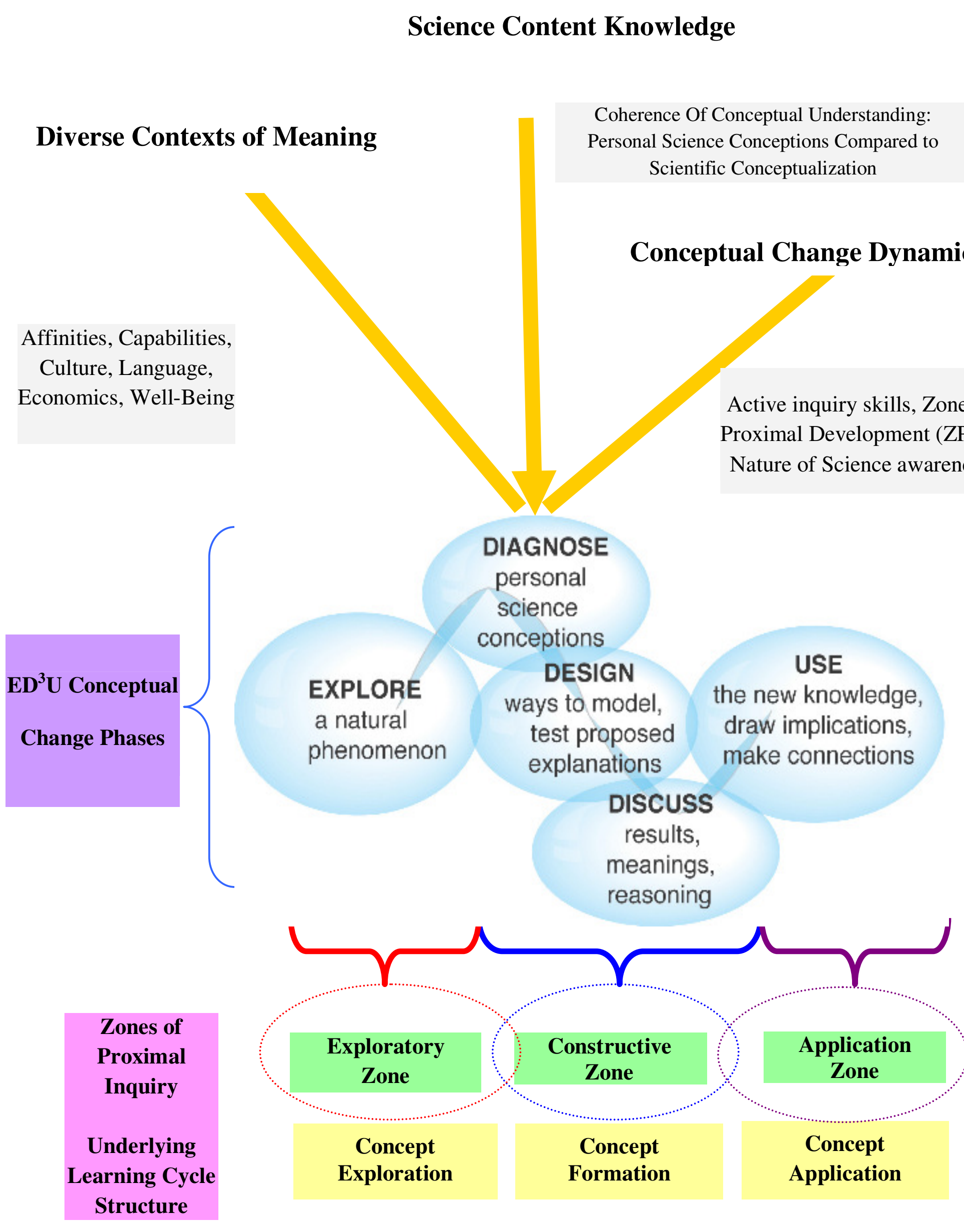


Figure 2.1: The ED^{3}U Model of teaching science for conceptual change

Source: Shope (2006). http://theaste.org/pubs/proceedings/2006proceedings/Shope_1%201 %20.htm

In the *exploring phase*, teachers allow learners to explore the scientific phenomenon in the form of a visual display such as concept mapping and hands-on activities as learners connect and link words. In so doing, teachers expose learners to a variety of information sources that enable them with a common base of experiences where concepts, processes, and skills are identified and developed through practical work to think toward proposing explanations of the phenomenon and other concepts selecting from a substrate of ideas (Bybee, 1997). One such practical experience that a teacher can provide is by introducing learners to concept mapping as a learning tool that could enable them to understand science concepts and learn new science concepts meaningfully. Furthermore, exploration could be used in a variety of formats such as practical techniques, investigations, training skills, and teacher demonstration in order to promote discussion about phenomena as well as to raise questions and generate problem-solving activities. According to Watson (2000), exploration phase seem to have the following uses:

- encourage accurate observation and description;
- make phenomena more real;
- arouse and maintain interest; and
- promote a logical and reasoning method of thought (p. 58).

The researcher's idea was to include some of the mentioned ideas in preparing lessons by using concept mapping as a tool for exploration activities. Turning to the *diagnosing phase*, now during this phase teachers are supposed to: evoke learners' expressions of their personal science conceptions; assess learners understanding of science concepts on how they view alternative conceptions to being reasonable; select strategy that brings misconceptions to front as well as to guide learners to search for more accurate explanations (Piaget, 1985; Shope & Chapman, 2001). It is, thus important to provide opportunities to learners in order for them to become aware of their alternative science conceptions and their hypothetical nature of their beliefs and presuppositions (Piaget, 1985; Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001). It is, therefore, important for science teachers to be able to: plan their instructions; sequence science activities in such a way that new knowledge is more easily built on previous learning; use strategies that aim to help learners restructure their scientific understanding (Morrison & Lederman, 2003). Thus, it is important to accommodate these ideas by using concept mapping in order to diagnose learners' prior science conceptions that are not in alignment with accepted scientific beliefs. However, the present study did not accommodate this phase as the purpose of the study was to investigate the teachers' understanding of concept mapping and use of concept mapping in teaching science content.

In the *designing phase*, learners design strategies and procedures for collecting data to investigate science related problem in order to test strength or weakness of a proposed explanation in both its explanatory and predictive value (Novak, Mintzes, & Wandersee, 2000). The designing phase involves learners in activities that could enhance their conceptual understanding as they discuss procedures as designed to be followed in their investigation process (Hinrichsen, Jarrett, & Peixotto, 1999). Therefore, such activities provide learners with opportunities to explore the phenomenon in new ways. During such activities, learners could be able to identify and explain why certain variables were selected and controlled. Designing activities also seem able to provide room for learners to explain why certain materials were used or why one approach was favoured over another, as well as describe constraints they encountered in the design of the investigation activities. Designing activities also allow learners to analyse gathered data and how they could be used in explaining the definitions and existence of some science concepts. Thus, concept mapping seems to offer such opportunities to teachers and it was constructively used in designing classroom activities for the present study.

In the *discussion phase*, learners are involved in discussions, both in small groups and whole class situations. Discussion provides the means by which learners become more aware of their own - and other learners' ideas and understandings (Hewson, 1996; Hewson, 1996; Westbrook & Rogers, 1996). Discussion sessions, generally make various demands on learners such as the need to listen to, construct the meaning of, and evaluate another point of view. Learners seem to build meaningful understanding through discussion and it is also through discussions that learners shape their existing cognitive structures to accommodate new ideas after being confronted with different viewpoints that enable them to apply such understandings to other event in a meaningful manner (Scott, Asoko, & Driver, 1992; Vosniadou, Ioannides, Dimitrakopoulou & Papademetriou, 2001). However, one has to keep in mind that not all discussions are fruitful. Some may have little or no effect on learners' thinking if not arranged appropriately (Scott et al., 1992; Westbrook & Rogers, 1996). Teachers, therefore, need to be responsive to the ideas and understanding of the learners to enable them to learn new concepts, which could be achieved by using different approaches such as the concept mapping provide opportunities for class discussions.

In the *using phase*, any approach to teaching and learning science needs to consider the nature of the knowledge to be taught. Literature in the field of science emphasises that scientific practices cannot be characterised in a simplistic, unitary way, i.e. there is no single nature of science (Millar et al., 1993). For example, it is important in science education to appreciate that scientific knowledge is symbolic in nature and is socially negotiated by both teachers and learners together. Therefore, the best way considering learners' new knowledge in science instructions, is to expose learners to natural phenomena in order to enable them to interpret nature (Millar et al., 1993). Therefore, it becomes a need for science teachers to provide opportunities to their leaners that would allow them to encounter science phenomena that could initiate impressions and activate curiosity (Carey, 2000; Millar, Driver, & Leach, 1993). Carey (2000) states that:

> "teachers and science educators should be made aware of the important and perhaps surprising consequences of looking at the problem of science education in terms of conceptual change. For example, I have often heard teachers and science educators blame students' misconceptions on faulty education to the earlier stage in the curriculum. Rather, student misconceptions are inevitable. Not having the target concepts is not an undesirable stage in students but an absolutely necessary one. Indeed, students will construct intermediate steps and misconceptions that do not conform to the views of developed science, and educators should recognize when these steps constitute progress not problems" (p. 15).

In short, the model provides a guiding tool which science teachers could use in designing constructive learning cycles. Scott, Asoko, and Driver (1992) defined six stages of pedagogical strategy in teaching science concepts and theoretical learning for conceptual change:

- preparation: the teaching process which precedes the intervention, and which may contain tools and concepts that may be drawn on;
- initiation: an open-ended problem is posed;
- performance: this comprises all or part of the following sequence: formulating questions or hypotheses; planning and performing experiments; making observations; theoretical discussions; formulating findings;
- discussion of findings: in a class forum;
- comparison with science: class findings are compared with similar historical theories or modern ideas. Differences are stated and possible reasons for those differences are discussed; and
- reflection: students are encouraged to look back on the performance process and to consider particular questions or difficulties which arose (pp. 317 – 318).

It is, however, not only teachers who have roles to play in teaching science for conceptual change. Learners also have a role. They must be convinced that the goal of learning is to understand the topic under consideration (Zoldosova & Prokop, 2006).

2.3 Science teaching for conceptual understanding

According to Mbano (2004), conceptual understanding is the "ability to transfer and understand ideas in science which are based on facts, laws, principles and basic scientific concepts such as energy, matter, solubility and photosynthesis, and tools used in the process of a scientific investigation" (p. 105). This process is a connection between science concepts in everyday life and connections between different science concepts in a discipline. American National Assessment of Educational Progress (NAEP) (2005) defines conceptual understanding as “a suggestion of what students should learn … and be assessed on … how to apply efficiency in the design and execution of scientific investigations and in practical reasoning” (p. 16). Learners need to develop the scientific skills crucial for them to be able to think critically and reason scientifically when conducting an investigation (Osborne, Erduran, & Simon, 2004). Such activities should allow learners to shift from error-laden but personally relevant conceptions, toward broader, deeper, and more coherent conceptions of scientific phenomena (Hewson, 1992; Strike & Posner, 1992; Tobin, 1993). The mastery of basic science concepts can best be demonstrated by a learner’s ability to use information to conduct a scientific investigation, or to engage in practical reasoning (NAEP, 2005). Some areas of conceptual understanding which are regarded as optimal and essential in the science assessment measures of science concepts involve a variety of forms of information, according to NAEP (2005), these are:

- facts and events learned from science instruction and through experiences with the natural environment;
- scientific concepts, principles, laws, and theories that scientists use to explain and predict observations of the natural world;
- information about procedures for conducting scientific inquiries;
- procedures for the application of scientific knowledge in the engagement of practical tasks;
- procedures about the nature, history, and philosophy of science; and
- types of interaction between and among science, technology and society (p. 34).

For these reasons, the goal of school science is to engender conceptual understanding. Learners should therefore acquire information in ways that enable efficient application in the design and execution of scientific investigations and in practical reasoning; and it is acknowledged that the emphasis should be shifted from the richness of experience to a reasonable scientific interpretation of observations. This should be done in accordance with how well reasoned an interpretation learners present, and not whether it reflects the most sophisticated scientific reasoning (NAEP, 2005).

Conceptual understanding addresses teaching challenges such as, how to help learners to advance in science concepts. In fact, teaching science for conceptual understanding creates an innovative approach in learners. According to Hewson (1992), an innovative approach helps learners to use constructivist learning theory to respond to various misconceptions which can be difficult to change. Teaching science for conceptual understanding should increasingly be concerned with the congruence of learners' interpretations. If conceptual understanding is developed maximally, learners understanding could shift from alternative to accepted scientific interpretations, as well as to the sophisticated reasoning where learners could progress from observations of the natural world to more and deeper explanations and predictions of science phenomena. In a similar view, Costu, Ayas, Niaz, Ünal, and Calik (2007) conducted research in Turkey and Venezuela, and found that learners lacked conceptual understanding in science education. This study shows that learners struggled to become active participants in the learning context, assuming instead a more passive state of being "an empty cup that needs to be filled" (Costu, Ayas, Niaz, Ünal, & Calik, 2007,

p. 525). Therefore, incorporation of applications when learning science concepts is relevant to learners' daily lives (Haney, Czerniak, & Lumpe, 1996).

Moreover, science teachers themselves should understand the science concepts being investigated in order to assist learners through the process of conceptual understanding (Perkins, 1993). This conforms to Haney, Czerniak, and Lumpe (1996) views who state that science teachers should teach the concepts needed for the higher order thinking capacity and processing skills that foster conceptual understanding amongst the learners.

2.4 Uses and importance of a concept mapping in science teaching

The most common uses of concept maps fall under three basic categories, namely: brainstorming, study aid and instructional tool. *Brainstorming* supports the importance of generating ideas (Prediger, 2008). For example, the teacher will use flash cards (various sizes) written concepts such as solid, liquid, gas, wood and water. Some cards contain linking words such as *is a type of* and *has a property of*. Then learners will be asked to place them in a meaningful order. The *study aid* facilitates the effectiveness of newly taught concepts and leads itself to reflective thinking (Young, 2009). For example, the teacher will check how learners categorised concepts for clear explanation. It helps learners' discovery of the meaningful relationship among concepts and connections between concepts, rather than memorisation of facts. The *instructional tool* serves as visual aid to demonstrate complex relationships and to assess learners' understanding of concepts (Safdar et al., 2012).

Elhelou (1997) conducted a study on the use of concept mapping in learning science with Arab learners. The study found that Arab learners in the experimental class achieved better results than those of the control class. Elhelou (1997) also revealed that concept mapping is more flexible to use and it allows teachers to express their subjects' knowledge boarder and present topics in a simplicity way (Rollnick, Mundalamo, & Booth, 2012; Wilson, 1996). A study conducted by Cantú et al. (2004) found that concept mapping allows learners and teachers to engage in extended science discourses, organise and structure their subjects' knowledge.

2.5 Science pedagogy in relation to scientific concepts

According to Duit and Treagust (1998), science pedagogy involves a systematic presentation of science facts, ideas, skills, and techniques which are used by learners in their daily lives. Generally, people learn new knowledge through investigation and the use of appropriate cultural tools such as semiotics, graphs, pictures and symbols. In this way the process stimulates a way of synthesising, comparing new discoveries with existing knowledge, and predicting how things will behave in the universe (Hartmann-Petersen, Gerrans, & Hartmann-Petersen, 2004). Therefore, using concept mapping properly in science pedagogy could create opportunities for learners to assimilate and accommodate science concepts.

2.6 Exposing learners to scientific concepts

Science is observed and experienced in everyday life and scientific knowledge and skills are, therefore, required in order to scientifically discover and explore the natural phenomena. It is through exposure to the natural environment that learners acquire knowledge and skills of the natural environment. In fact, learners' knowledge of the natural environment start to increase alongside increased exposure to natural environment. Eshach and Fried (2005) are of the assumption that there is a need to expose children to natural environment. They further reasoned that:

- children naturally enjoy observing and thinking about nature;
- exposing learners to science develops positive attitudes towards science;
- early exposure to scientific phenomena leads to better understanding of scientific concepts later studied in a formal way;
- the use of informed scientific language at an early age influences the eventual development of scientific concepts;
- children can understand scientific concepts and reason scientifically; and
- science is an efficient means for developing scientific thinking (p. 319).

The advantages lie not only in the exposure of learners to the natural world, but also in the exposure to a world constructed by human beings, in which learners observe many objects of fascination and objects to which they apply their scientific understanding. Such information leads to the formation of deep reservoirs of science materials which may gradually become organised into adequate science concepts (Lee, 1992). Furthermore, Lee (1992) argues that children may be in danger of losing interest and a sense of speculation and, in order to avoid this, science teachers are required to nourish learners and expose them to teaching and learning environment in which they would better understand scientific concepts. Thus, exploration of science activities could be used in order to guide learners to the eventual formation of scientific concepts (Galili & Hazan, 2000; Eshach & Fried, 2005).

As alluded above, exploration activities are important in science teaching. Concept mapping could be used as teaching and learning tool in order to expose learners to the natural environment where science is observed and experienced in our daily life. Concept mapping could be used to expose learners to a variety of science concepts as observed and identified in the natural environment. Such activities could allow learners to observe, identify and categories things as is they are in the natural environment. Therefore, the use of concept mapping during class activities could open doors for learners to be equipped with a sense of speculation (So, 2003). In other words, exposing learners to science concepts at an early age may enhance their motivation, further their natural interest and instil positive attitudes towards science.

2.7 Teaching science concepts for conceptual understanding

Conceptual understanding is a sensible word to use, and is described in reference to how teachers and learners settle in handling scientific knowledge (Biddulph & Osborne, 1984). For example, learners normally change their conceptual understanding through reflection by using a variety of strategies including concept mapping (Mwakapenda, 2004). For example, in science teaching, the role of science teachers is to work alongside learners in order to re-shape, expand, apply, and build on what learners already know (Wang & Lin, 2008). It becomes important for science teachers to play a pivotal role in teaching science concepts in order to mediate and transform learners' conceptual understanding. Wang and Lin (2008) outline the following as the critical roles of science teachers in the transformation of learners' understanding of science concepts. These are:

- to help learners to understand the basic principles, concepts, and theories of science;
- to help learners to understand the nature of science;
- to provide learners with the process of learning scientific concepts and researching skills within all the science disciplines;
- to promote an open-minded, rigorous attitude towards science in learners;
- to help learners to understand the inter-relationship between all science related disciplines; and
- to demonstrate applications of science and technology in daily life and society (pp. 462 – 463).

There is, therefore, need for teachers to collaborate in developing scientific understanding, thus, assisting learners to construct their understanding of science concepts. Science teachers should, hence, first understand how to best support and encourage learners in learning science before learners engage in such activities (Crawford, 2007). Teachers should facilitate learning by providing opportunities which encourages learners to interact with each other and – which would be effective in promoting conceptual understanding in science (Costu et al., 2007). Science teachers should, therefore, assist learners to explore and make sense of science concepts thereby forming a network that transforms learners' knowledge, skills and ideas within, and across, all disciplines of science pedagogy (Davis, 2003).

On the other hand, science teachers should keep in mind that 'conceptual understanding' is demonstrated when learners create their own relational structures that reflect upon the taught science concept and refers to the changes in thinking that result from discussing ideas in a science context (Prawat, 1996). Moreover, several studies (Guba & Lincoln, 1989; Lincoln & Guba, 1985; Osborne, 1996; Wang & Lin, 2008) describe the wider sets of teaching practices which are likely to promote learners' understanding of science concepts. One such strategy that could be used to explore learners' conceptual understanding in science teaching is the concept mapping stategy. Concept mapping has the power to visualize and transform science concepts in an understandable manner as well as making science concepts more accessible to learners (Roth, 1995). Therefore, concept mapping seem to be the tool that could be used in teaching and learning environment to promote classroom discussions as well as to enhance learners' learning of science concepts (Mwakapenda, 2004).

2.8 Conclusions

This chapter presented a review of the literature on the theoretical framework by Ausubel's Assimilation Theory (AAT) of cognitive and meaningful learning, Conceptual Change Framework (CCF) and ED^3U models for conceptual understanding, science teaching for conceptual change; science teaching for conceptual change, uses and importance of concept mapping, science pedagogy in relation to scientific concepts, importance of exposing learners to scientific concepts, and teaching science concepts for conceptual understanding. The literature discusses the importance of concept mapping and its application in science teaching in enhancing learners' conceptual understanding as compared to traditional teaching methods of rote learning.

The next chapter will discuss the research methodologies and procedures used to collect data for the current study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter provides a brief description of methods and procedures used and followed to collect data in this study as well as strategies used in analysing data such as the research design, population and sample, sampling procedure, research instruments, data collection procedure, data analysis and research ethics.

3.2 Research design

Research design is a plan or the structure that researchers use during investigation (McMillan & Schumacher, 1989; 2010) in order to facilitate the most valid and accurate possible answers to research questions. In this study, both the qualitative and quantitative research methods were used.

Qualitative approach was used to collect primarily descriptive narrative as well as to probe deeply and gain a clear understanding of "matter and its properties" during investigations (Gay, Mills, & Airasian, 2011). In this regard, a case study design was used to explore science teachers' understanding of concept mapping teaching strategy. According to Creswell (2012), a case study research is "an in-depth exploration of a bounded system (e.g., activity, event, process or individuals) based on extensive data collection" (p. 465). In addition, a case study involves the conceptualization of a research problem, the investigation, interpretation of findings and their application in the world beyond the study (Cohen, Manion, & Morrison, 2007; Leedy & Ormrod, 2005).

In this study, the researcher employed a case study because he wanted to explore in-depth how Grade six Natural Science teachers understand and use concept mapping as a strategy for meaningful teaching and learning of science concepts. As a case study, the data collected from each school were presented and analysed as a single case study. Then, the results were compared and discussed as a multiple case studies in terms of learners' outcomes (McMillan & Schumacher, 2010).

A case study is a strategy of inquiry in which the researcher explores in depth about a program, event, activity and/or process of one or more individuals (Creswell, 2007). A case study design was appropriate to use here because the research was conducted at two schools to gather information about the teachers' understanding of concept mapping as well as to understand opinions about concept mapping (Cohen, Manion, & Morrison, 2002).

Case study has advantages and disadvantages. The advantages of a case study among others are that: it is able to deal with a variety of evidence collected from documents, interviews and observations; it observes effects in real context, recognising that context as a powerful determinant of both causes and effects; and it also allows a lot of detail to be collected and produce richer and greater depth that would not normally be easily obtained by other research and/or experimental designs (Cohen et al. 2007; Creswell, 2004).

However, there are some disadvantages as noted by Denzin and Lincoln (2000). Researchers should watch on being subjective or being bias in gathering and analysing data. For example, researcher might push their viewpoints on data in the way they think that the data might mean and by so doing they do not actually let the data talk to them freely. Therefore, it is important for researchers to guard against potential biasness and limit their biasness in order to ensure the essence of live experiences of the participants and be able to capture such experiences as portrayed in natural settings (Lincoln & Guba, 1994).

The researcher was aware of not being involved in biasness activities and not being subjective during the research process. Therefore, he also constantly remained objective during the data collection and data analysis processes. The researcher was an active participant during data collection, particularly in the teaching process in order to get involved with the learners physically, collect the desired and reality data, and to avoid the outsiders who might contaminate the data and influence the expected outcomes. Being an active participant, the researcher presented the lessons on “matter and its properties” to both schools using traditional lecture and concept mapping methods; actively involved with learners in teaching and learning process while observing their participations; administered and marked learners’ pre-test and post-test; captured and documented teachers and schools’ background information; and took field notes during the interviews with teachers. For validity purpose, the researcher did cross-checking of many of his doubts, prejudices and expectations (Rajendran, 2001) to avoid personal influence and biases in the study. In addition, the researcher used the research assistant to help him during data collection process.

A research assistant seemed to be an ambitious and self-motivated young lady who completed her Grade 12 in 2011. She is currently upgrading her results in Mathematics and Biology through the Namibia College of Open Learning (NAMCOL). She did computer literacy in school from Grade 8 and she is 22 years old. Due to her background knowledge of technology, it only took the researcher two days to train her on how to operate the video recorder and capture quality video pictures during the entire treatment period at both schools. The assistant was trained for two days by focusing on class activities that took place during instruction and she needed strongly avoid being tempted to focus on unnecessary events rather than the main aim of instruction.

A quantitative research approach in particular, quasi-experimental was used to collect numerical data (Creswell, 2012; 2014) and to find out whether concept mapping could be used to enhance learners' understanding or not. The two variables that were studied in quantitative approach were the traditional lecture and the concept mapping strategies. Quasi-experimental design is a design that does not meet all requirements necessary for controlling influences of irrelevant variables (Moore, 2008). According to Gay, Mills and Airasian (2011), a quasi-experiment is an empirical study that is used to estimate the causal impact of an intervention on its target population. Quasi-experiment also allowed the researcher to control the assignment to the treatment condition using some criterion other than random assignment (Creswell, 2012, Moore, 2008). In quasi-experimental design, the researcher assigns two selected groups (experimental and control), administer a pre-test to both groups, conducts experimental treatment activities with experimental group only, and then administers a post-test to both groups to assess the differences between the two groups (Cohen et al. 2007; Creswell, 2012).

Therefore, this study is a quasi-experimental in nature because it assessed the uses of concept mapping in improving learners' understanding of science concepts as compared to traditional method of teaching. Learners at Omega Primary School were exposed to treatment (concept mapping) whereas learners at Alpha Primary School were given a normal teaching (traditional lecture). In short, this study administered pre-tests (at both schools), conduct a treatment (at one school), then post-tests (at both schools). Thereafter, the differences of means scores between the two groups of learners were determined.

Quasi-experimental design has advantages and disadvantages. The advantages are that: it is a valuable tool that the researcher has control over assignment to treatment condition; it does not allow anyone to make final causal link between the treatment condition and observed outcomes; it can also provide necessary and valuable information that cannot be obtained by other experimental methods alone; and it minimises the threats to external validity as the natural environments do not suffer the same problems of artificiality as compared to a well-controlled setting (Creswell, 2012; Moore, 2008; Over, 2011). The disadvantages are that: it lacks the element of random assignment of participants to treatment or control group and this may allow the study to be more feasible, but this also poses many challenges for the researcher in terms of internal validity that might provide weaker evidence; and due to lack of randomness, it brought less useful information to the study because it narrows the results and therefore it gives a poor representation of the population as a whole (Creswell, 2012; Moore, 2008; Over, 2011).

3.3 Population and sample

A purposeful sampling was used to select the participants. Cohen, Manion, and Morrison (2007) state that purposeful sampling "is used in order to access knowledgeable people who have in-depth knowledge about particular issues…" (p. 115). They concur with Creswell (2012) who says in purposeful sampling, the "researcher intentionally selects individuals and sites to learn or understand the central phenomenon" (p. 206). Three schools were used from the population of 45 public primary schools in the Khomas Educational Region. One of the three schools was used for piloting instruments whilst the other two schools were used in order to collect data for the main study. At each school, one teacher participated in the study; that means, one Grade six Natural Science teacher with his class that he was teaching was selected for the study. The targeted schools were given pseudonym names as Alpha Primary School and Omega Primary School with a class of 33 and 37 learners respectively. In the same vain, the piloting school was also given a pseudonym name as Middle-Class Primary School with 31 learners.

3.3.1 *Schools' profiles*

3.3.1.1 Alpha Primary School

Alpha Primary School is an old school that was established during the apartheid era in early 1969 and it is about 44 years old at the time of data collection. There are 38 teachers altogether including the principal and four Heads of Department (HODs).There are approximately 1005 learners, with close to 27 classrooms ranging from Pre-primary to Grade seven. In addition to the teaching staff, there are two secretaries and four institutional workers. Figure 3.1 below portrays Alpha Primary School.

Figure 3.1: Alpha Primary School as seen from outside

Unfortunately, the school does not have a science laboratory or science kits / equipments to enable learners do science practical work but it has a library and computer laboratory. Besides Internet as a source of information, each learner was in possession of Natural Science textbook as a teaching aid.

3.3.1.2 Omega Primary School

Omega Primary School one of the oldest school in the country that was established in early 1956. It is about 56 years old at the time of data collection. There are 25 teachers altogether including the principal and two HODs and about 635 learners, with close to 25 classrooms including three storerooms. Classrooms ranged from Pre-primary to Grade seven. In addition to the teaching staff, there is one secretary and two institutional workers. Omega Primary School is allocated in the same circuit with Alpha Primary School. Figure 3.2 below portrays Omega Primary School.

Figure 3.2: Omega Primary School as seen from outside

Omega Primary School is an old school but it still does not have a science laboratory. However, the school only has a science kit that it received from the Ministry of Education to enable learners do science practical work. The science kit consisted of equipments such as blue litmus papers; battery holders; wood cuboids; metal cuboids; rubber bands; magnification glass; magnet; full circuit equipment. Apart from the science kit, the school has a library and computer laboratory. Computers at Omega Primary School are also connected to the Internet to allow some teachers and learners to access relevant science information. Each learner had a Natural Science textbook as another source of information and teaching aid.

According to the National Standardise Achievement Tests' (NSATs) report of 2009, 2011 and 2013 in English in Namibia primary schools, Mathematics and Natural Science, learners at Omega Primary School always perform higher than Alpha Primary School learners (Ministry of Education, 2013).

3.3.1.3 Middle-Class Primary School

Middle-Class Primary School is a new school that was established after independence in mid 2001. The school opened its doors with Grade one, two and three only. In 2002, Grades four to Grade six were introduced while Grade seven was commenced in 2003. In 2004, the school had only a principal, two HODs, one secretary and three institutional workers. Now there are 46 teachers altogether including the principal and four Heads of Department (HODs) and approximately 1545 learners. It has close to 35 classrooms ranging from Pre-primary to Grade seven. In addition to the teaching staff, there are presently two secretaries, four institutional workers and one computer technician who is also a computer instructor. Middle-Class Primary School is also allocated in the same circuit with Alpha Primary School and Omega Primary School. Figure 3.3 below portrays Middle-Class Primary School.

Figure 3.3: Middle-Class Primary School as seen from outside

Unfortunately, Middle-Class Primary School does not have a science laboratory and enough Natural Science textbooks as another source of information and teaching aid but fortunately it has a library and computer laboratory. Computers in the laboratory are not connected to the Internet but only the computers in the staffroom that used by the teachers. Some teachers use Internet to access relevant science information. The secretaries' computers were also connected to the Internet.

3.3.2 Teachers' profiles

As described under the section on population, the sample consisted of two primary school science teachers for the main study and one primary school science teacher for the piloting school. The researcher used pseudonym names in order to protect the teachers.

3.3.2.1 Teacher 1: Mr Golden

Mr Golden is 30 years old. He is a qualified teacher and holds a Basic Education Teachers Diploma (BETD) of former colleges of education in Namibia. He taught for approximately six years at Alpha Primary school. He is has been teaching Natural Science to Grade six at Alpha Primary School since 2009. In addition to Natural Science, Mr Golden is also teaching Mathematics to Grade six, both which are promotion subjects.

Mr Golden appears to be an open-minded person when it comes to discussions. During our interview, he told me that he prefers to teach in a learner-centred arranged classroom that allows him to interact easily with learners during the teaching process. My first day entering in Mr Golden's class, he was teaching learners Natural Science using teacher-centred approach.

3.3.2.2 Teacher 2: Mr Silveren

Mr Silveren is 33 years old. He is a qualified teacher and holds a Basic Education Teachers Diploma (BETD) and Advanced Certificate in Education (ACE). Mr Silveren obtained his first diploma from the same college of education where Mr Golden was trained and Mr Silveren taught for approximately eight years at Omega Primary School. He has been teaching Natural Science to Grade six at Omega Primary School since 2008. In addition to Natural Science, Mr Silveren is also teaching Social Studies to Grade six, both subjects are promotion subjects.

Mr Silveren is a friendly and broad-minded teacher who seems not to tolerate nonsense when it comes to learners' discipline. Mr Silveren was using teacher-centred method besides his classroom's arrangements that portray learner-centred.

3.3.2.3 Teacher 3: Ms Bronzen

Ms Bronzen is 37 years old. She is a qualified teacher and holds two teaching diplomas: a Basic Education Teachers Diploma (BETD) and Diploma in Education from the former colleges of education in Namibia and Belveder Technical Teachers' College in Zimbabwe respectively. She has approximately ten years of teaching experience and she taught about five years at Middle-Class Primary school. She has been a science teacher and she has been teaching Natural Science to Grade six at Middle-Class Primary School since 2009. In addition to Natural Science, Ms Bronzen is also teaching Mathematics to Grade five and seven and both subjects are promotion subjects.

Ms Bronzen is a bit tall with a skinny body and a friendly lady. In addition, Ms Bronzen appears to be an out-spoken and open-minded person when it comes to discussions and she seems not to tolerate undisciplined learners. During our interview, she articulated to me that she taught her classes using both learner-centred and teacher-centred approaches. Apparently, her teaching approach depends merely on the topic that she teaches and the number of learners in the classes. Like Mr Silveren, Ms Bronzen was using the teacher-centred approach besides her classroom's arrangements that portray learner-centred arrangement.

3.4 Sampling procedure

The researcher used the following criteria to select the schools and teachers: (a) the schools must not be adjacent to one another in order to reduce the possibilities of learners communicating to one another about how the teacher is instructing them and, thus, contamination of data; (b) the schools must be in the same circuit within the selected educational region; and be kept confidential in order to keep the homogeneity of the groups as far as possible as well as to prevent teachers and learners to communicate to one another for consistency purposefully; (c) the schools must have internet connections to enable teachers to access information as part of teaching aids and must have a resourced library; and (d) teachers must have at least five years teaching experience.

Permission to conduct this study at the two schools was sought and granted by the Ministry of Education and the two schools' principals. After having been granted permission, the researcher approached the two Natural Science teachers and explained to them the purpose of the study and procedures involved. After the teachers' expression of their willingness to participate, the researcher was shown the classes, given the timetables, textbooks and syllabuses. Thereafter, the timeframe for the interviews, teaching practices and administering of tests were arranged

3.5 Research instruments

The researcher used the pre-test and post-test, interviews and video recorder to collect data. Multiple research instruments are, generally, considered to be superior as multiple instruments allow for data triangulation. They are more likely to capture complex, multifaceted aspects information during investigations (Kagan, 1990). Triangulation is a technique that attempts to arrive at the same findings by using at least independent different research instruments or multiple case studies. In addition, triangulation tends to improve trustworthiness of the research findings (Schwandt, 2007). The researcher used triangulation to ensure validity and reliability of the data obtained through the tests and interviews questions. These questions were similar in intent, structure and format but yielded different results. The researcher also used triangulation to re-play back the video recorder and re-read again the tests' scripts as much as possible to look for commonalities and differences within the collected data in the two case studies of Alpha Primary School and Omega Primary School.

3.5.1 Pre- and post-tests

The pre-test and post-test were used to collect data from the learners in order to assess their understanding of science concepts on "matter and its properties" after being exposed to science content by using two different teaching strategies, namely the traditional lecture and the concept mapping teaching strategies. The tests were used to collect data as an indirect method of finding out about the use of the concept mapping teaching strategy in teaching and learning science concepts. Learners were given a pre-test, followed by treatment lectures for about two weeks, followed by a post-test. Table 1 below shows the scheme of work for twelve days that the researcher spent at the two main schools during data collection. This scheme of work was adapted from the one that the researcher used at the piloting school except the date change.

Table 1: Scheme of work for twelve days spent during data collection

SCHEME OF WORK **Subject:** Natural Science			**Grade:** 6
Date	**Theme:** Matter	**Topics:** Properties of matter	**Basic Competencies**
Day 1 28.09.13	Researcher introduced himself and explained the purpose of the study to the participants and gave them an informed consent forms to sign as an agreement. The researcher received the timetables and teaching materials such as syllabi and textbooks. He arranged the day and time for interviews and he also informed the learners about the pre-test, treatments and post-tests.		• Analyse everyday materials in their local environment to establish properties and uses of the materials. • Collect and classify different types of plastic, paper, glass, wood, fabric and metal. • Identify and compare properties (such as hardness, texture, colour, lustre, flexibility, smell, brittleness and malleability) of paper, glass, cotton, plastic, wood, and metal.
Day 2 29.09.13	**Lesson 1:** Conducted the interviews with teachers and administered the pre-tests to the learners.		
Day 3 30.09.13	**Lesson 2:** Introduced "matter and properties" to the learners and its states/phases: solid, liquid and gas and gave practical examples to each state/phase by making use of everyday materials like wood, water, balloon, smoke, ice cubes, stones, perfume bottle etc.		
Day 4 01.10.13	**Lesson 3:** Explained and compared the properties of matter in terms of particles and discussed the uses of local materials used.		
Day 5 02.10.13	**Lesson 4:** Explained and discussed matter and its properties in terms of concepts such as evaporation, condensation, freezing point (0°C), melting and boiling point (100°C).		

Day 6 03.10.13	**Lesson 5:** Explained and discussed matter and its properties in terms of concepts such as steam, water vapour, deposition, sublimation, energy absorbed and energy released.	
Day 7 04.10.13	**Lesson 6:** Differentiated between physical change and chemical change in terms of matter and its properties and provided examples to each type of change.	
Day 8 07.10.13	**Lesson 7:** Used materials such as paper, glass, plastic, wood and metal so that learners can identify and compare the properties of matter in terms of hardness, texture, colour, lustre, flexibility, smell, brittleness and malleability.	
Day 9 08.10.13	**Lesson 8:** Learners wrote the summary on what is matter, states/phases of matter and examples on each, particles (drawings) of matter with explanations and examples of each state/phase.	
Day 10 09.10.13	**Lesson 9:** Learners wrote the summary on concepts such as melting, boiling, freezing, sublimation, deposition, condensation, evaporation, physical change and chemical change.	
Day 11 10.10.13	**Lesson 10:** Administered the pre-tests to the learners.	
Day 12 11.10.13	Discussed the results of the pre-tests and post-tests with the learners and thanked them for their participations and immerse contributions.	

A forty-four multiple choice questions and six structured questions for pre- and post-tests were drafted and pilot tested at a school within the same educational circuit in order to check the questions' validity and reliability (Creswell, 2012; Gay, Mills, & Airasian, 2009; Gay, et al., 2011). At the piloting school, the researcher administered a pre-test to two classes, then taught "matter and its properties" to the two classes. The researcher taught one class used traditional lecture method and concept mapping to another class. After nine days of teaching, he administered a post-test to the learners.

The main reason behind piloting the study was to check the questions' validity and the piloting process took about two weeks to be completed. As a result, the pre-test item 2, 15 and 21 on multiple questions were found to be not well structured. On the pre-test structured questions, there were no arrows indicated and learners found it hard to understand what was expected from them. The researcher had to re-structure the mentioned questions to enable them to collect the required data in the main study.

For the main study, half of the multiple choice questions were used for the pre-test and another half of the drafted multiple choice questions were used for the post-test, that is, 22 questions for the pre-test and 22 questions for the post-test focused on evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy. The six structured questions contained 22 science concepts and these are evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy on "matter and its properties" and again half of the science concepts were used for the pre-test and another half for the post-test. That means 11 science concepts (evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy) were used for each test. The test questions were structured in such a way that they focused on the same concept for both the pre- and post-test.

However, the pre-test and post-test questions were not exactly the same but both tested learners on same science concepts about "matter and its properties". Both multiple choice and structured questions were compiled by the researcher based on "matter and its properties". Some pictures and sketches used in the questions were taken from the

Natural Science textbook and Internet. Table 2 below illustrates how the pre- and post-test items were set-up and spread across the eleven concepts.

Table 2: Pre- and post-test items spread across the concepts (A)

Concepts	Pre-test item	Post-test item
Evaporation	1	20
Condensation	9	12 & 17
Boiling	1 & 8	3, 7, 10, 18 & 21
Deposition	2	19
Steam	3, 5, 11, 18 & 20	1
Water	16	8
Ice	10, 12, 15, 19 & 21	6, 9 &16
Sublimation	7 & 22	22
Melting	6	11
Freezing	4 & 17	2 & 5
Energy	13 & 14	4, 13, 14 & 15

At both schools, the pre-tests and post-tests were administered in the classrooms where the treatment took place. The pre-test was administered to learners at both schools at the same time, on the same day. A researcher assistant invigilated at Alpha primary school while the researcher invigilated at Omega primary school. Each test paper (pre- and post-test) consisted of two sections (multiple choice and structured questions) and it took learners approximately 45 minutes to complete.

3.5.2 Interviews

The researcher used the semi-structured interview schedules to collect data from the science teachers in order to determine their understanding of concept mapping in teaching science. Cohen et al. (2007) define interview as "a two-person conversation initiated by the interviewer for the specific purpose of obtaining research relevant information" (p. 351). The purpose of such an interview is to allow researchers to "enter into another person's perspectives" (Patton, 2002, p. 341) with the view of obtaining relevant information as seen from that particular person's viewpoint.

The semi-structured interview schedules was used to conduct an individual face-to-face interview (Creswell, 2003) with the selected science teachers with the purpose of determining their understanding of the concept mapping teaching strategy. The interview guide questions (See appendix 12) were first piloted before the main study. During the piloting period, the researcher informed the participants about the purpose of the study and sought their permission which was granted. Then, the teacher-participant was interviewed to determine the validity of the questions. The interview questions were found to be relevant and no amendment was done.

The interview guide consisted of five open-ended questions and it was conducted within the first week of the study during break time with Mr Golden and after school with Mr Silveren. Each teacher was interviewed once for 10-15 minutes. Due to the sensitivity of the video recorder and to avoid outside distractions, the researcher conducted interviews with the participants in their Heads of Department's offices.

During the interviews, the researcher was handling the video recorder simply because the research assistant was handling the pre-test process at Alpha Primary School. The permissions to video record the interviews were given by the two participants.

3.5.3 A video recorder

A video recorder was used to capture the face-to-face interviews and the instructions/ teachings. The research assistant was trained by the researcher on how to operate the video recorder. She was also oriented on how to capture quality video sounds and pictures during the entire teaching practices at both schools. The research assistant was trained for two days before piloting the interviews' instrument.

A video recorder was used to capture the interviews sessions with the permission of the teachers involved (Jorde, 2002). According to Jackson (2000) a video recorder allows the researchers to "record the nonverbal behaviour of the participants" (p. 5).

To maintain validity and trustworthiness of the study, the researcher played and listened to the whole video recordings many times to familiarise, validate and comprehend what was said by the participants in the interview sessions. Thereafter, the researcher transcribed the whole interview taking into consideration part of the interview that had pauses and inaudible parts. The researcher managed to transcribe and describe the interviews in detail so that the readers would "draw their own conclusions from the data presented" (Leedy & Ormrod, 2005, p. 100).

3.5.4 Treatment

The treatment was offered in a way of instruction and focused on science concepts about 'matter and its properties'. Two types of lessons were prepared each day in advance, one as a traditional lecture and another lesson that involved the use of concept mapping. The traditional lectures were offered at Alpha Primary School while the concept mapping lessons were offered at Omega Primary School. In this case, the researcher presented lessons used concept mapping as treatment or an intervention while traditional lecture method was used as a normal daily lecture. During the treatment, learners were exposed to concept mapping on which they were taught and wrote the summary using concept mapping and both lessons were offered over, about, two weeks. Both groups were pre-tested and post-tested using the same test on both occasions.

3.6 Data collection procedure

The data collection commenced immediately after permission was granted (approval) from the Ministry of Education, principals, teachers and learners. Creswell (2012) urges that "permission is often necessary before you can enter a site and collect data" (p. 147). The participants were given the informed consent form to sign as an agreement. Informed consent is defined by Cohen et al. (2007) as "the procedures in which individuals choose whether or not to participate in an investigation" (p. 52). The researcher made further arrangements concerning the teaching timetable, teaching materials such as syllabus and textbooks including the day and time for the interviews.

Learners were also notified in advance when they were expected to write the pre- and post-tests.

Firstly, teachers' interviews were conducted a day before the teaching and administration of the pre-test to learners. Secondly, the pre-test was administered to learners at both schools at the same time, on the same day before starting with instruction about 'matter and its properties'. The researcher made use of the research assistant who invigilated at one school while the researcher invigilated at another school. Thirdly, ten lessons (one lesson per day) were conducted on science "matter and its properties" for two weeks. Each lesson took approximately 45 minutes. As an active participant, the researcher conducted the lessons at the two schools, that is, one period of traditional lecture and a concept mapping lesson per day per school for two weeks.

Fourthly, after the teaching was completed, the post-test was administered at both schools at the same time. The data collection process took the researcher about two weeks to finish. The twelve days of data collection included ten lessons (one lesson per day and two days of administering the tests) both focused on "matter and its properties", one day of introduction and one day of discussing the practice and tests' results (See Table 1).

3.7 Data analysis

Data analysis is a process of making sense and meanings of the raw data as well as interpreting data (Cohen et al., 2007; Gay et al., 2009). Two types of data were gathered, namely (i) qualitative data through interviews and (ii) quantitative data through pre- and post-test.

3.7.1 Pre- and post-tests

The pre- and post-tests scores were analysed in order to determine the t-test value at alpha level = 0.05. The data of both pre- and post-tests were analysed to find the mean (M) scores and t-values the two groups (schools) separately. The p and t values were determined on both scores (pre- and post-test) to determine differences between the means of the two groups. The results were analysed per case site. Then the researcher compared the two groups in terms of the outcomes of the results (McMillan & Schumacher, 2010).

3.7.2 Interviews

The researcher transcribed the interviews verbatim and returned the transcribed papers to the teachers to verify the written version of what they had said in order to establish the trustworthiness of the data (Creswell, 2012). During the analysis process, the researcher perused through all the transcripts and made notes on the interview transcribed papers. The researcher read through the transcribed data carefully again and again, line by line in order to code the data by labelling relevant words, phrases, sentences, concepts and opinions before organising them into themes, then broke down the themes into categories. Finally, the researcher synthesised and searched for patterns of similarities and differences within the identified categories (Cohen et al., 2007).

3.8 Research ethics

The researcher sought permission to conduct the study from the Permanent Secretary and the office of the Khomas Education Director, schools' principals, teachers and learners. The researcher explained the nature of the study to both parties and they were ensured that the information provided was for study purposes only. The researcher also obtained informed consent from the participants for further reference.

Furthermore, the participants were informed that their participation was a free will exercise (Creswell, 2012). Participants' personal information would be kept confidential and no real names of the schools, teachers and learners would be used to ensure that the dignity and integrity of the participants were protected (Gay et al., 2011). Despite the photos inserted, the permission to take photos and publish them was granted by the participants. The researcher maintained the well-being of the participants and built trust between the participants him and. There were no risks foreseen, unpleasant or damaging effects on the individual, the team and the setting (workplace) involved. The participants were informed of the expected outcomes, and there was no compensation involved during the study. Scherman (2007) states that "in any research project the researcher has a responsibility not to act unethically" (p. 57).

3.9 Conclusions

In this chapter, the researcher explained the research designs, population, sample, sampling procedures and research instrument used in the study. The background and biographical information of the schools and teachers who were included in the study were described in details. The data collection procedure was also discussed followed by the data analysis and the research ethics. The next chapter presents the findings and discussions of the study.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter is divided into two main sections in line with the research questions of the study. The results are presented, analysed and discussed according to the two main research questions as indicated above, starting with the first research question and then the second question:

1. How do Grade six Natural Science teachers understand and use concept mapping?
2. Is there a significant difference between learners' understanding on "matter and its properties" taught through concept mapping as compared to the learners taught through the traditional lecture method?

4.2 Research question one: How do Grade six Natural Science teachers understand and use concept mapping?

In presenting the above research question, the researcher interviewed primary school teachers who were teaching the Integrated Natural Science subject at two urban schools. The interview consisted of five open-ended items in order to explore how Natural Science teachers understand the concept mapping as a teaching method. The interview schedule consisted of five open-ended items in order to explore the understanding the concept mapping as a method of teaching by Natural Science teachers. The five open-ended items of the interview schedule are as follows:

1. *Have you ever come across the word "concept mapping"? If yes, when? What was the concept map all about? In your own words, can you describe what a concept map is all about?*
2. *Have you ever tried to make use of concept mapping in your teaching? If yes, what content did you teach?*
3. *Can you describe to me how you use the concept mapping strategy during that instruction?*
4. *To what extent did you use concept mapping strategy in teaching science? Is it poor, adequate, good, very good or excellent?*
5. *Did your studies or professional development courses prepare you to teach using concept mapping?*

A total of two male teachers were interviewed one-to-one separately at a quiet place during school hours during their free timeslots. Mr Golden taught at Alpha Primary School and Mr Silveren taught at Omega Primary School in the Windhoek urban areas. The results are presented as per teacher in order to provide answer to the main research question one. The interview with Mr Golden went as follows:

Researcher: *Have you ever come across the word "concept mapping"?*
Mr Golden: *Yes, I came across it.*
Researcher: *When did you come across it?*
Mr Golden: *When I was trained at the college.*
Researcher: *What is a concept map about then? In your own words, can you describe what a concept map is about?*

Mr Golden:	*Yes, my understanding of it…* (pausing)*; let me take it the way I understand it… It is a diagram, it is a diagram actually that's made to generate ideas…* (pausing)*, generate different ideas. So, it has different lines where you can fill in and obviously at the end you come up with conclusion about the topic that you what to understand. Yes, the ideas normally are…* (pausing) *the way I know it you generate ideas, for example, from the learners that's the ideas according to the topic. So, different learners can come up with different ideas so you fit them on the concept map".*
Researcher:	*Have you ever tried to make use of concept maps in your teaching?*
Mr Golden:	*Yes, I did! Ok.*
Researcher:	*What content did you teach?*
Mr Golden:	*I used it…* (Mr Golden paused) *it on the characteristics of living organisms, normally.*
Researcher:	*Can you describe to me how you used the concept map during that instruction?*
Mr Golden:	*So, I grouped different characteristics of living organisms. But I also used it in other topics… Yes, I tried some but I did not go in detail maybe just a little bit. I never, actually tried to go into details. I only used it more on that topic.*
Researcher:	*To what extent can you understand the concept map in teaching science? Is it poor, adequate, good, very good or excellent?*
Mr Golden:	*Very good, let me say very good.*
Researcher:	*Did your studies or professional development prepare you on how to use concept mapping during instructions?*
Mr Golden:	*I would say… the exposure was not that much… So, on certain topics, but it was not that much.*

Mr Golden seems to have a vague idea about what concept mapping is about and he was unable to provide a clear description of a concept mapping although he acknowledged that he was introduced to concept mapping as a method of instruction during his college education where he was trained as a teacher. Mr Golden's description of concept mapping goes along with Novak and Canas (2008) definition of concept mapping. However, Mr Golden mentioned that a concept map consists of different lines that are completed during teaching. He does not seem to have a deeper understanding of concept mapping. His description does not include any explanation of the relationships that exists between science concepts in different science topics. He seemed to have failed to provide relevant examples in order to illustrate some scientific phenomena amongst certain science concepts or ideas (Prediger, 2008).

When Mr Golden was asked if he was using concept mapping during instruction, he simply provided a science topic without relevant examples on how he used it during instructions. Concept mapping is used in different ways such as to generate new ideas about a particular science concept, to illustrate relationships amongst science concepts, to visualize some abstract concepts in relation to an overegging science concept, to promote meaning making amongst different science concepts including engaging learners in constructive and transformative operations during learning and revising previous concepts taught (Asan, 2007; Safar et al., 2012; Young, 2009; Wang & Lin, 2008). However, Mr Golden mentioned one of the functions of the concept mapping strategy during instruction which is brain-storming in generating innovative ideas about concepts under discussion (Pediger, 2008).

Furthermore, using the concept mapping strategy requires time from the side of the teacher in order to pose constructive questions and to provide useful and relevant answers. It helps the teacher to assess learners' understandings and takes quick decisions on whether the answers are correct or wrong as well as provides information about what was correct. In addition, meaningful connections and relationships of concepts are also important in teaching and needs to be considered when using concept mapping. Teaching science for understanding is more important than teaching science in a vacuum. It makes learners to understand science concepts better and get science ideas more easily when taught through concept mapping than pure lectures (teacher-talk) method. Therefore, concept mapping seems to be more encouraging and recommendable in teaching science than the traditional lecture method. Moreover, learners seemed to remember science concepts easier and in better way when teachers use illustrative and visual teaching aids in stimulating their thinking (Asan, 2007; Novak & Canas, 2008; Safdar et al., 2012). In Mr Golden's case, he didn't go extra miles in his explanation on how he used concept mapping during instruction of living organisms.

Mr Golden said that his exposure to the use of concept mapping at the college during his studies was not that much. It appears that he was only introduced to how to use the concept mapping on certain topics and not in details whilst at the college. If Mr Golden happened to be properly and well trained on how to use concept mapping during his career training, then he would have applied the concept mapping strategy in his daily teaching. Although, Mr Golden was not well exposed to the use of concept mapping at the college, he rated his understanding of concept mapping as "very good" though in a hesitant manner. Mr Golden hardly defined a concept map and could not recall that he was taught at the college on how to use a concept map at all. For Mr Golden to rate himself high while he knew that he did not know much about concept mapping, it remains uncertain as to whether he knows / understands concept mapping. It seems that Mr Golden was trying to deceive and/or lie purposefully to the researcher by making false assertions so that the researcher wouldn't notice that he did not know much about concept mapping. His rating also appeared to impress the researcher and not as to be seen as unqualified, incompetent and unskilled teacher if he happened to be honest and told the truth that he had no much idea about concept mapping or did not apply it in his teachings after his graduation or training.

According to Okebukola and Jegede (1991), science teachers who received training and practice session in concept mapping developed a favourable attitude towards the use of concept mapping. The researcher's opinion is that teachers who were trained and know how to use concept mapping also tend to use it in their daily teaching and learning process (Safdar, cited in Safdar et al., 2012).

The following section presents and discusses the interview with Mr Silveren, the primary school teacher at Omega Primary School.

Researcher: *Have you ever come across the word "concept mapping"?*

Mr Silveren: *Concept map…* (he paused then he said), *aahh… never at all. Not even to use it in my teaching*. After a pause, Mr Silveren said: *yes, concept map… concept map… I use it* (although the researcher was not sure that he knew what he was saying).

Researcher: *When did you come across it?*

Mr Silveren: *Aahh… not remember.*

Researcher: *What was the concept map about? In your own words, can you describe what a concept map is about?*

Mr Silveren: *Concept map… Can you put it in… concept map, is it this…* (illustrating a diagram of the concept map in the air), *no this one we are doing it.*

Researcher: *Have you ever tried to make use of concept maps in your teaching?*

Mr Silveren: *Concept map…, that, that term… yes I did use it.*

Researcher: *What content did you teach?*

Mr Silveren: *I used it in solid, liquid and gas.*

Researcher: *Can you describe to me how you use the concept map during that lesson?*

Mr Silveren: *That concept…* (he then stopped).

Researcher *To what extent can you say you understand concept map in teaching science? Is it poor adequate, good, very good or excellent?*

Mr Silveren: *Very good, let me say very good… because nothing is excellent.* (he laughed) … *very good to excellent* (laughed sarcastically).

Researcher: *Did your studies or professional development courses prepare you on how to use concept maps during instruction?*

Mr Silveren: *It was very excellent because they were preparing us at the very experienced teachers.*

Mr Silveren's understanding of concept mapping was not clear. Simply because he initially responded that he never came across concept mapping strategy and he was unable to remember whether he used concept mapping in his teaching or not. When he was asked to explain the term "concept mapping" in his own words, he struggled. He was trying to get a clue from the researcher when he requested the researcher to put it differently. In Mr Silveren's case, he admitted that he never attempted to use concept mapping in his teachings. One moment he also said that he never came across the term "concept mapping" and on the other hand he proclaim to have used it in solid, liquid and gas although he said it in a sarcastic manner. When he was asked to describe how he used the concept mapping in teaching solid, liquid and gas, he didn't even say a word to respond to the question. Then later, he tried to explain what concept mapping was, by illustrating it in the air and still he was not getting to its meaning. This implies that Mr Silveren appears to have no knowledge and idea of what concept mapping was about.

In addition to the above mentioned information, Mr Silveren rated himself high and to be knowledgeable on how he understood and used concept mapping. He rated himself as to being "*very good*" and even to the extent of "*being excellent*" as well, although he seemed to have a vague understanding of what concept mapping is about. Mr Silveren also said that he was well trained on how to use concept map and that he was prepared to be a good teacher although he said that he never came across the term concept mapping during his education. Mr Silveren said "*it was very excellent because they* (lecturers) *were preparing us*". Still, it remains unclear as to whether to conclude that he was trained during his professional development career. Thus, it implies that he seems neither to know nor to understand what concept mapping is about at all. The fact that some studies at the college prepared him on how to use the concept mapping and ending up not using it is another question on its own.

Mr Silveren's lack of knowledge, ideas and understanding of concept mapping could be seen as a result of not being introduced to the strategy or may be lack of interest in the strategy or even having some difficulties in using the strategy in teaching. Mwakapenda (2003) and Nyambe and Griffiths (2010) noted that lack of understanding is more likely due to the fact that science teachers seem not to implement proper teaching strategies in practice. It seems clearly that Mr Silveren lacked sufficient information and appears to lack knowledge and understanding of concept mapping besides his self-proclaimed knowledge.

Certainly, the literature argues that teachers should possess knowledge and understand the teaching methods they use to facilitate meaningful learning (Ausubel, 1963; Safdar et al., 2012). Meaningful learning takes place when the science teachers allow learners to draw together concepts they learned in a resourceful and fundamental manner (Asan, 2007; Mwakapenda, 2003).

According to Carey (2000), teachers' knowledge and understanding of teaching strategies can only be gained through practice and professional development. Carey's views concur with Okebukola and Jegede (1991) who claim that teachers who received a training and practice session in concept mapping developed a favourable attitude towards the use of concept mapping. Therefore, Mr Silveren's professional development and/or training seem to be opposing with the literature review. He claimed to be well trained on how to use concept mapping and rated his understanding of concept mapping as being very good to excellent but at the same time he failed to define what concept mapping was about. Mr Silveren's responses found to be contradicting and appeared to be too vague and ambiguous. Mr Silveren appeared not to tell the truth about his knowledge or understanding of concept mapping.

Both Mr Golden and Mr Silveren seemed to have a vague understanding of what concept mapping is about although they went through the same teacher education training system.

According to Slabbert and Greenhalgh (1998), one of the main aims of the BETD programme was train teachers to become professional expertise in the areas of their specialisations. In Namibia, learner-centred approach is accepted as an approach that should be used during instruction and is compulsory for teachers to apply learner-centred approach in their instruction. Concept mapping as one of the learner-centred strategies was taught at colleges of education and most student teachers are trained and equipped with skills and knowledge in applying concept mapping during instructions (Alausa, 2000).

Amongst other aspects of teacher education, teachers were expected to develop reflective attitude and creative, analytical and critical thinking. For example, the programme of the Natural Science focuses on the following aspects in training the primary school teachers: inculcates teachers to create effective and conducive classrooms, empowers science teachers with subject content knowledge and subject teaching methodologies, underscores on specific ideas related to the Learner Centred Education (LCE) and Continuous Assessment (CA) strategies that teachers had to use in science teaching, focuses on continuous professional development of teacher educators rather than on qualification upgrading, introduces learners to the scientific concepts and explanation of the phenomena by using scientific terminologies and inculcating new strategies of teaching science such as concept maps (Pomuti, Shilamba, Dahlström, Kasokonya, & Nyambe, 1998). This however was not demonstrated in the participating classrooms.

Overall, Mr Golden seemed to have slight idea of what concept mapping is about than Mr Silveren. Both teachers seemed to lack adequate knowledge on how to use it in their teachings. The results of this study seem to lack broader understanding of concept mapping due to the limited numbers of participants, thus, few teachers as subjects were targeted for this study. The researcher suggests that further research should be conducted in order to broaden the scope of such studies.

The following section presents results and discussion about research question two of the study.

4.3 Research question two: Is there a significant difference between learners' understanding on "matter and its properties" taught through concept mapping as compared to the learners taught through the traditional lecture method?

The sequence of presentation and discussion of the results obtained in this study is in accordance with the hypothesis formulated for this question.

Hypothesis: There is no a statistically significant difference in learners' understanding of science on "matter and its properties" taught through concept mapping and those taught through a traditional lecture.

To answer the aforementioned hypothesis, the researcher administered pre- and post-tests to explore the understanding of learners on "matter and its properties" and focused on evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy in order to assess the use of concept mapping as a teaching strategy. Learners at both schools (Alpha primary school and Omega primary school) were given the same pre-test and post-test. Treatment (teaching) was provided for two weeks at both schools after the administration of the pre-test. At Alpha primary school, learners were taught using traditional lecture method whilst at Omega primary school learners were taught using concept mapping and the whole research study took the researcher two weeks and two days to be completed. Forty-four multiple choice questions and six structured questions were drafted.

A t-test was applied to determine whether there was a significant difference (at the alpha level of 0.05) on multiple choice questions and structured questions between the mean scores of the two groups of 31 and 34 learners (traditional lecture group versus concept mapping group) at Alpha Primary School and Omega Primary School respectively. The results of both pre- and post-tests were analysed to find the Mean (M) scores in order to determine which group scored and/or performed better than the other on pre-test and post-test. The p and t values for the two-tailed means were calculated on both scores' pre-test and post-test. The t-test was used because of its powers to detect differences between the means of two groups (at the alpha level of 0.05) (Tolley, Johnson, & Koszalka, 2012; Wambugu & Changeiywo, 2008). Similarly, the two-tailed test was used than one-tailed test because it focuses on the differences in the mean scores and it is best for non-directional hypothesis that only indicates the difference and not where the differences lie (Cohen et al, 2007). Moreover, the paired samples t-test was the appropriate statistical test because of measuring the same group of participants twice on pre-test and post-test (Krause, Kelly, Tasooji, Corkins, Baker, & Purzer, 2010). Table 3 and 4 show the M-scores and t-value of the traditional lecture group and concept mapping group respectively on pre- and post-tests.

Table 3: Pre- and post-test results of traditional lecture group

Traditional Lecture Group	**Mean**	**N**	**Std. Deviation**	**Std. Err Mean**	**t**	**Sig.(2-tailed)**
Pre-test	20.29	31	6.948	1.248	-2.830	.348
Post-test	27.94	31	14.606	2.623		

p<0.05

The results in Table 3 revealed that there was no significant difference in learners' understanding of "matter and its properties" taught through normal lecture strategy when comparing their scores in the pre- and post-test (*t*-test = -2.830, at $p < 0.05$). That means that the critical value of 2.042 is significant (*t*-test = -2.830, at $p < 0.05$) within the same group. As the critical value of 2.042 obtained for the degree of freedom (df) = 30, p = .348. The calculated t-value is higher than the critical value, therefore, the Null hypothesis is rejected and the results are significant at $p = 0.05$.

While looking at, Table 4 below, the results of learners taught through concept mapping indicate otherwise.

Table 4: Pre- and post-test results of concept mapping group

Concept Mapping Group	**Mean**	**N**	**Std. Deviation**	**Std. Err Mean**	**t**	**Sig.(2-tailed)**
Pre-test	33.97	34	14.400	2.470	-4.574	.000
Post-test	47.32	34	21.506	3.688		

p<0.05

Table 3 and 4 also show that the overall achievement of mean of scores of the learners taught through traditional lecture strategy and concept mapping strategy, with a grand mean of 33.97, the learners exposed to concept mapping had the highest adjusted post-test mean achievement score of 47.32. When comparing the scores of learners in concept mapping on the pre- and post-test (t-test = -4.574, at $p < 0.05$). That means that the critical value of 2.035 is significant (t-test = -4.574, at $p < 0.05$) within the same group. As the critical value of 2.035 obtained for the degree of freedom (df) = 33, p = .000. The calculated t-value is higher than the critical value, therefore, the Null hypothesis is rejected and the results are significant at $p = 0.05$. The results indicated that there is less improved learning in learners who were taught through the traditional lecture strategy as compared to those taught through the concept mapping strategy.

It is observed that the mean scores of the two groups on pre-test were different, traditional lecture group is 20.29 as compare to 33.97 of concept mapping group. As a result, some learners chose wrong answers and/or left some items not answered on pre-test as compared to learners who were taught through concept mapping. Learners who were taught through concept mapping strategy, out-performed learners who were taught through traditional lecture strategy at alpha level of 0.05. The t-test results show that the improvement of concept mapping group in scores from the pre-test to the post-test.

For example, Sarina is one of the learners who left some questions unanswered on pre-test but she managed to answer all the questions on post-test. These also may illustrate that most learners with reading difficulties could learn easily through concept mapping rather than reading long sentences.

The results presented above showed that teaching strategies through the use of concept mapping intervention has a potential to improve learners' understanding in primary school Natural Sciences than the traditional lecture intervention. This finding provides contradicting empirical information that the traditional lecture strategy contributes to better performance as supported by Cravalho (2010). On the contrary, learners in the traditional lecture intervention performed poorly as compared to the concept mapping intervention group. The findings also provide empirical evidence supported by earlier findings that established that generally learners taught through traditional lecture strategies performed poorly as compared to learners taught through concept mapping strategy (Safdar et al., 2012; Tolley et al., 2012; Wambugu & Changeiywo, 2008). Therefore, concept mapping could be considered as an excellent teaching and learning strategy that could allow both learners and teachers to engage in extended science discourses, organise and structure subjects' content (Krause et al., 2010).

Despite the benefits of using concept mapping, there are some challenges in using concept mapping especially by the novice teachers and learners. These are: lack of communication – not all the learners understood well and gained the knowledge from concepts taught because they learn differently, prevent meaningful learning – learners might not be given an opportunity to critic and reflect on the relationships between concepts; unfamiliarity with the strategy – it might take time for the learners to adapt to the concept mapping if not well explained to them and it can be frustrating for novice map makers; time-consuming and tedious – training learners to use concept mapping technique seem to take time and unexciting (Chiou, 2008; Mwakapenda, 2004). Using a concept mapping tool seems to require sufficient time so that learners and teachers may engage in the meaningful teaching and learning. According to the ministerial policy, the allocated teaching time is 40 minutes per period (Ministry of Education, 2010). From the researcher' experience, 40 minutes period is not sufficient to teach and assess learners' understanding through concept mapping.

4.4 Difference in pre-test and post-test mean of scores

4.4.1 Mean scores for learners exposed to the traditional lecture method

In order to establish the differences in the mean of scores between the learners taught through traditional lecture strategy and concept mapping strategy, further analysis of results were conducted. A mean score for each pre-test and post-test item were determined in order to find out how learners performed for multiple as well as for structured items. The next section presents the mean scores of how learners performed on each pre- and post-test item (multiple choice items).

4.4.2 Mean scores for multiple choice items for the traditional lecture group

The following graph shows the mean scores of traditional lecture group on multiple choice questions (items) on pre-test and post-test.

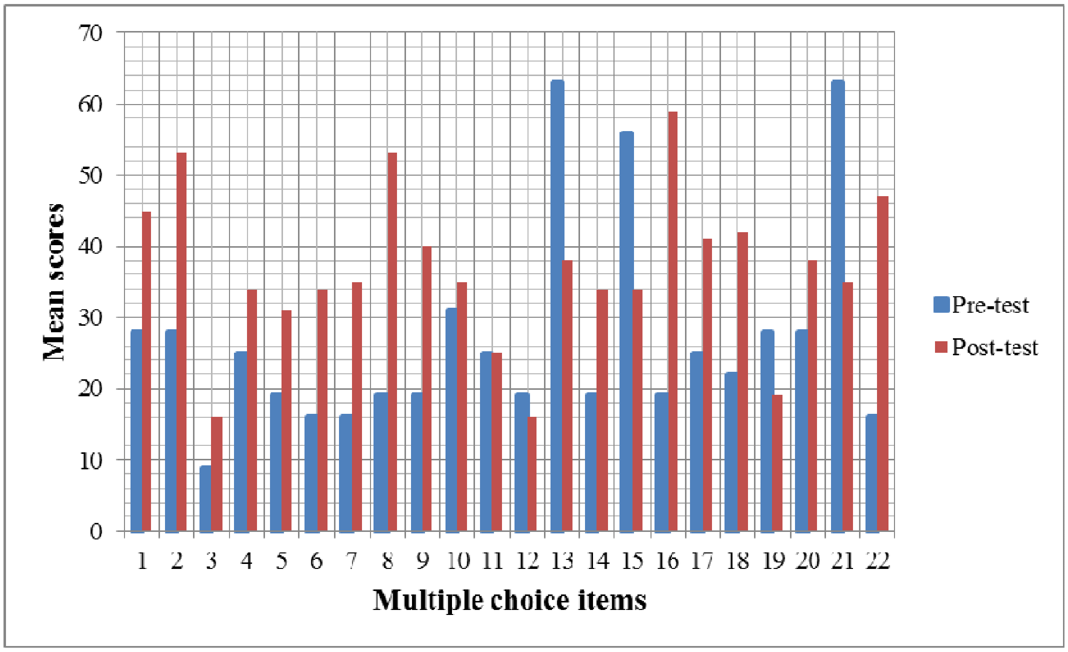


Figure 4.1: Learners' mean scores for each multiple choice item of traditional lecture group

Figure 4.1 shows an improvement in item 2, 8, 16 and 22 from the pre-test mean scores of 28%, 19%, 19% and 16% to the post-test mean scores of 53%, 53%, 59% and 47% focusing on freezing, water, ice and sublimation. The improvement can be found on questions answered in the post-test. Figure 4.2 shows the mean difference of improvement in item 2, 8, 16 and 22 between pre- and post-test results of traditional lecture group.

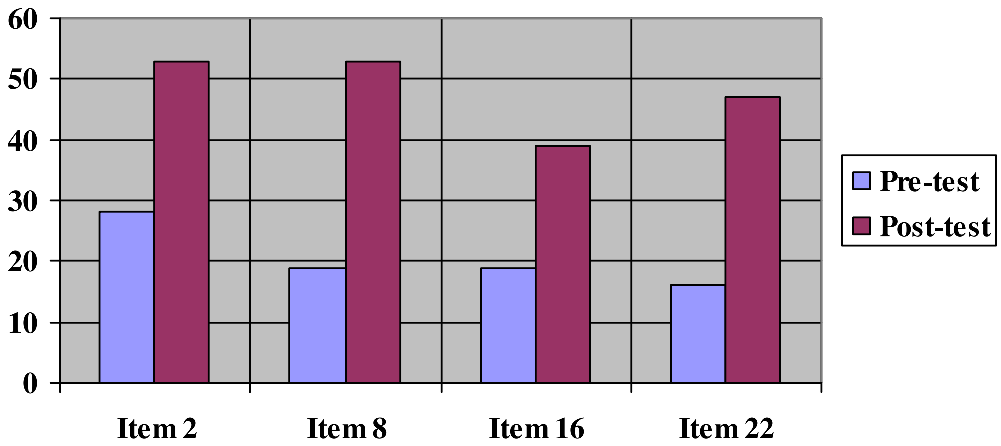


Figure 4.2: Mean difference of improvement between pre- and post-test results (A)

Although the levels of the questions of post-test were similar to those on the pre-test, learners seem not to have performed well on pre-test. One could explain this difference due to learners' anxieties of not knowing the content, not having enough knowledge about specific concepts such as energy and condensation as well as the fact that it is their first time to be involved in research hence the mean scores improved after the intervention in item 2, 8, 16 and 22 as seen from Figure 4.2.

Figure 4.1 also shows that there is a slight decrease in learners' performance in item 11 12, 13, 15, 19 and 21 that focused on melting, condensation, energy, deposition and boiling. Figure 4.3 shows the mean difference of a slight decrease in item 11 12, 13, 15, 19 and 21 between pre- and post-test results of traditional lecture group.

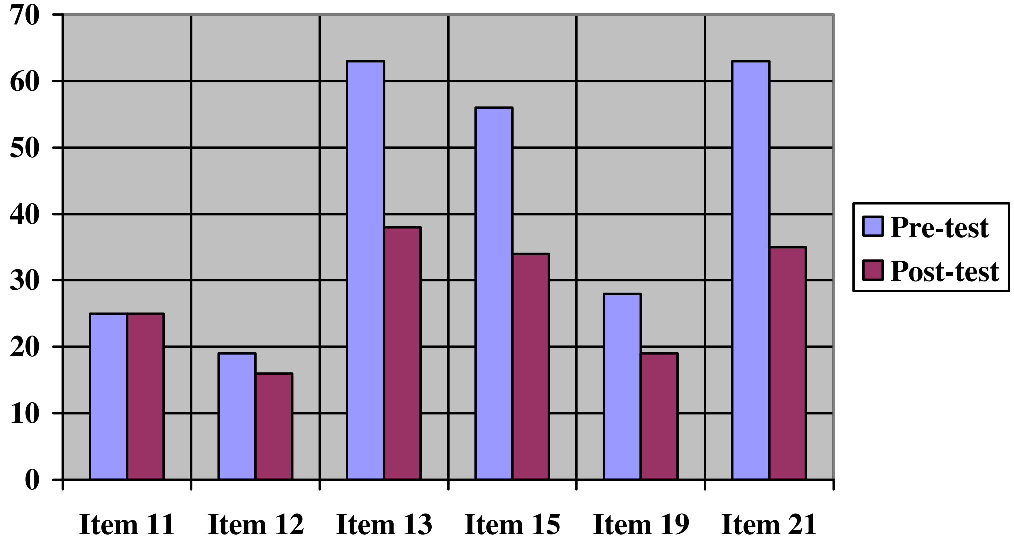


Figure 4.3: Mean difference of slight decrease between pre- and post-test results

Figure 4.3 shows that learners performed badly on some items of the post-test. It seemed that learners experienced some problems in comprehending some of the science concepts. For instance, learners lacked understanding on what physical changes involve in order for them to differentiate between boiling and condensation concepts. The common mistakes that were observed from the learners were that they seemed not to differentiate between vaporisation and evaporation and also to distinguish between the states of matter in terms of their particles.

This view is supported by Candan et al. (2006), who states that "it is widely concerned that students in early grades have difficulty to comprehend the concepts…" (p. 28). Therefore, for learners to learn science concepts they should comprehend the similarities and differences between concepts presented and what they already know to avoid confusion (Duit & Treagust, 2010; Safdar et al., 2012). It might be also the case that learners in control group answered questions by guessing. The study that was conducted by Fauzan (2002) on applying realistic mathematics education in teaching geometry in Indonesian primary schools found that most learners at lower grades in control classes answered the items by guessing or by using their impressions while in experimental group solved the item by using the formula.

4.4.3 Mean scores for structured questions for the traditional lecture group

Learners who were exposed to the lecture intervention were assessed on eleven concepts on matter and its properties through structured questions in the pre- and post-tests. The scheme of work and content presented to the learners during the two weeks is shown in Table 1.

Figure 4.4 shows the results of learners' performance on some of the science concepts on matter and its properties that they were tested on.

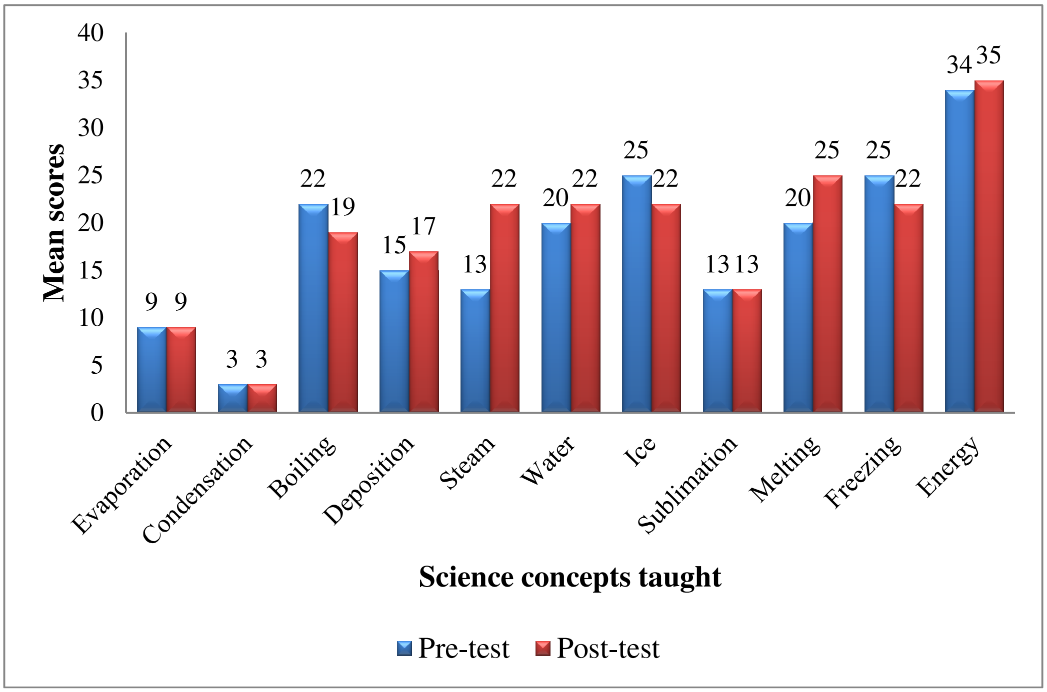
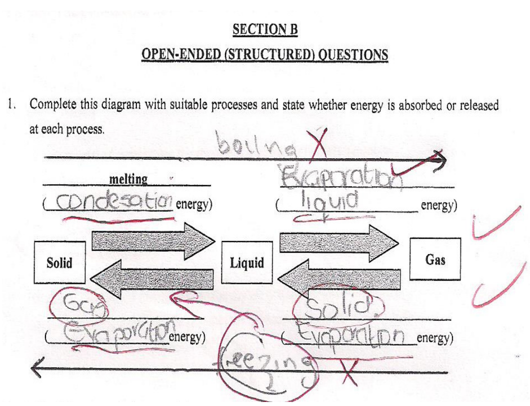
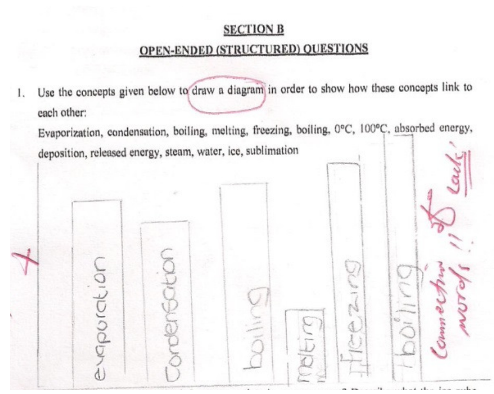


Figure 4.4: Learners' mean scores of science concepts taught through traditional lecture method

Figure 4.4 shows that there was no change in learners' performance in relation to understanding science concepts such as 'evaporation', condensation' and 'sublimation'. While there was a slight increase in learners' performance in other concepts such as 'deposition', 'steam', 'water', 'melting' and 'energy'. There was also a slight decrease in learners, performance on 'boiling', 'ice' and 'freezing' concepts.

Looking at structured questions, it seemed to offer a better explanation of learners' performance. When analysing the learners' work, they seemed not to have provided answers to some items in the post-test while they provided answers to all items in pre-test. Such conditions also tend to bring down the average performance of the learners. Another reason could be that learners did not have enough content information when they wrote the pre-test and this too, brought down their performances. The next extracts show how some learners performed on pre-test as compared to post-test. Looking at Katherine's performance on structured choice items focusing on evaporation, she gained higher scores on pre-test than on post-test.





Pre-test question vs Post-test question

Extract above shows Katherine' work on both tests focusing on evaporation. Katherine appears to confuse concept mapping with bar graph when looking at her answer in the post-test. She also seemed not to have comprehended the meaning of what a diagram was and how to relate the concepts to each other. The extract below shows the concepts presented at Alpha Primary School using the traditional lecture strategy.

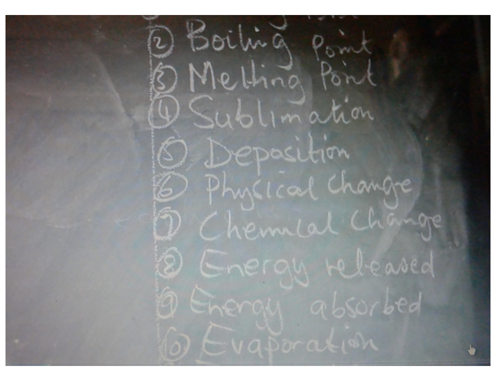
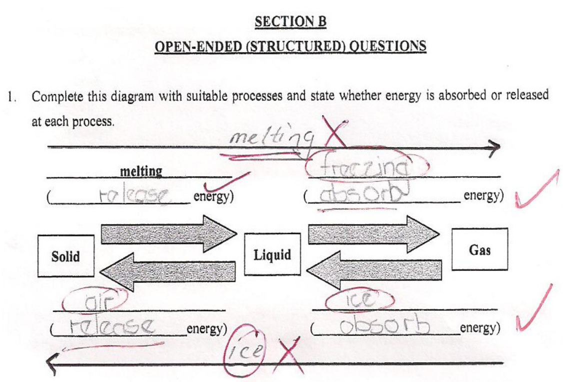
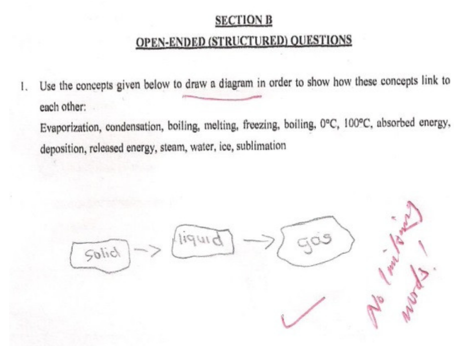


Figure 4.5: Science concepts presented using traditional lecture strategy

During instructions, learners were exposed to class participations and discussions so that they can clarify their understanding of the concepts and their relationships (Crawford, 2007; Nyambe, & Griffiths, 2010; Waters-Adams, 2006).

The following extract shows Job's work on pre-test and post-test (structured questions) focusing on energy, boiling, evaporation, condensation, freezing and melting.





Pre-test question vs Post-test question

Looking at how Job answered the above item focusing on evaporation (pre-test), it is noticeable that he could not use the processes properly, just like Katherine. The process that takes place through which a solid changed to a liquid state is melting which is already given in the diagram and then from liquid to gas which is evaporation. However, Job did not recognise that and he added boiling as a process.

On post-test, Job only used few concepts from the given list. Instead, he concentrated only on the state of matter (solid, liquid and gas) but not on the processes. However, Job shows some understanding of what was asked in the question. He, at least, provided a concept map although the linking words were missing and not graph like Katherine.

Some problems that were observed during instructions were as follow: firstly, most learners seemed to misunderstand the difference between processes of boiling and evaporation, that is, the process that takes place when liquid (water) change to gas state (water vapour); secondly, boiling is a term that many people use in their daily lives. However, boiling has another meaning as a science concept, particularly, in this context. Thus there is a need that teachers should teach with care when using some of these terminologies in science context. Heating and boiling do not have the same meaning in scientific context, in particular, as used in changing the state of matter. They seem not to know that evaporation can take place from boiling water from the kettle or pot on the stove too and change the state of water to water vapour. Similarly, most of the learners seem to know the process of freezing as solidifying or condensation and not as freezing. Not knowing the meaning of some words also seem to have contributed to learners' misunderstanding of some science concepts and also may have contributed to the slight decrease in learners' performance. It also seems that the treatment was not plausible enough in order to change their mind set on evaporation, condensation, boiling, ice, sublimation, and freezing as well as energy.

Looking at the boiling concept (structured items), the result shows that 24 learners got correct answers on pre-test as compared to 11 learners on the post-test. In addition, 1 learner left questions on boiling concept unanswered on pre-test as compared to 2 learners on post-test. The two items: 1 and 8 on pre-test were testing learners' understanding of boiling and most of the learners seemed to have been confused by the concept temperature which was in the items.

Again, in multiple choice items, learners were assessed in five items (10, 12, 15, 19 and 21) on pre-test and three items (6, 9 and 16) on post-test based on ice concept. On pre-test items, 12 learners got the item correct. Besides the correct answers, 17 learners got the item wrong. It seemed as if learners were not fully aware that an ice is also part of a solid state like other substance such as stones, wood block etc. and the ice particles are also fixed together. The poor performance of the learners on pre-test was not only caused by the wrong answers given by the learners but 2 learners also left items unanswered specifically item 17 which was on the arrangement of particles in an ice concept. On post-test, 18 learners got the ice concept correct whilst 13 learners got the concept wrong. Figure 4.6 shows how learners performed in items focused on ice concept on pre- and post-tests of traditional lecture group.

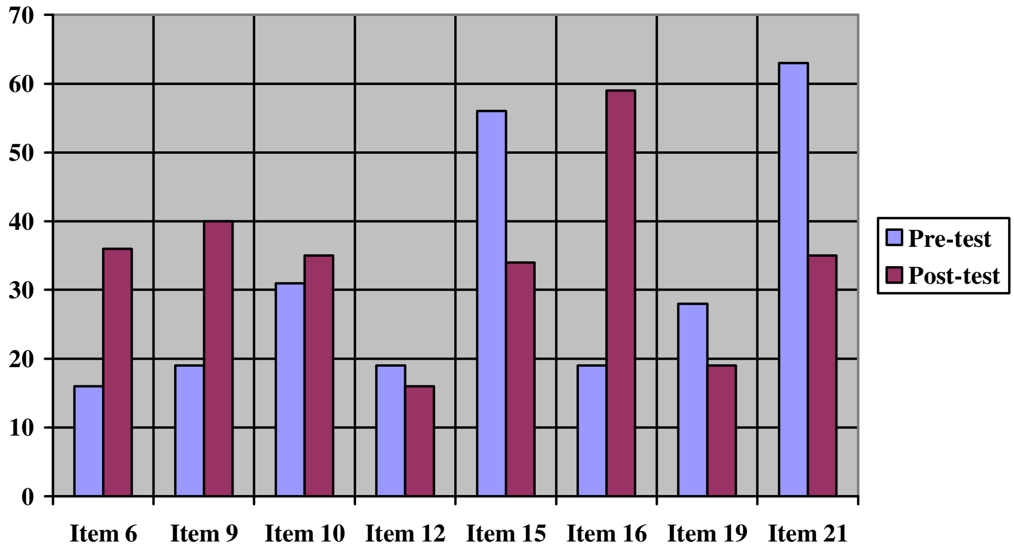


Figure 4.6: Learners' performance on ice concept on pre- and post-test

There seem to be a need for teachers not only to consider learner's misconceptions and challenges as barriers but also to find the sources and causes of these misconceptions and challenges (Kang, Scharmann, Kang, & Noh, 2010). The study that was conducted by Rice with the in-service elementary science teachers on their subject content knowledge in the USA reveals that many similar misconceptions such as to differentiate between boiling and condensation concepts are weakening learners' understandings (Rice, 2005). Markow & Lonning (1998) state that learners are normally confused about what constituted concepts and examples in questions and unclear about general map structure (hierarchy).

In multiple choice items, there were four questions (two on pre-test and two on post-test) on freezing concept. This indicated that 8 learners got the question correct while 23 learners got it wrong on pre-test. On the post-test, 12 learners got the questions correct whilst 19 learners got the questions wrong. The results show that not only on structured questions did learners perform badly about freezing but also in the multiple choice items. On pre-test, most of the leaners seemed not to have understood that 0°C is the freeing point of any pure liquid. On post-test, it appeared that learners didn't know that freezing point is the opposite of melting point. Figure 4.7 shows how learners performed in multiple choice items focused on freezing concept on pre- and post-tests of traditional lecture group.

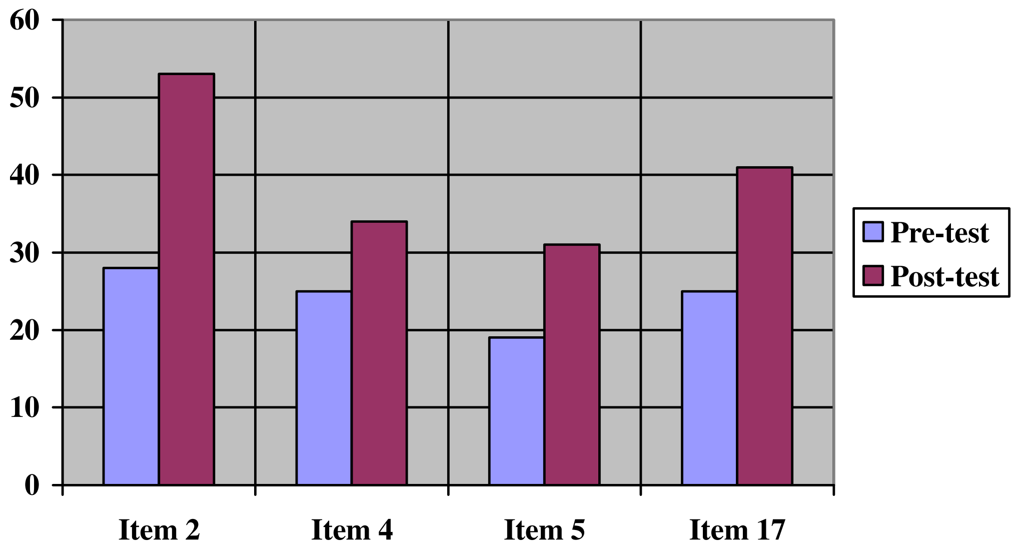


Figure 4.7: Learners' performance on freezing concept on pre- and post-test

Aldous (204) indicates that the plainly incorrect or misinterpretations of concepts can develop into misconceptions that can cause failure. According to Aikenhead and Ryan (1992), the language can create a barrier, particularly when learners hold a different view or meaning of such scientific terminology and may lead to misinterpretations of terms. In addition, teaching science could also contribute to learners' misunderstanding of the science concepts as well as discourage learners. Teachers need to provide opportunities - exploratory activities for leaners in order to identify and reveal a common misunderstanding, that is, plausible teaching.

4.4.4 Mean scores for multiple choice items for the concept mapping group

Table 5 below illustrates how the pre- and post-test items were spread across the eleven concepts.

Table 5: Pre- and post-test items spread across the concepts (B)

Concepts	Pre-test item	Post-test item
Evaporation	1	20
Condensation	9	12 & 17
Boiling	1 & 8	3, 7, 10, 18 & 21
Deposition	2	19
Steam	3, 5, 11, 18 & 20	1
Water	16	8
Ice	10, 12, 15, 19 & 21	6, 9 &16
Sublimation	7 & 22	22
Melting	6	11
Freezing	4 & 17	2 & 5
Energy	13 & 14	4, 13, 14 & 15

The following graph shows the results of the mean scores of twenty-two multiple choice questions (items) of concept mapping group focused eleven concepts mentioned in Table 5 above.

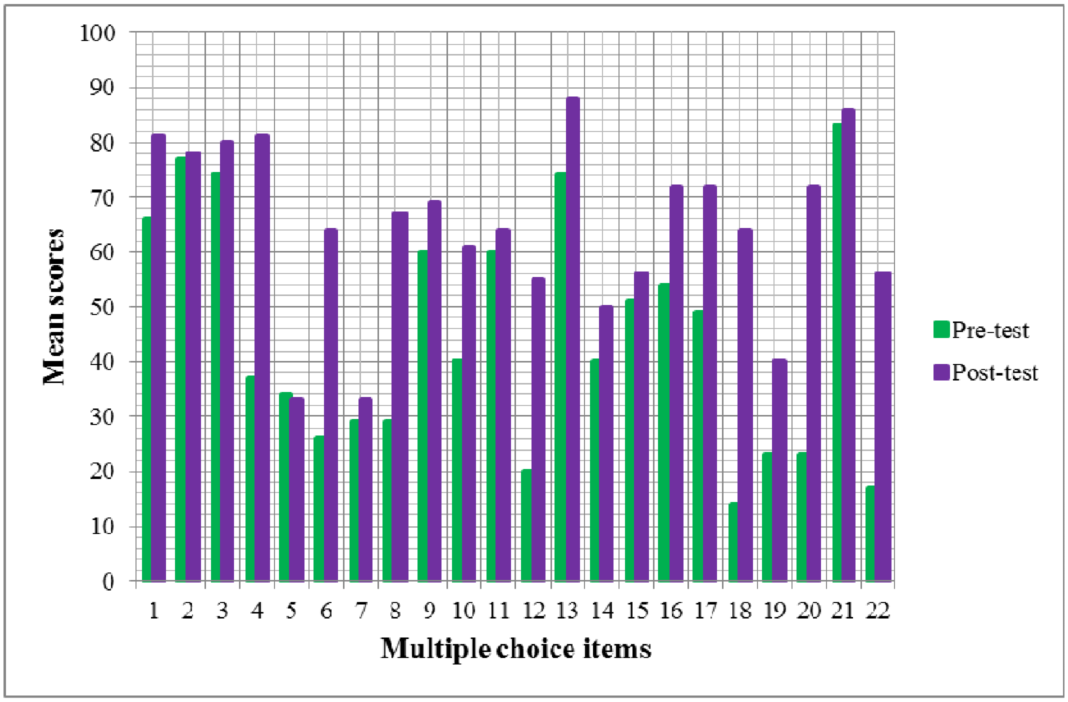


Figure 4.8: Learners' mean scores for each multiple choice item of concept mapping group

Figure 4.8 shows that learners performed well on most of the pre- and post-test questions except item 5 where there is a slight decrease in learners' performance (34% to 33%). Pre-test, item 5 focused on steam whilst post-test focused on freezing. Figure 4.8 also shows improvement in learners' performance on several questions such as item 4, 6, 8, 12, 18, 20 and 22 from the pre-test mean scores of 37%, 26%, 29%, 20%, 14%, 23% and 17% to the post-test mean scores of 81%, 64%, 67%, 55%, 64%, 72% and 56% respectively. The items focused on freezing, melting, boiling, ice, steam, sublimation, energy, water, condensation, boiling and evaporation (See Table 5).

Figure 4.9 shows the mean difference between the pre-test and post-test results of the concept mapping group in the seven items whereby learners have improved well after intervention.

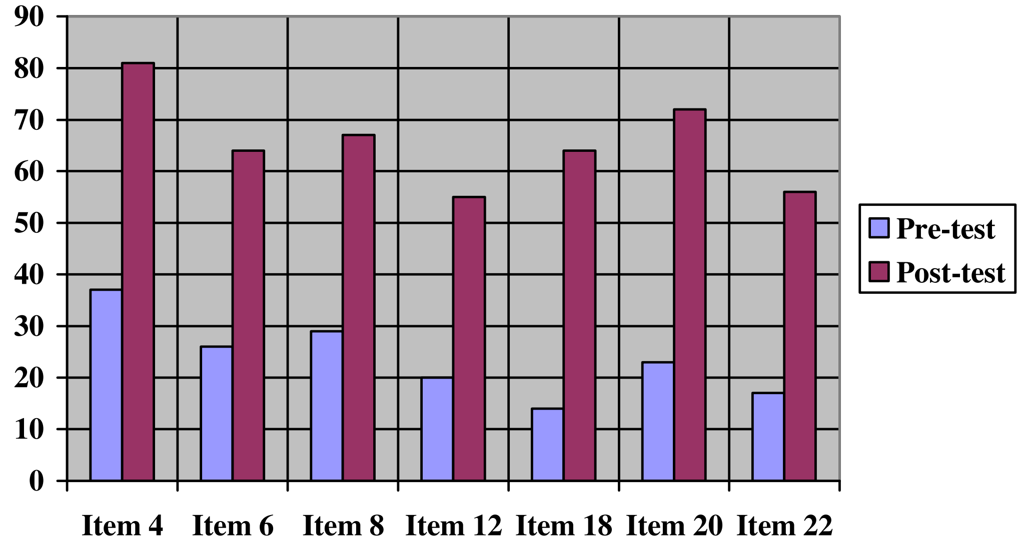


Figure 4.9: Mean difference of improvement between pre- and post-test results (B)

Although there is no huge difference in performance in learners' mean of scores on item 5, it seems to be challenging to the learners both on pre- and post-tests. Learners performed poorly on this specific item as compared to other items. The mean score for item 5 is below 40 on both pre- and post-test as compared to other items. There were 35 learners who wrote item 5 on pre-test and one learner was absent during the pre-test of which 12 learners got correct answer while 23 learners got wrong answer. Looking at the learners who provided answers, one can observe that learners experienced a problem in answering this item. The item was posed as follows and it focused on steam:

Item 5 on pre-test was posed as:

Which state of matter has no definite shape and no definite volume?

A Gas

B Liquid

C Solid

D Plasma

Thirty-six learners provided an answer to item 5 in the post-test. The results show that 12 learners provided correct answers while 24 learners provided incorrect answers. The item was as follows and it focused on freezing:

Item 5 on post-test was posed as:

What is likely to be the same as the freezing point of water?

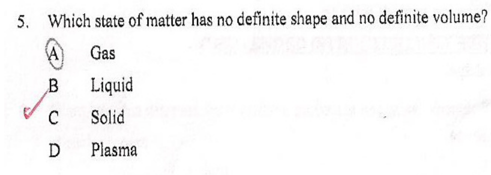
A Melting point

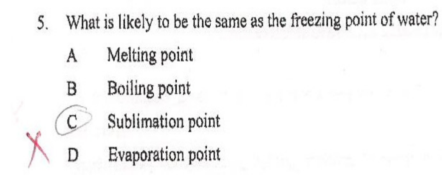
B Boiling point

C Sublimation point

D Evaporation point

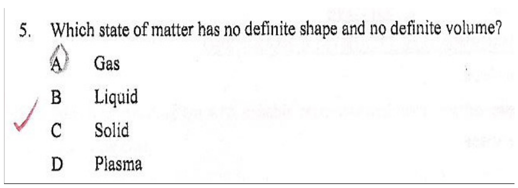
The mean scores slight decreased from pre-test (34%) to post-test (33%). On post-test, learners performed badly. The following extract shows how Tania performed in item 5 on pest-test compared to post-test.

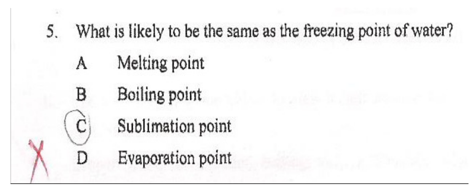

5. Which state of matter has no definite shape and no definite volume?
A Gas
B Liquid
C Solid
D Plasma


5. What is likely to be the same as the freezing point of water?
A Melting point
B Boiling point
C Sublimation point
D Evaporation point

Pre-test item vs Post-test item

The following extract was taken from Sangula's tests to show how he performed in item 5 on pest-test compared to post-test.


5. Which state of matter has no definite shape and no definite volume?
A Gas
B Liquid
C Solid
D Plasma


5. What is likely to be the same as the freezing point of water?
A Melting point
B Boiling point
C Sublimation point
D Evaporation point

Pre-test item vs Post-test item

Learners performed badly on post-test because it appears that they made a common mistake since many learners happened to choose sublimation point as an opposite to 'freezing' point instead of choosing melting point.

It seems that learners experienced problems in understanding the science concepts about matter and its properties. One possible effect of making wrong choices and diminishing learners' own understanding of concepts is the science language which is likely to limit learners' abilities to identify conceptual links between science concepts (Mwakapenda, 2004, Stoffels, 2005; Koosimile (2005).

4.4.5 Mean scores for structured question for the concept mapping group

Learners taught through concept mapping were also tested in eleven science concepts on matter and its properties which are evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy. Figure 4.10 shows the mean scores of learners' performance for both pre- and post-test.

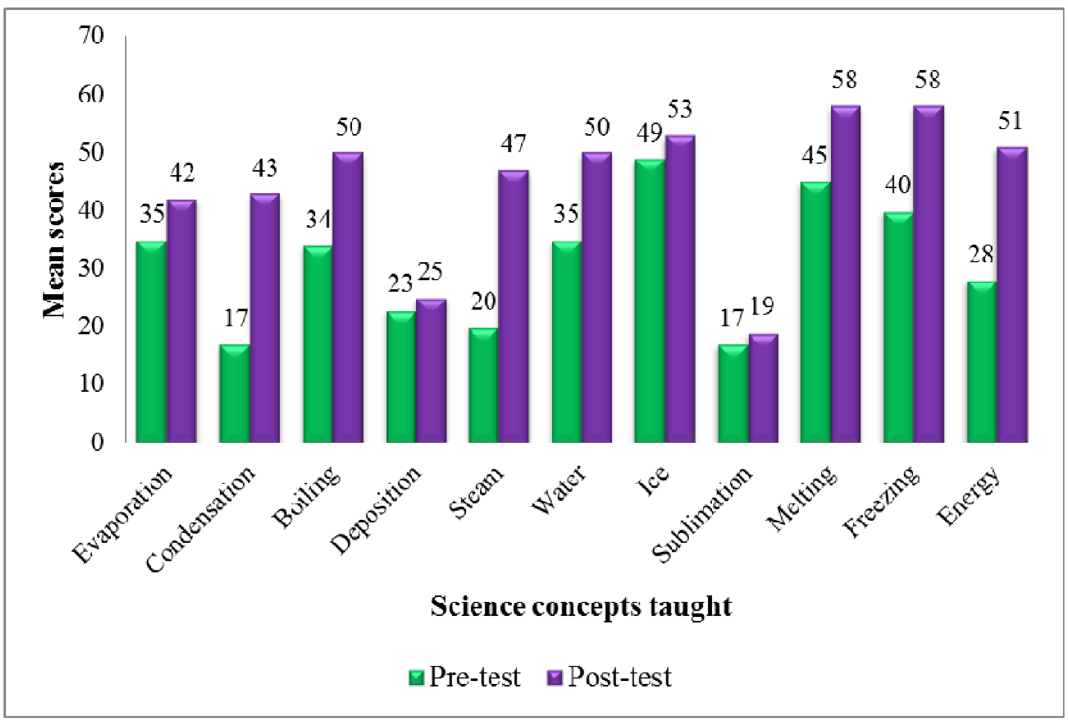
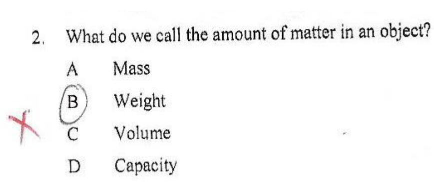
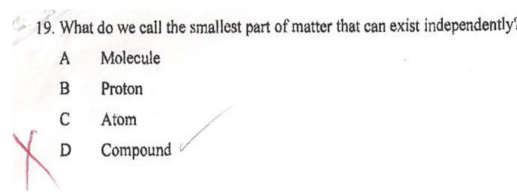


Figure 4.10: Learners' mean scores of science concepts taught through concept mapping method

Figure 4.10 shows improvement in learners' performance in almost all of the science concepts except on the deposition and sublimation concepts where learners show a slightly lower improvement in their performance. The following extract shows how Temus got wrong answers on the question items focusing on the deposition concept.


2. What do we call the amount of matter in an object?

A Mass
B Weight
C Volume
D Capacity

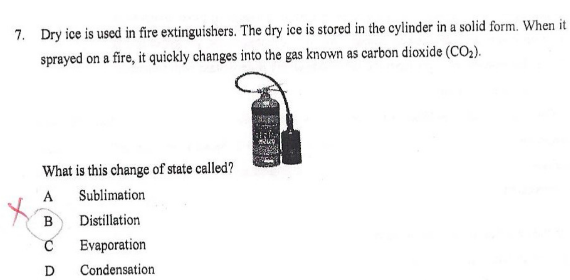

19. What do we call the smallest part of matter that can exist independently?

A Molecule
B Proton
C Atom
D Compound

Pre-test item vs Post-test item

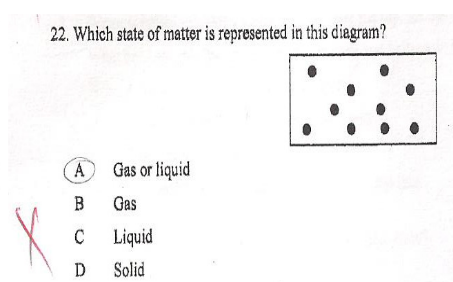
Temus with other learners who happened to get the deposition concept wrong from the multiple choice item appear to be confused with the word amount used in the question and weight from the stems since most of the learners chose weight as their option. Still, most learners did not comprehend how atom is related to matter as the smallest part of it. These confusions lead to poor performance or slightly improvement on learners' work.

The following extract was taken from Selma's work to illustrate how she performed on the items that were focused on sublimation concept. She got wrong answers on both items.


7. Dry ice is used in fire extinguishers. The dry ice is stored in the cylinder in a solid form. When it sprayed on a fire, it quickly changes into the gas known as carbon dioxide (CO_2).

What is this change of state called?

A Sublimation
B Distillation
C Evaporation
D Condensation

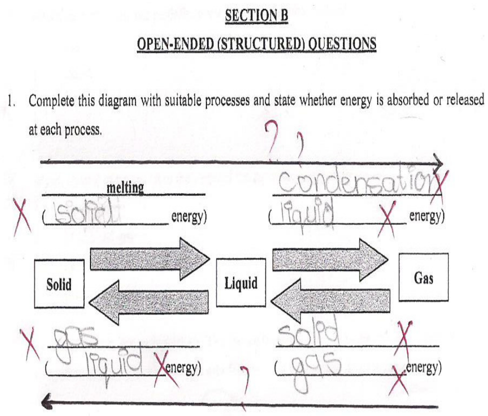

22. Which state of matter is represented in this diagram?

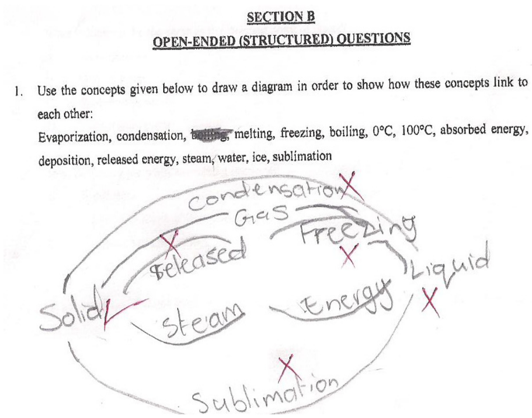
A Gas or liquid
B Gas
C Liquid
D Solid

Pre-test item vs Post-test item

There were three items that focussed on sublimation concept, that is, item 7 and 22 on pre-test and item 22 on post-test. The results of multiple choice items indicate that 9 learners got item 7 correct. Most learners including Selma did not realise that inside the fire extinguisher there is powder (dry ice) in a form of solid and when it started to be sprayed out, it turned to a gas and that is sublimation. The learners seemed to have experienced problems with words such as extinguishers, cylinder and dry ice used in item 7 on pre-test where most learners performed badly. Instead of choosing sublimation, they choose distillation which is the process of purifying impurity water. In addition, learners did not realise the diagram in item 22 as in a gas state only and that it could be changing from the solid state directly to the gas state such as burning cigarette or wood. These were some of the common mistakes that most learners made.

However, this shows that learners' performance on sublimation concept slightly improved in multiple choice from pre-test to post-test as compared to the slight improvement in structured questions. The next extracts show how Angeline answered the structured item 1 focused on concept mapping involving concepts such as evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy.

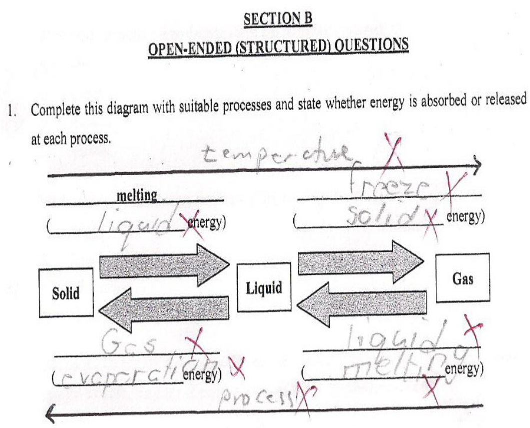


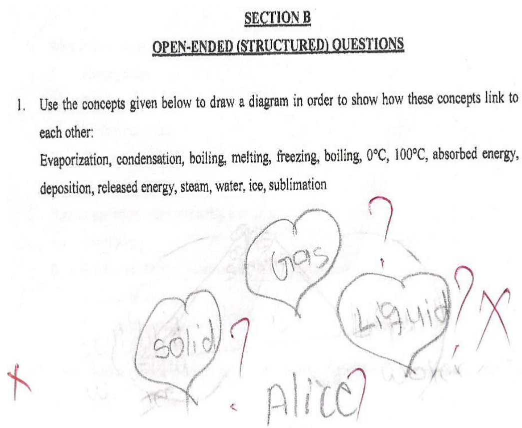


Pre-test question vs Post-test question

Looking at Angeline's work on structured question item 1 on pre-test and post-test, it comes out that she failed to conceptualise or figure out where the correct concepts should be placed in the given spaces. Angeline performanced badly on both the pre-test and post-test in the structred questions. She might have experienced some misconceptions and misunderstandings in drawings and placement of concepts in the right places. Those misunderstandings of the drawing lead her not to write or fill in any of the concepts to make a meaningful sketch of a concept map and not filling in almost all the concepts correctly. The misunderstandings might have been caused by not reading the instructions well.

Hindjou's responses are as follows:





Pre-test question vs Post-test question

The extracts above show how Hindjou performed on a structured question focused on concept mapping both on pre-test and post-test. He also failed to fill in concepts such as evaporation, condensation, boiling, deposition, steam, water, ice, sublimation, melting, freezing and energy in the right spaces on the post-test question. In addition, his way of drawing a concept map on the post-test question demonstrates unwillingness or misunderstanding of what should be done with respect to the science concepts. It also appears that Hindjou experienced more difficulties with regard to drawing a concept map, that's why he performed poorly on both the pre-test and the post-test.

Overall results seem to show that learners who were taught through concept mapping out-performed learners who were taught through the traditional lecture method, again some learners seemed to have experienced problems with drawing up concept maps. It is noticed that concept mapping has a positive impact on learners' performance. Chiou

(2008) also argue that concept mapping strategy has the capability to enhance learners understanding and engaging them in the teaching and learning activities with positive results. In addition, using concept mapping especially by the novice learners might not be easy because they are unfamiliar with the strategy and might take time to adapt it especially if the concept is not well explained to them (Mwakapenda, 2004). Learners seem to be frustrated and lose interest when they spend much of their time struggling with the work that they do not understand well and not making connections between concepts (Chiou, 2008; Elhelou, 1997; Krause et al., 2010).

However, it is important to provide opportunities to learners to participate and discuss science concepts during instructions in order for them to clarify their understanding of the concepts and their relationships to each another (Crawford, 2007; Nyambe, & Griffiths, 2010; Waters-Adams, 2006). Most importantly, learners need to be taught how the arrows and words in concept maps linked to each other (Canas, 2003; Safdar et al., 2012; Stoica et al., 2011). For the learners to achieve high academic standards and improve achievement in core subjects including science, the correct reading of instructions should be prioritised (Shaver, Cuevas, Lee, & Avalos, 2007).

4.5 Conclusions

In this chapter, the researcher presented the results and discussions of the data collected from the two primary schools, the two science teachers and their learners. The study found that Mr Golden seemed to have a slight idea and understanding of what the concept mapping strategy was about than Mr Silveren. Both teachers seemed to lack adequate knowledge on how to use concept mapping in their teachings. It was also found that the two teachers did not also try to use the strategy in their daily instructional practices since they started with their professional career.

It was also found that learners taught through concept mapping out-performed the learners who were taught through the traditional lecture method at statistically significant difference of alpha 0.05. That means that the overall critical value of 1.998 is significant (*t*-tests = -4.574 and -2.830, at $p < 0.05$). As the critical value of 1.998 obtained for the degree of freedom (df) = 63, p = .000. The calculated t-value is higher than the critical value, therefore, the Null hypothesis is rejected and the results are significant at $p = 0.05$.

Both learners mostly of the traditional lecture group seemed to have encountered some problems with regard to concept mapping. For example, these learners were requested to sketch a concept map using the given concepts and instead of sketching, some learners drew bar graphs and made long chains with concepts, some learners seemed not to have read the instructions given, not to comprehend the meanings of each concept and its application, and/or not even contextualise linking words and how they relate to each other.

The next chapter presents the conclusions and recommendations that emerged from the findings of the study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings, conclusions and recommendations that emerged from the study.

5.2 Summary

5.2.1 Research question one: How do Grade six Natural Science teachers understand and use concept mapping?

The results revealed that:

- The two science teachers who participated in the study have a vague idea about the uses of concept mapping during instruction.
- The two science teachers appeared not to have practiced the concept mapping strategy at all in their classes since they started with their professional careers.

5.2.2 Research question two: Is there a significant difference between learners' understanding on "matter and its properties" taught through concept mapping as compared to the learners taught through the traditional lecture method?

The results revealed that:

- Some facts such as learners' of not knowing the subject content; not having enough knowledge about specific concepts; not knowing the meaning of some words like fire extinguisher used in the items and having experienced some problems in comprehending some of the science concepts contributed to the learners' poor performance on both pre- and post-tests.
- Some learners appear to confuse themselves and not knowing that evaporation can take place from boiling water, from the kettle or pot on the stove too and change the state of water to water vapour. Similarly, most of the learners seem to know the process of freezing as solidifying or condensation and not as freezing.
- Some learners performed badly on post-tests because of the possible effect of making wrong choices and diminishing learners' own understanding of concepts is the science language which is likely to limit learners' abilities to identify conceptual links between science concepts and by not reading the instructions well.
- Learners mostly taught through traditional lecture seemed to have encountered some problems with regard to using concept maps. For example, learners were requested to use sketches to illustrate the particular concept instead some learners drew bar graphs. Some learners seemed not to have read the instructions given, not comprehended the meanings of each concept and its application, and/or not even

contextualised linking words and how they relate to each other.

- Learners taught through concept mapping out-performed those learners who were taught through the traditional lecture at statistically significant difference of alpha 0.05. That means that the overall critical value of 1.998 is significant (t-tests = -4.574 and -2.830, at $p < 0.05$). As the critical value of 1.998 obtained for the degree of freedom (df) = 63, p = .000. The calculated t-value is higher than the critical value, therefore, the Null hypothesis is rejected and the results are significant at $p = 0.05$. This proves that the concept mapping strategy has a noticeable positive impact on learners' achievements than the traditional lecture method in teaching science concepts.

5.3 Recommendations

5.3.1 Research question one: How do Grade six Natural Science teachers understand and use concept mapping?

The institutions of higher learning, that is, the University of Namibia, Colleges of Education as well as the Ministry of Education in collaboration with curriculum developers (NIED) are, thus, encouraged to include the concept mapping strategy into their curriculum. The involvement of the Continuing Professional Development (CPD) unit in partnership with NIED is also very crucial in propagating the use of concept mapping offered to practicing teachers. For the meaningful teaching and learning of science concepts, learners need to be taught how to use concept mapping as from primary school level to university level. According to Mwakapenda (2008), introducing concept mapping strategy at primary level of schooling will provide learners with opportunities to display relationships among concepts in a topic, between topics and between domains. Therefore:

- Concept mapping will, thus, equip student-teachers well in advance and impart them with necessary skills and knowledge on how to construct and use concept map for the effectiveness of teaching and learning of science concepts.
- As a new teaching strategy in the Namibian context, learners are unfamiliar with it; therefore, teachers are warned not to rush when introducing a concept map to the learners; otherwise, learners get frustrated and discouraged as learners learn differently. For the science teachers who practice and plan to use concept mapping strategy in their classrooms, they should make sure that concept maps need to be well planned in advance with correct and meaningful linking words. Learners' ideas as presented on concept maps need to be properly monitored and corrections should be done immediately to avoid misconceptions, misunderstandings and misinterpretations of concepts.
- Teachers are also advised to use correct language when teaching science concepts using concept mapping. In so doing, it gives learners an opportunity to learn with excitement, understand concepts well in relation to linking words and enhance learners' meaningful learning.
- Most teachers in Namibia seem to focus on using lecture methods of teaching rather than new and innovative methods of teaching (Kapenda et al., 2002). Therefore, this study argues for a shift from traditional lecture method to concept mapping strategy because knowledge acquired through traditional method will not be remembered.

5.3.2 Research question two: Is there a significant difference between learners' understanding on "matter and its properties" taught through concept mapping as compared to the learners taught through the traditional lecture method?

- The use of concept mapping should be extended to other subject areas in order to enhance effective teaching and learning.
- It is, thus, recommended that further researches on concept mapping should focus on the implementation and application of concept mapping strategy in all areas of science subjects including Mathematics.
- The study should also caution that the findings could be as obtained because the two schools were so different – therefore, more and in-depth studies are needed for future concept mapping applications in teaching science concepts.

5.4 Conclusions

The curiosities behind the research questions of this study were answered in terms of teachers' understanding of concept mapping and learners' achievements through the interventions (concept mapping and traditional lecture). Despite the challenges that concept mapping strategy might have in teaching and learning of science concepts, this study proved that concept mapping strategy is one of the effective and useful teaching strategies of science concepts that promotes meaningful learning among the learners. The concept mapping strategy can enhance learners' thinking capacities and promote their scientific skills. As a result, learners' achievements are improved. However, concept mapping strategy itself would not emerge as a success in teaching and learning without the interest and seriousness of teachers and learners. Therefore, teachers and learners should be more widely encouraged to use concept mapping for the effectiveness of teaching and learning of science.

5.5 Summary

This chapter presented a summary, conclusions and recommendations of the study in relation to the use of concept mapping in teaching of science concepts.

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APPENDICES

Appendix 1: A granted permission letter from the University of Namibia to carry out a research

UNIVERSITY OF NAMIBIA

Private Bag 13301, 340 Mandume Ndemufayo Avenue, Pionerspark, Windhoek, Namibia

The School of Postgraduate Studies
P.Bag13301
Windhoek, Namibia
Tel: 2063523

E-mail: cshaimemanya@unam.na

Date: 4 September 2013

TO WHOM IT MAY CONCERN

RE: RESEARCH PERMISSION LETTER

1. This letter serves to inform that student: Jafet Shikongo Uugwanga (Student number: 201176939) is a registered student in the Department of Mathematics, Science and Sport Education at the University of Namibia. His/her research proposal was reviewed and successfully met the University of Namibia requirements.
2. The purpose of this letter is to kindly notify you that the student has been granted permission to carry out postgraduate studies research. The School of Post Graduate Studies has approved the research to be carried out by the student for purposes of fulfilling the requirements of the degree being pursued.
3. The proposal adheres to ethical principles.

Thank you so much in advance and many regards.

Yours truly,

Name of Main Supervisor: Dr. H. U. Kandjeo-Marenga

Signed:---

Dr. C. N.S. Shaimemanya

Signed:---------------------------------

Director: School of Postgraduate Studies

Appendix 2: A letter requesting permission from the permanet secretary (Ministry of Education)

P.O. Box 2588
Windhoek
NAMIBIA

06 September 2013

Attention: Mr. Alfred M. Ilukena [*Permanent Secretary*]
Ministry of Education
Directorate of Education
Private Bag 13185
WINDHOEK

Dear Madam

RE: APPLICATION FOR CONDUCTING A RESEARCH PROJECT

I am **Jafet Shikongo Uugwanga**, student number: **201176939**, a maths & science teacher by profession and Head of Department at in Khomas Region. Currently, I am a final year student doing my Master degree (M. Ed) in Science Education with the University of Namibia.

This letter serves to request your permission to conduct a study in three primary schools, namely: [illegible] **Primary School**, having Grade six Natural Science in the Khomas Education Region. One of the three schools will be used for piloting instruments whilst the other two schools will be used for the main study. The research is part of my course and will be conducted this term (3rd term) between September and October 2013. This research study is funded by the Namibia Government Scholarship and Training Programme (NGSTP) – Ministry of Education and an approval to carry out the research project is granted from the University of Namibia (*see attached letter*).

The topic of my research project is "***An Investigation on the Effectiveness of Concept Maps in Teaching Natural Science: Cases of two Primary Schools in the Khomas Education Region***" under the supervision of Dr. Hedwig U. Kandjeo-Marenga and Mrs. M. Vries. The study explores the Natural Science teachers understanding of concept mapping in the teaching and learning environment as well as its effectiveness during instruction. The findings of this study will be shared with the participants, the schools and the Ministry of Education.

I would like to assure you that I will strictly adhere to research ethics and all information received from participants will be treated with utmost confidentiality and will entirely be used for the for educational purposes. I am looking forward to receive your favourable response.

Yours faithfully,

....

Mr. Jafet S Uugwanga
Cell: 085 555 302 0
E-mail: jsuugwanga@yahoo.com

Appendix 3: A letter requesting permission from the director of education (Khomas Region)

P.O. Box 2588
Windhoek
NAMIBIA

06 September 2013

Attention: Ms. T. Seefeldt [*Director of Education*]
Ministry of Education
Directorate of Education
Khomas Regional Council
Khomas Region
Private Bag 13236
WINDHOEK

Dear Madam

RE: APPLICATION FOR CONDUCTING A RESEARCH PROJECT

I am **Jafet Shikongo Uugwanga**, student number: **201176939**, a maths & science teacher by profession and Head of Department at in Khomas Region. Currently, I am a final year student doing my Master degree (M. Ed) in Science Education with the University of Namibia.

This letter serves to request your permission to conduct a study in three primary schools, namely: ;

Primary School, having Grade six Natural Science in the Khomas Education Region. One of the three schools will be used for piloting instruments whilst the other two schools will be used for the main study. The research is part of my course and will be conducted this term (3rd term) between September and October 2013. This research study is funded by the Namibia Government Scholarship and Training Programme (NGSTP) – Ministry of Education and an approval to carry out the research project is granted from the University of Namibia (*see attached letter*).

The topic of my research project is "***An Investigation on the Effectiveness of Concept Maps in Teaching Natural Science: Cases of two Primary Schools in the Khomas Education Region***" under the supervision of Dr. Hedwig U. Kandjeo-Marenga and Mrs. M. Vries. The study explores the Natural Science teachers understanding of concept mapping in the teaching and learning environment as well as its effectiveness during instruction. The findings of this study will be shared with the participants, the schools and the Ministry of Education.

I would like to assure you that I will strictly adhere to research ethics and all information received from participants will be treated with utmost confidentiality and will entirely be used for the for educational purposes. I am looking forward to receive your favourable response.

Yours faithfully,

……………………………

Mr. Jafet S Uugwanga
Cell: 085 555 302 0
E-mail: jsuugwanga@yahoo.com

Appendix 4: A follow-up letter requesting permission from the director of education (Khomas Region)

P.O. Box 2588
Windhoek
NAMIBIA

13 September 2013

Attention: Ms. T. Seefeldt [*Director of Education*]
Ministry of Education
Directorate of Education
Private Bag 13185
WINDHOEK

Dear Madam

RE: AN AUTHORISATION TO ENTER AND CARRY OUT MY RESEARCH PROJECT

This letter serves to request an authorisation to enter and carry out my research project at the three schools in Khomas Region. The requesting letter dated 06th September 2013 with an approval letter granted from the University of Namibia and proof of my registration were submitted at your office on Friday, 06 September 2013 (*see attached copies of the submitted documents*).

Also attached, kindly see a letter dated 10th September 2013 from the office of the Permanent Secretary – Ministry of Education with reference to the mentioned study project.

I am looking forward to receive your favourable response.

Yours faithfully,

....

Mr. Jafet S Uugwanga
Cell: 085 555 302 0
E-mail: jsuugwanga@yahoo.com

Appendix 5: An approval letter from the permanent secretary (Ministry of Education)

REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION

Tel: 264 61 2933200
Fax: 264 61 2933922
E-mail: Matthew.Shimhopileni@moe.gov.na
Enquiries: MN Shimhopileni

Private Bag 13186
Windhoek
NAMIBIA
10 September 2013

File: 11/2/1

Mr. Jafet Shikongo Uugwanga
P. O. Box 2588
WINDHOEK

Dear Mr J S Uugwanga

RE: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH AT THREE PRIMARY SCHOOLS IN KHOMAS REGION

Your letter dated 6 September 2013, requesting permission to conduct a research at three primary schools in the region concerned, has reference.

Kindly be informed that the Ministry does not have an objection to your request to conduct a research at the schools concerned.

However, you are kindly advised to approach the Regional Council Office, Directorate of Education, for authorization to enter and carry out your study at the schools concerned. Participation by both teachers and learners should be on a voluntary basis.

Kindly ensure that your research activities do not disturb the normal school programmes.

By copy of this letter the Regional Director of Education is made aware of your request

Yours sincerely

MINISTRY OF EDUCATION Office of the Permanent Secretary 10 SEP 2013

....
A Ilukena
PERMANENT SECRETARY
cc: Director of Education: Khomas Region

Appendix 6: An approval letter from the director of education (Khomas Region)

KHOMAS REGIONAL COUNCIL

DIRECTORATE OF EDUCATION

Tel: (0926461)293 4410
Fax: (09 264 61) 231367
Enquiries: A. Murere
File No.: 12/2/6/1

Private Bag 13236
Windhoek

17 September 2013

Mr. J. Uugwanga
P. O. Box 2588
Windhoek

Dear Mr. J. Uugwanga

SEEKING PERMISSION TO CARRY OUT RESEARCH WITH REGARD TO AN INVESTIGATION ON THE EFFECTIVENESS OF CONCEPT MAPS IN TEACHING NATURAL SCIENCE AT PRIMARY SCHOOLS IN KHOMAS REGION

Your letter dated 06 September 2013 is hereby acknowledged.

Your request to conduct a research at
School with regard to "An investigation on the effectiveness of concept maps in teaching natural science at primary schools in the Khomas Region" is approved with the following conditions:

- The Principal of the schools to be visited must be contacted before the visit and agreement should be reached between you and the principal.
- The school programme should not be interrupted.
- Teachers and Learners who will take part in this exercise will do so voluntarily.
- Khomas Education Directorate should be provided with a copy of your findings.

Wish you all the best.

Yours sincerely

....
MS. A. STEENKAMP
DEPUTY DIRECTOR OF EDUCATION

MINISTRY OF EDUCATION
PRIVATE BAG 13236. WINDHOEK
17 SEP 2013
DIRECTOR OF EDUCATION
KHOMAS REGION

Appendix 7: A letter requesting permission from the school principals (Khomas Region)

P.O. Box 2588
Windhoek
NAMIBIA
19 September 2013

The School Principal
(*School name*)

Attention: (*Principal's name*)

RE: APPLICATION FOR CONDUCTING A RESEARCH PROJECT

I am Jafet Shikongo Uugwanga, student number: 201176939, a maths & science teacher by profession and Head of Department at (*school name*) in Khomas Region. Currently, I am a final year student doing my Master degree (M. Ed) in Science Education with the University of Namibia.

This letter serves to request your permission to conduct a research study at your school as part of my degree. This research study is funded by the Namibia Government Scholarship and Training Programme (NGSTP) – Ministry of Education and an approval to carry out this research project is granted from the University of Namibia, Director of Education and office of the Permanent Secretary – Ministry of Education (*see attached letters*).

The topic of my research project is "***Investigating the effectiveness of concept mapping in teaching Natural Science: cases of two primary schools in Windhoek, Khomas Region***" under the supervision of Dr. Hedwig U. Kandjeo-Marenga and Mrs. M. Vries. The study explores the Natural Science teachers understanding of concept mapping and the effectiveness of concept mapping on learners' understanding. I will conduct a research study with one of your Grade six Natural Science teacher together with his/her class on "matter" as a topic. I will be an active participant-observer during the data collection, administer a pre- and post-tests to the learners, conducting a short interview with the teacher for approximately ±15 minutes. The findings of this research will be shared with the participants, the schools and the Ministry of Education.

I would like to assure you that your school, teachers and learners will not be named in any further correspondences or in any reports. The participation of your school, teachers and learners in this research is entirely for educational purposes, and all the information will be treated with utmost confidentiality.

I am looking forward to receive your favourable response.

Thank you for your time and understanding in advance.

Yours faithfully,

……………….……….
Mr. Jafet S Uugwanga
Cell: 085 555 302 0
E-mail: jsuugwanga@yahoo.com

Appendix 8: A letter requesting permission from the teachers (consent form)

P.O. Box 2588
Windhoek
NAMIBIA

07 October 2013

Enquiries: Mr. Jafet S Uugwanga
Cell: 085 555 302 0
E-mail: jsuugwanga@yahoo.com

Dear Teacher

Teacher's name: ………………………………………………….

RE: REQUESTING YOUR PERMISSION TO PARTICIPATE IN THE RESEARCH STUDY

> *The World is proud of having truly maths & science educators, as beings who are positively changing the world in numerous ways. This is a small gesture, but an enormously significant one. As a matter of fact, "we are producing the best citizen, and --- producing the best workers, we are building the strongest society and the most prosperous economy, and teachers are the role models of any other professions" (McGuinty, in Andrews, 2006, p.299)*[1].

I am Jafet Shikongo Uugwanga, student number: 201176939, a maths & science teacher by profession and Head of Department at (*school name*) in Khomas Region. Currently, I am a final year student doing my Master degree (M. Ed) in Science Education with the University of Namibia.

This letter serves to request your permission to participate in this research study that I am currently conducting as part of my degree. This research study is funded by the Namibia Government Scholarship and Training Programme (NGSTP) – Ministry of Education and an approval to carry out this research project is granted from the

[1] Remarks made by Dalton McGuinty, Premier of Ontario. In Andrews, H. A. (2006). *Awards and Recognition for Exceptional Teachers*: K-12 and Community College. Programs in the U.S.A., Canada and Other Countries. USA: Matilda Press.

University of Namibia, Director of Education, office of the Permanent Secretary – Ministry of Education and your school principal (*see attached letters*).

The topic of my research project is "***Investigating the effectiveness of concept mapping in teaching Natural Science: cases of two primary schools in Windhoek, Khomas Region***" under the supervision of Dr. Hedwig U. Kandjeo-Marenga and Mrs. M. Vries. The study explores the Natural Science teachers understanding of concept mapping and the effectiveness of concept mapping on learners' understanding. I will conduct a research study with one of your Grade six Natural Science teacher together with his/her class on "matter" as a topic. I will be an active participant-observer during the data collection, administer a pre- and post-tests to the learners, conducting a short interview with you for approximately ±15 minutes.

You reserve the right to withdraw from the study at any time after its commencement. The data will be shared with you during the analysis for the verification before the final report is written. Thereafter, the findings of this research will be shared with you, the school and the Department of Education.

I would like to assure you that in the final report, your identity will be disguised and pseudonyms will be used. Your participation in this research is entirely for educational purposes and all the information will be treated with utmost confidentiality.

…………………………………………..……………………………………………

INFORMED CONSENT

In terms and conditions of the ethical requirements of the University of Namibia and the Ministry of Education, you are now requested to complete the following section to declare yourself.

I understand the contents of this letter and I am willing to take part in this research project. I understand that I may withdraw from the study at any time and that anonymity will be guaranteed.

***Participant's Signature:* __________________________ *Date:* ________________**

***Researcher's Signature:* __________________________ *Date:* ________________**

Appendix 9: A letter requesting permission from the learners (consent form)

P.O. Box 2588
Windhoek
NAMIBIA

07 October 2013

Mr. Jafet S Uugwanga
Cell: 085 555 302 0
E-mail: jsuugwanga@yahoo.com

Dear Learner

Learner's name: ……………………………………………….

RE: REQUESTING YOUR PERMISSION TO PARTICIPATE IN THE RESEARCH STUDY

I am Jafet Shikongo Uugwanga, student number: 201176939, a maths & science teacher by profession and Head of Department at (*school name*) in Khomas Region. Currently, I am a final year student doing my Master degree (M. Ed) in Science Education with the University of Namibia.

This letter serves to request your permission to participate in this research study that I am currently conducting as part of my degree. This research project is granted from the University of Namibia, Director of Education, office of the Permanent Secretary – Ministry of Education, school principal and your class teacher (*see attached letters*).

The study explores the Natural Science teachers understanding of concept mapping and the effectiveness of concept mapping on learners' understanding. You reserve the right to withdraw from the study at any time after its commencement. I would like to assure you that in the final report, your identity will be disguised and pseudonyms will be used. Your participation in this research is entirely for educational purposes and all the information will be treated with utmost confidentiality.

……………………………………………..……………………………………………

INFORMED CONSENT

In terms and conditions of the ethical requirements of the University of Namibia and the Ministry of Education, you are now requested to sign the attached class list to declare yourself.

I understand the contents of this letter and I am willing to take part in this research project. I understand that I may withdraw from the study at any time and that anonymity will be guaranteed.

Learner's Signature: ____________________________ ***Date:*** __________________

Researcher's Signature: _________________________ ***Date:*** __________________

Appendix 10: PRE-TEST ITEMS ON "MATTER AND ITS PROPERTIES"

SECTION A ***(Multiple Choice Questions)***

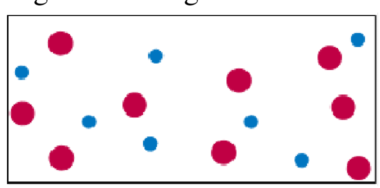
Learner's No: _______ **Date: _______________**

Answer all the questions. For each question there are ***four*** *possible answers:* ***A****,* ***B****,* ***C*** *and* ***D****. Choose the one that you consider as correct and mark your choice in SOFT pencil. If you want to change your answer, thoroughly erase the one you wish to delete.*

1. Which factors influence evaporation in nature?
   A Condensation
   B Frosting
   C Raining
   D Temperature

2. What do we call the amount of matter in an object?
   A Mass
   B Weight
   C Volume
   D Capacity

3. What can we say when two gases mix together?



   A Condense
   B Melt
   C Diffuse
   D Evaporate

4. The freezing point of a substance X is $0^{o}C$. If X is heated from $0^{o}C$ to $100^{o}C$, it changes from which state to which one?
   A Gas to liquid.
   B Liquid to gas.
   C Solid to liquid
   D Liquid to solid.

5. Which state of matter has no definite shape and no definite volume?
   A Gas
   B Liquid
   C Solid
   D Plasma

6. Which state(s) of matter takes the shape of the container they are placed in?
   A Liquid only
   B Liquid and gas
   C Gas only
   D Liquid and solid

7. Dry ice is used in fire extinguishers. The dry ice is stored in the cylinder in a solid form. When it sprayed on a fire, it quickly changes into the gas known as carbon dioxide (CO_2).

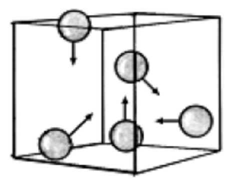
   What is this change of state called?
   A Sublimation
   B Distillation
   C Evaporation
   D Condensation

8. When the temperature of a liquid is increased a little, what happens to its particles?
   A They come closer together.
   B They start vibrating more.
   C They move so far apart that the liquid becomes a gas.
   D They stop vibrating.

9. What has mass and takes up space?
   A Weight
   B Volume
   C Space
   D Matter

10. A solid is a state of matter. What does it has?
   A An indefinite volume and an indefinite shape.
   B An indefinite volume and a definite shape.
   C A definite volume and definite shape.
   C A definite volume and an indefinite shape.

11. Study this diagram carefully. It shows the way that the particles of a gas occupy space.



The particles of gas have lots of space and move randomly at high speeds in three dimensions and collide with each other and with their container. The arrows represent the velocities of the gas particles. Select the property of a gas from the list below which is consistent with (matches) this micro-view of this state of matter.
   A Does not flow.
   B Definite volume.
   C Definite shape.
   D Can be compressed.

12. What happens to the particles of ice when it melts?
   A They lose energy and begin to move.
   B They come close together and lose energy.
   C They gain energy and begin to move.
   D They move very far apart and gain energy.

Mr Uugwanga made observations as he watched a white candle burn. Use his data to answer the next two questions.

Time	***Observations***
0 minute	Candle is lit, black smoke rises, flame starts
1 minute	Flame glows red and orange
2 minutes	Wax drips down sides
3 minutes	Candle is shorter than when it started
4 minutes	Hot gases are rising

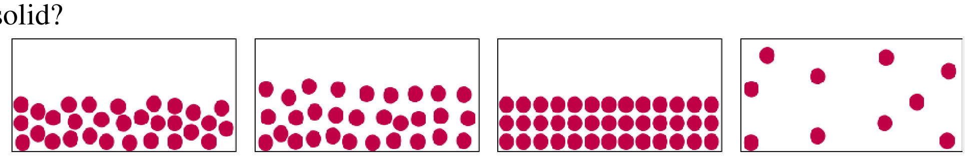
13. Which of Mr Uugwanga's observations would show that a burning candle has chemical change?
    - A Black smoke is given off; hot gases are rising.
    - B The wax starts to melt.
    - C The candle is white and made of wax and a wick.
    - D Time passes one minute at a time.

14. Which of Mr Uugwanga's observations would show that a burning candle has physical change?
    - A Black smoke is given off; hot gases are rising.
    - B The wax starts to melt.
    - C The flame glows red and orange.
    - D Time passes one minute at a time.

15. Which one of the following is not a property of a solid?
    - A Definite colour
    - B Definite mass.
    - C Definite shape
    - D Definite volume

16. How can we describe the particles of a liquid?
    - A Are tightly packed together and stay in a fixed position.
    - B Have no viscosity.
    - C Decrease in volume with increasing temperature.
    - D Are free to move in a container but remain in close contact with one another.

17. Which one of the following diagrams best represents a model of the particles in a solid?



A B C D

18. The term fluid may describe more than one state of matter. Which one of the following best describes a fluid?
    - A Liquid or solid
    - B Solid or liquid or gas
    - C Gas or liquid
    - D Solid or gas

19. A house made of toy blocks is weighed. It is taken apart and each block weighed separately. If the weight of all the blocks is added, what will it total?
    - A A little less than the weight of the house.
    - B The same as the house.
    - C A little more than the weight of the house.
    - D It would depend on how large the house was.

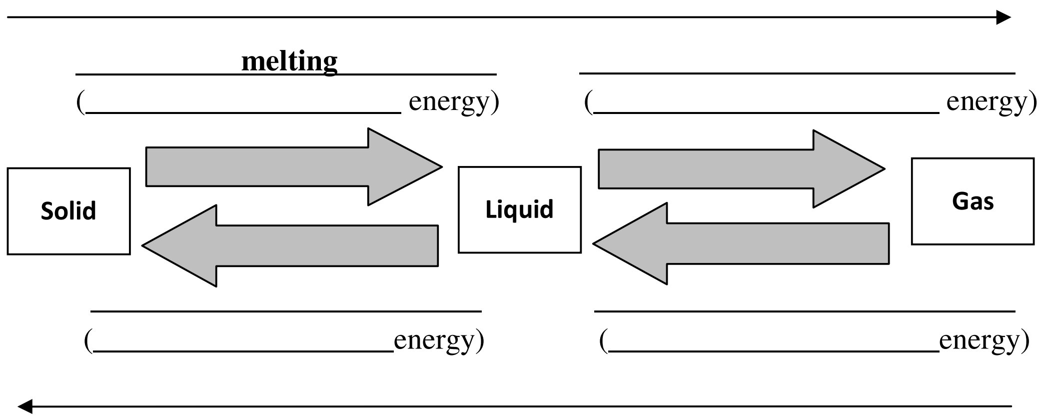
20. In which state of matter do the particles spread apart and fill all the space available to them?
    - A Plasma
    - B Liquid
    - C Gas
    - D Solid

21. Which one is an example of man-made materials?
    - A Wood
    - B Glass
    - C Oil
    - D Rocks

22. What happens during the process of sublimation?
    - A A solid turns directly into a gas.
    - B A solid turns into a liquid.
    - C A gas turns directly into a solid.
    - D A liquid turns into a gas.

SECTION B
OPEN-ENDED (STRUCTURED) QUESTIONS

1. Complete this diagram with suitable processes and state whether energy is absorbed or released at each process.



2. Fifty (50) grams of vinegar and 2 grams of baking soda are mixed together. A bubbling reaction takes place. The mixture is weighed again and now weighs 49 grams. Clearly describe what happens to the missing weight by using diagrams?

3. Use a diagram in order to show the physical change (property) of any substance.

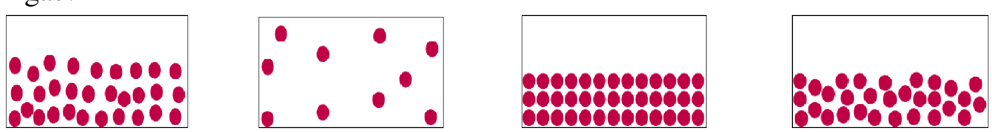
Appendix 11: <u>POST-TEST ITEMS ON "MATTER AND ITS PROPERTIES"</u>

<u>SECTION A</u> ***(Multiple Choice Questions)***

Learner's No: _______ **Date: _______________**

Answer all the questions. For each question there are ***four*** *possible answers:* ***A***, ***B***, ***C*** *and* ***D***. *Choose the one that you consider as correct and mark your choice in SOFT pencil. If you want to change your answer, thoroughly erase the one you wish to delete.*

1. Which one of the following diagrams best represents a model of the particles in a gas?



A B C D

2. What do we call the change from liquid to solid or the reverse of melting?
   A Condensation
   B Boiling
   C Sublimation
   D Freezing

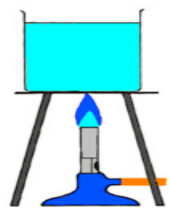
3. Water is boiled in a flask with a balloon over the top. As the water heats, the balloon expands. What has happened to the weight of this flask and balloon in this experiment?
   A It has increased as the balloon expands.
   B It has decreased as the water boiled away.
   C It has stayed the same.
   D It is unpredictable because the balloon is flexible.

4. Stretching of a rubber band is an example of what force?
   A Pushing force
   B Pulling force
   C Non-contact force
   D Man-made force

5. What is likely to be the same as the freezing point of water?
   A Melting point
   B Boiling point
   C Sublimation point
   D Evaporation point

6. How do you know when something is a solid?
   A It will pour.
   B It takes the shape of its container.
   C It cannot be seen easily.
   D It will hold its shape.

7. When a beaker of water is heated its volume increases a little. What is happening to the particles in the liquid?



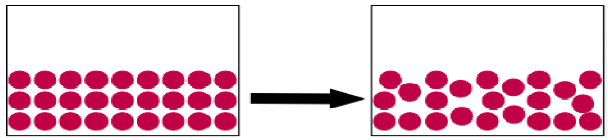
   A They are moving slower.
   B They are getting bigger.
   C They are getting smaller.
   D They are moving faster.

8. Which of these objects sink in water?
   A A balloon filled with air.
   B A glass bottle full of liquid.
   C An old bicycle tyre.
   D An old piece of mattress.

9. What evidence shows that ice has a physical change when left out in a room?
   A It reacts with oxygen in the air.
   B It changes to water.
   C It is hard and white.
   D It is cold to the touch.

10. What is vaporisation?
   A A gas becoming a liquid.
   B A liquid becoming a solid.
   C A gas becoming a solid.
   D A liquid becoming a gas.

11. Which change of state occurs when particles in a solid begin to move slowly past each other?



A Subliming
B Condensing
C Boiling
D Melting

12. What is the opposite of vaporisation?
A Condensation
B Sublimation
C Evaporation
D Freezing

The following data were collected by testing four substances. Each was tested to see if it floated in water, burned when lighted with a flame, or melt when heated. Use this data to answer the next two questions.

Substance	***Floated in water***	***Burned when lighted***	***Melted when heated***
1	Yes	Yes	No
2	No	No	No
3	Yes	Yes	No
4	No	No	Yes

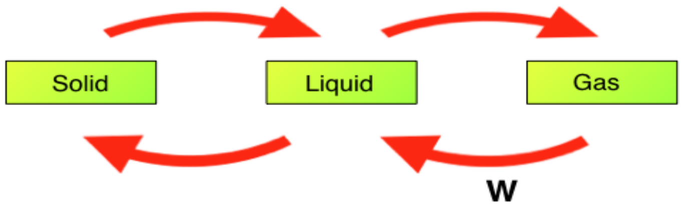
13. Which substance had a physical change?
1 A
2 B
3 C
4 D

14. Which of the tests is reversible?
A Floating in water
B Burning when lighted
C Melting when heated
D Burning and melting in water

15. What do we call the materials that can break easily?
    - A Flexible
    - B Brittle
    - C Waterproof
    - D Malleable

16. In which state of matter are particles packed tightly together in fixed positions?
    - A Gas
    - B Solid
    - C Liquid
    - D Plasma

17. The diagram shows the changes in state of water (H_2O). What is the process **W** called?



    - A Melting
    - B Condensation
    - C Boiling
    - D Freezing

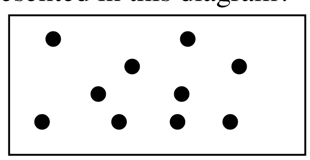
18. What does solar energy used for in our daily life?
    - A To pollute our environment.
    - B To cook our food.
    - C To generate income.
    - D To switch off the TV.

19. What do we call the smallest part of matter that can exist independently?
    - A Molecule
    - B Proton
    - C Atom
    - D Compound

20. It is an example of anything that has mass and takes up space.
   A Energy
   B Chemical change
   C Matter
   D Temperature

21. What is the difference between boiling and evaporation?
   A Evaporation occurs at one temperature only, while boiling may occur at different temperatures.
   B Boiling occurs at one temperature only, while evaporation may occur at different temperatures.
   C There is no difference between boiling and evaporation as in each case a liquid is changed into a gas.
   D Boiling changes the liquid into a gas while evaporation makes the liquid disappear.

22. Which state of matter is represented in this diagram?



   A Gas or liquid
   B Gas
   C Liquid
   D Solid

SECTION B
(OPEN-ENDED/STRUCTURED) QUESTIONS

1. Use the concepts given below to draw a diagram in order to show how these concepts link to each other:
   Evaporization, condensation, boiling, melting, freezing, boiling, 0°C, 100°C, absorbed energy, deposition, released energy, steam, water, ice, sublimation

2. What happens to an ice cube left out on a plate in a warm room? Describe what the ice cube looks like at first and what will happen next by using drawings.

3. Use a diagram to explain why burning a piece of wood is a chemical reaction.

Appendix 12: An individual inteview schedule for teachers

Opening statement

Mr (*teacher name*), it is my please to thank you for allowing me to interview you. The interview consists of five open-structured questions based on your understanding and use of concept mapping during your instruction process. You are therefore reminded that your responses will be treated with utmost confidentially and pseudonym will be used instead of your real name.

SEMI-STRUCTURED INTERVIEW:

1. Have you ever come across the word "concept mapping"? If yes, when did you come across it? What was the concept map all about? In your own words, can you describe what a concept map is all about?

2. Have you ever tried to make use of concept mapping in your teaching? If yes, what content did you teach?

3. Can you describe to me how you use the concept mapping strategy during that instruction?

4. To what extend did you use concept mapping strategy in teaching science? Is it poor, adequate, good, very good or excellent?

5. Did your studies or professional development courses prepare you on how to teach through the use of concept mapping?

Thank you for your time and valuable contribution!!