EXAMINING THE INFLUENCE OF CO-CURRICULAR ACTIVITIES ON LEARNER ATTITUDES AND ACHIEVEMENT IN PHYSICAL SCIENCES

ZUKISWA JUTA

3081406

submitted in fulfilment of the requirements for the degree of

Masters in Science Education

in the Science Learning Centre for Africa of Faculty of Education

at the University of the Western Cape

SUPERVISOR

PROFESSOR M.S. HARTLEY

Acknowledgements

A word of profound gratitude goes to my husband, son - Masixole, my maternal aunts, Koleka Pohleli and Nosipo Sonamzi; my in-laws, the Ndinisa family; Badi SSS, Isolomzi SSS, Zweliwelile SSS and Mtawelanga SSS management; the Dutywa and Butterworth education districts; the UWC faculty of education; and to Professor Chetty, Professor JM Smith, Professor Holtman, Dr Allie, and Melissa Petersen, my masters colleagues at UWC, whom were of great assistance in trying times, for their unwavering support.

The researcher also extends extensive gratitude and appreciation to Professor Shaheed Hartley, for not only being a supervisor but a mentor, a parent and a counselor. His constructive criticism, encouragement, constant inspiration and guidance has been invaluable.

Declaration

I, Zukiswa Juta, declare that the work **Examining the influence of co-curricular activities on learner attitudes towards and achievement in Physical Sciences,** is my own original work and has not been submitted to any other university for a degree. All sources have been fully acknowledged in the text and a list of references has been provided.

__________________________ ___________________

Zukiswa Juta **Date**

Dedication

This study is dedicated to Physical Sciences curriculum planners and developers, Curriculum advisors, teachers at large, education specialists, school management teams, Physical Sciences teachers, teacher development section across the Eastern Cape, Republic of South Africa and internationally.

ABSTRACT

This study seeks to examine the influence of co-curricular activities on learner attitudes in Further Education and Training (FET) Physical Sciences. Butterworth FET school in the Eastern Cape Province, South Africa was used as a case example, where Grade 10 and Grade 11 learners were exposed to various Science related activities that allowed them to have a direct interaction and hands-on experience with curriculum and co-curricular Science activities. The case study was conducted at the researcher's school. When benchmarked against various international and national tests, the level of general performance of South African learners in Science and mathematics are lagging behind the rest of the world. In cluster meetings, many science education colleagues hypothesized that the poor achievement of leaners in the NSC (National Senior Certificate) and equivalent qualifications could possibly be attributed to learners' attitudes towards the subject.

The purpose of this study was therefore to expose learners to various co-curricular Science activities **and used this as a basis** to examine learners' attitudes towards Physical Sciences. Learners were encouraged to actively engage in Science activities, investigations and projects, to explore if their attitude towards the subject could be influenced by these experiences. The study was underpinned by Constructivism, which helped learners to extract scientific meaning from what they already know, thus strengthening learners' cognition. A mixed method approach was used, using interviews and questionnaires as instruments for data collection. A sample of 35 learners and 3 teachers, was used. This research study found that context teaching through co-curricular activities helped learners to comprehend Physical Sciences better and gave them a chance to indulge with their science rich environment. They constructed scientific meaning from their experiences in the co-curricular science activities and appreciated this exposure as it assisted them to better understand science curriculum concepts. They related Physical Sciences to the context of their surroundings, which helped them to holistically grasp principles and laws used in the subject. This research study can add scientific value locally and nationally, as it provided a means to improve learners' attitudes towards Science in general, and Physical Sciences in particular. The research study further added to baseline data on limited South African studies and on learners' attitudes towards gateway subjects like Physical Sciences. This study recommended that the co-curricular activities should be merged with both GET and FET curricula.

Key words

Poor performance, Higher order questions, Attitudes towards Physical Sciences, Co-curricular activities, Constructivism, Scientific method, Scientific process, Scientific language, Perceptions about Physical Sciences, Interests towards Physical Sciences and learner achievement.

ACRONYMS USED IN THE STUDY

ARMSCOR - Armaments Corporation of South Africa

ATQ - Attitude Test Questionnaire

ANAs - Annual National assessments

CASS - Continuous Assessment

CCAIT- Co-Curricular Activities' In-Service Training

CBP-Confidence-Based Perception

CPTDP - Continuous Professional Teacher Development Programs

CL - Cognitive Level e.g. CL_1 means Cognitive Level 1

DOSE - Diffusion Of Scientific Emotions.

FI, L - Focus Group Interview for Learners e.g. FI, L_{10} means Focus Group Interview Learner 10

II, T - Individual Interview for Teachers e.g. II, T_1 means Individual Interview Teacher 1

FET- Further Education and Training Band

GET- General Education and Training Band

ICT - Information Communication Technology

LAIS - Learner Attainment Intervention Strategy

LBP - Learner-Based Perception

LTSM - Learner Teacher Support Material

LOLT - Language Of Teaching and Learning

MST- Mathematics, Science and Technology

MSTE - Mathematics, Science & Technology Education

NDP - National Development Plan

NSC - National Senior Certificate

NSLA - National Strategy for Learner Attainment

PBP - Parent-Based Perception

PBTL - Practical-Based Teaching and Learning

PLC's - Professional Learning Communities

SBA – School-Based Assessment

SLBI - Scientific Language-Based Improvement

SLSM - Science Learner Support Material

SMT - School Management Team

TIMSS - Trends in International Mathematics and Science Study

TOSRA - Test of Science-Related Attitudes

WSU - Walter Sisulu University

Table of Contents

List of tables

List of figures

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This introductory chapter provides the rationale for the study addressing the background and context of the study. It also provides an understanding of the state of Science education in South Africa, and interventions used to address the challenges in Science education. The research problem is described leading to the research question, significance and limitations of the study.

1.2 BACKGROUND TO THE STUDY

There is an old saying which goes, *"The attitude determines the altitude,".* (Zig Ziglar - American motivational speaker and author, 2002). Within this context, it could mean that learners need to be motivated at an early age to be successful, especially in the General Education and Training (GET) band. GET band is a range of learners from Grade R to Grade 9. If learners' interest in Science is developed at an early age, the learner will develop scientific knowledge, problem solving skills, comprehension, analysis and synthesis. Several studies found that the erosion of children's interest in School Science occurs between nine (9) and sixteen (16) years of age (Hadden and Johnstone, 1983). International findings indicate that learners experience difficulties with certain Physical Science concepts, especially in those that need application in real-life situations (Harlen and James, 1997). It is therefore the duty of the communities and schools to instill positive attitude towards Physical Sciences in learners. Within both schools and broader communities in South Africa, there is a perception that Physical Sciences is a difficult subject, and is meant for the academically strong learners only. Society should fully support the learning of scientific values by learners.

This study is conducted in the Eastern Cape Province of South Africa. The Eastern Cape Province is faced with poor results in Physical Sciences, especially in rural schools in comparison to the semi-urban schools. Table 1 below represents the Physical Sciences Matriculation results over the past four years (2013 - 2016, National Diagnostic Reports). The table is portraying a consistent decline in matric results especially at school level. The decline in

Physical Sciences results is not only the concern in Eastern Cape Province, but a national concern as well, as shown in Table 1.

There is a consistent decline in the Physical Sciences pass percentages from national to provincial levels, which is extended to the district in which the school where this study is conducted. This lowest pass percentage was produced in 2014.

Table 1: Physical Sciences NSC results for the period 2012 to 2016

Year	National	Provincial	District	Research school
2013	67,4	55,8	52,8	64
2014	61,5	51,5	46, 3	20
2015	56,5	49,5	41, 4	23,20
2016	62.0	49.6	42.8	37

The poor performance problem extends from educational districts down to individual schools. The setbacks can be viewed in the graph below (Figure 1) which summarizes the question-by-question analysis of the first paper (Physics) of the National Senior Certificate (NSC) Physical Sciences 2014 final examination, published in the Chief Marker's Report (2014). As depicted by the graph, learners poorly answered questions 1, 2, 5 and 7, which required problem solving skills (calculations), scientific inquiry (investigations and experiments) and scientific application (application of Physical Sciences laws and principles). The inability of learners to express themselves in questions of this nature revealed their lack of scientific grounding and scientific knowledge. Vhurumuku (2010) argued that testing of ideas is not confined to pen and paper, but rather active involvement of learners in investigative lessons. In other words, Vhurumuku agreed that lessons learnt at school need to be supplemented with hands on activities that develop learners' critical thinking.

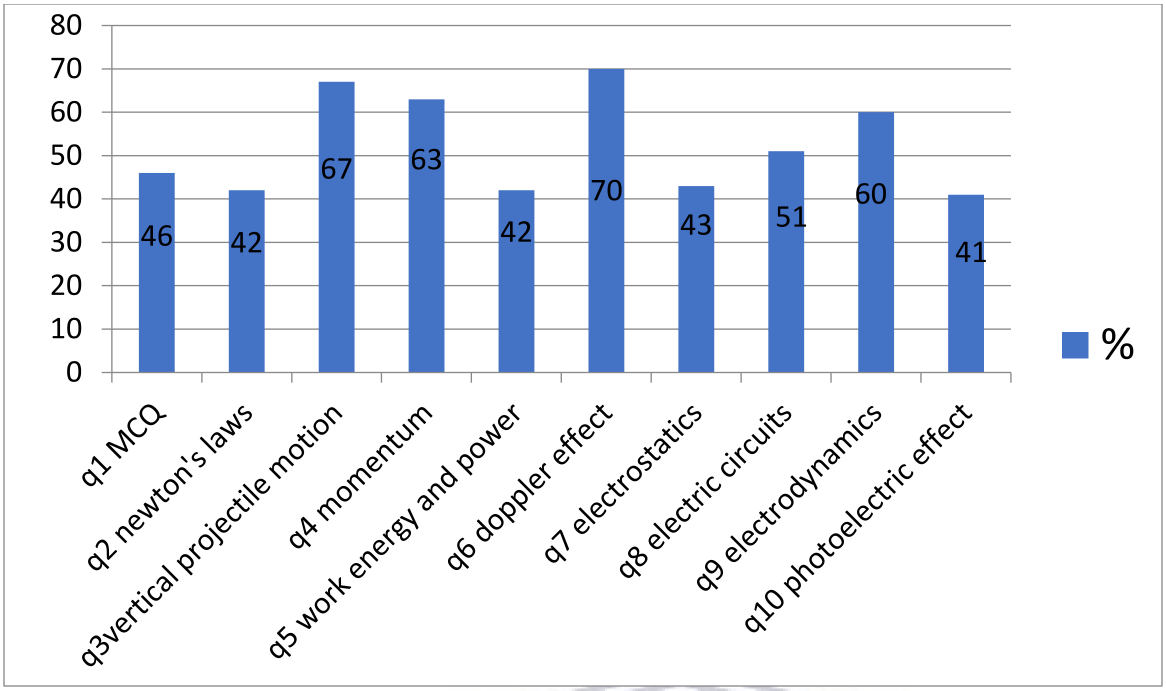

Figure 1: Question-by-question analysis of the 2014 Physical Sciences NSC examination

1.3 CONTEXT OF THE STUDY.

1.3.1 Background of the researcher

The researcher holds a Secondary Teacher's Diploma (STD), Bachelor of Science (BSc), Advanced Certificate in Education (ACE) in FET Physical Sciences and Bachelor of Education Honors (B.Ed. Hons) in Science Education. The researcher has been teaching Physical Sciences for 20 years in the FET band.

1.3.2 The research school and its geographical setting.

The school in which the research was conducted is a previously disadvantaged school in a deep rural village in the dusty town of Ngqamakhwe, which falls under the Butterworth education district in the Eastern Cape, South Africa. There were three teachers offering Physical Sciences, of which one is under-qualified, possessing only a matric certificate. This teacher did not receive formal training as a teacher and depends only on the support given to him by his immediate supervisor (Head of Department) and curriculum advisor during cluster meetings. The Head of Department is limited in her knowledge of Physical Sciences, as she majored in Life Sciences and Agricultural Sciences. She has been teaching in the General Education and Training (GET) band for several years. The research school laboratory has no equipment to enhance teaching and learning of Physical Sciences through practical work.

Many teachers in South Africa use outdated teaching practices and lack basic content knowledge (Makgato & Mji, 2006:254). The research conducted by (Makgato & Mji, 2006:254) holds the truth as it is the case in the research school. During the apartheid era, schools in South Africa were organized and run on a racially segregated basis in terms of facilities, human and material resources, curriculum content and assessment procedures. The background to this history is concisely presented by the former Minister of Education, Professor Kader Asmal (2002) when he stated:

"…. *The profile of our society still reflects gross inequalities in education attainment across racial lines. Many people have lost the opportunity of pursuing their education through formal schooling because of the education policies of the apartheid government, especially 'bantu' education. The few who were fortunate to obtain the education they could, had do to so under extremely trying circumstances, characterized by low morale and a poor culture of teaching and learning. Major unrest and dilapidated school buildings were the norm (p.15)."*

The school at which the study is conducted continues to suffer the conditions and consequences of this political imbalance, as it is a previously disadvantaged school and a pure Xhosa racial school as per group areas acts of 1966. The school is situated 80 km from Butterworth town, and is an under-resourced school. Christie (2008) highlighted that during the apartheid era, the black population was considered inferior, and a few years of free education were regarded as sufficient to prepare black people for laborers' roles. In support of Christie's statement, it was fact that very few teachers were trained and could specialize in Physical Sciences. Act No 47 of 1953 confirms the segregation of blacks in various fields of education, as explained in Hlatshwayo (2000) study.

1.3.3 Socio-economic context of the research school community

According to Baker & Jones (2005), there is an association between low socio-economic status and inferior performance in Science in school. These researchers also found that the socioeconomic status does not directly affect the learners' performance; instead the living conditions associated with it, such as the resources available at home, the type of informal education received by the learners at home as well as the values and norms upheld by the community are factors that could have an impact on the achievement of learners. As the saying goes, *"it takes the whole village to raise a child"*, so learners construct meaning from the information and phenomena at their disposal, in addition to what they already know.

Most households in the research school village live below the poverty line in South Africa. A poverty line divides the population into two groups: below the line a household/individual is considered to be poor, and above the line it is considered better-off (Woolard, 2002). Several reasons, including illiteracy, unemployment and lack of skills, mean most of parents of learners at the research school are living below the poverty line and unable to assist their children with school work, particularly Physical Sciences. Breakwell (1992) identifies attitudes to Science as being more critically dependent on the support of the mother, and she points out that mothers may be unwittingly perpetuating the inequalities in Science by encouraging their sons more than their daughters. Furthermore, Breakwell identifies extra-curricular activities as being correlated with parental support, particularly that of the father. Contrary to Breakwell's study, learners in the research study received no assistance from their parents.

1.4 STATE OF SCIENCE EDUCATION IN SOUTH AFRICA

A large component of studies and research are focused on mathematics education with a limited emphasis on Science education. Many universities offer mathematics education; the researcher knows this from personal experience. The researcher always wanted to further studies in FET Physical Sciences as early as 1996, but could not find a university that offered ACE in Physical Sciences until 2010 when the researcher registered with the University of Western Cape. The research that was conducted by Murphy (2017) confirms that most teachers at black high schools were not qualified to teach Science, with less than 20% having appropriate university diplomas. In the light of Murphy's research, the teachers generally lack Science pedagogy and do not understand the nature of Science, nor the scientific world view. Such teachers would struggle with curriculum reforms, which could lead to under-performance.

The newspaper "The Teacher" (2010) revealed that funding to fuel-up Science by resourcing Science centres to develop both teachers and learners is a challenge. Although the centres strive to make Science available to as many people as possible, funding remained the biggest challenge. Centres need a steady injection of funds to help cover the costs of needy learners and teachers attending workshops and enrichment programmes (The Teacher, 2010). The problem of inferior performance at the FET band is a result of poor foundation at GET level, and the inability of teachers to implement curriculums at that level, as posited by the Department of Basic Education (DBE, 2011 & 2012). Along with the recently implemented curriculum, namely Curriculum and Assessment Policy Statements (CAPS) (DBE, 2011), the Annual National Assessments (ANAs) in Grades 1–6 and 9 have been introduced. The ANAs were explicitly focused on providing system-wide information on learner performance aimed at allowing for comparisons between schools, districts and provinces (DBE, 2012). While their introduction indicates increased monitoring of the 'crisis' in education, it does little to support the improvement of learners' performance. As observed in the Trends in international Mathematics and Science Study (TIMSS), the results of these assessments show alarmingly poor mathematics skills across learners in the primary grades, with average performance steadily declining each year from 68% in Grade 1 to 27% in Grade 6 (DBE, 2012).

Chisholm and Chilisa (2012) pointed out that South Africa suffers from extreme income inequality and crippling poverty, and the effects of these social handicaps have not been examined in terms of the impact they have on Mathematics and Science education. They further explain that there are many poor countries, including our direct neighbours, achieving better Mathematics and Science performance, none of which suffer the consequences of elevated levels of inequality, or a history in which the education of most of the people was deliberately and violently undermined. As articulated by Chisholm and Chilisa (2012), Science education has been one of the many casualties the Department of Education has suffered as a consequence of the apartheid regime, manifesting today in a high failure rate in grade 12 Physical Sciences. A firm grounding and understanding of curriculum reform is vital, since it constitutes the foundations of teaching and learning, informing polices and guidelines on lesson planning, teaching and assessment stages, including remedial work and feedback to learners. Moreover, quality and competency of the teacher is vital, as learners' performances can be directly linked to not only what their teacher has exposed them to, but also how.

Chisholm and Chilisa (2012) in agreement with Carnoy, Chisholm, Chilisa (2012), pointed to teacher quality and opportunity to learn (e.g. average of 52 lessons in SA and 78 in Botswana over a ten-month period) as key influencing factors on the differential performance across the border. While their study did not pose particular questions addressing learner and teacher agency and dispositions, they did note a '*'South African effect'*— suggesting that the effects of apartheid may still weigh on teachers' and students' perceptions of how successful both can be academically.

Additionally, South Africa's history of 'Bantu Education' in the 1950s, and the Bantustan system of the 1960s and 1970s, was accompanied by physical and symbolic violence. This included the violence of repression of opposition, and the violence of the subordination of aspiration and possibilities through the limited (and limiting) education made available (Chisholm & Chilisa, 2012). This research points to the effects of repression on the dispositions and mindsets of South African learners and teachers as a problem possibly unique to South Africa, and that needs to be further interrogated in relation to its impact on under-performance when considering ways to counteract it. The Carnoy, Chislom, Addy, Arends, Baloyi, Irving and Raab (2011) study focused on the North-West Province, which gathered information on student and teacher knowledge, indicated low levels of mathematics teacher knowledge in all but the highest-performing schools. However, they emphasized that one should not argue simplistically that higher levels of mathematical content knowledge (CK) and pedagogical content knowledge (PCK) for teachers are causal factors in higher performance of learners. They note that it could also mean that *''higher scoring teachers did not 'produce' these higher test scores, but rather were 'matched' in some way with higher scoring students,''* (p.95). In the summary, they write: *''Better teachers tend to be attracted to schools with better performing learners,''* (p.7).

An important aspect of this study is that it measured gains in student learning through pre- and post-tests over an academic year, rather than simply looking at performance at a particular point in time. Having cited and been supported by literature, the researcher concludes that Science education must be taken seriously by curriculum planners, policy makers, curriculum advisors, curriculum implementers, communities, parents and learners, because it is a key foundation for producing future sustainable scientists.

1.5 INTERVENTIONS IN SCIENCE EDUCATION IN SOUTH AFRICA AND EASTERN CAPE PROVINCE

Learner Attainment Improvement strategy (LAIS) programs that are in place as a form alleviating challenges in Physical Sciences include:

1. Incubation classes which take a few learners from a large pool of learners and only cater for academically strong learners, whereas most learners are those who are struggling with Physical Sciences.
2. Winter and spring schools which are marked by overcrowded classes and do more to cater for individual attention for learners.
3. The Dinaledi program, which supports and develops the schools that are already performing better and in the province, takes only 60 schools.
4. The Min and Astro quiz competitions that take place in March can take only two learners per school.
5. The National Science Festival - held in Grahamstown once a year - which not all learners are able to attend, as it far from many schools in the province.
6. NMMU (Nelson Mandela Metropolitan University) program for FET Physical Science teachers which aims at developing teachers in Physical Sciences.
7. Science Olympiads, SAASTA (South African Agency for Science and Technology Advancement), schools' Science debates and Science weeks, while encouraging, target only a few learners, and other schools do not bother participating.
8. 1+4 program, which is aimed at developing foundation phase teachers in numeracy, an essential base for Physical Sciences.
9. The Mathematics, Science and Technology Grant, which is aimed at supporting schools that struggle with Physical Sciences.
10. University of the Western Cape Programs in the Eastern Cape Province from 2010 to date:

- Advanced Certificate Education (ACE) in FET (Further Education and Training) Physical Sciences which was a course that was offered to FET Physical Sciences teachers and equipped them with content gap, development of Science Clubs, and understanding of nature of Science scientific knowledge.

- The programme took the teachers with ACE to Honours level, where they studied and gained an in-depth understanding of Science and Science education through curriculum and pedagogy, ICT (Information Communication Technology) learning, Science education and Indigenous knowledge systems. The Honours Degree exposed teachers to various educational strategies during teaching and learning, from which they learnt measures of adapting to curriculum reforms.
- The Honours group proceeded to a Masters Degree, where they wrote theses addressing the challenges faced by the Eastern Cape Province's FET Physical Sciences, and means to combat them.
- The Short Course Certificate for Natural Science teachers which gave them the base for matter and material needed in grade 12.

In my opinion, the programmes that need to be employed in learner/teacher development are long term programmes that leave teachers with accredited certificates, as opposed to one day or one-week programs. Once the teacher or learner has been involved in a continuous learning programme, they seem to value and take ownership of the results, enabling them to pass it on from generation to generation.

1.6 RESEARCH PROBLEM

The Republic of South Africa is faced with a high failure rate in Physical Sciences, especially within the province of the Eastern Cape, which always comes last or second last in national Matriculation results. This research study seeks to explore the approaches that can be employed to mitigate this and improve results. At the school where my research was conducted, most learners show various attitudes towards Physical Sciences which hinder their performance, even though they elected to take the subject voluntarily. Learners are unable to handle higher order questions due to a lack of understanding the nature of scientific inquiry, the ability to hypothesize, to apply or develop problem solving skills and to express their findings through scientific interpretation. Miller (1997) also cited that the level of scientific literacy in his study is deplorably low due to negative attitudes shown by learners towards Science. Miller (1997) therefore in his study confirms that the attitudes shown by learners towards Physical Sciences is a worldwide challenge, confirming that there is a dire need to improve learners' attitude towards Science and Science activities to improve their interest, aptitude and involvement in Science, engineering and technology. Given the background of learners, the socio-economic status in the district and the lack of exposure to Science, it would prove challenging for learners to improve their achievement in Science subjects and Science examination. This study was therefore directed at improving learners' attitudes towards Physical Sciences through the application of co-curricular activities.

1.7 RESEARCH QUESTION

This study addresses the following research question:

WHAT IS THE INFLUENCE OF SCIENCE EXPO AND OTHER CO-CURRICULAR ACTIVITIES ON LEARNERS' ATTITUDES AND ACHIEVEMENTS IN PHYSICAL SCIENCES?

1.8. SIGNIFICANCE OF THE STUDY

This study is significant for several reasons. Firstly, the study could provide useful indicators on improving learners' attitudes towards Physical Sciences. Secondly, the study could provide a guide to fellow teachers, curriculum advisors and curriculum planners on strategies to improve learners' involvement in Science and selection of Science subjects. The research study could also provide baseline data on improving learners' attitude towards Physical Sciences and Science subjects for future studies nationally and internationally. Lastly, the study could provide a standard on how to develop learners' interrogative and problem-solving skills by establishing ways to increase learners' confidence and comprehension, through providing a thorough grounding in Physical Sciences by exposing them to projects which have real life context, such as Science Expos, National Science weeks, as well as other co-curricular activities.

1.9 LIMITATIONS TO THE STUDY

One of the challenges faced by the researcher was having to change schools from the Dutywa to the Butterworth district. This meant having to survey the learners' problems and check if my proposal and the research topic fit well with the learners' challenges at the new school, but fortunately the school is a deep rural school and learners had almost lost the hope to pass Physical Sciences, as they had no teacher before the researcher arrived. Letting learners explore without supplying them with resources proved to be too much of a challenge for learners. The proceedings of the study that involved participants occurred in the afternoons, and were disturbed by extracurricular activities like music, sports, meetings and cultural activities.

Ten learners pulled out of the study which reduced the sample size to 35 instead of 45, as originally planned. Some learners did extensive investigations where they compared a number of variables, and the researcher had to assist them to narrow their research project to required variables and eliminate others. Some learners who refused to be part of the sample at the beginning wanted to join participants and the researcher had to be firm and explain the sampling criterion to them.

1.10 STRUCTURE OF THE THESIS

The outline of the thesis is designed such that it is divided into the following chapters:

Chapter 1: Introduction

This chapter provides the rationale for the study by providing the background to the research problem.

Chapter 2: Literature review

This chapter outlines the theoretical framework and relevant literature concerning co-curricular activities and their impact on learner attitudes and performance in Physical Sciences.

Chapter 3: Methodology

This chapter explains the methodology employed in the form of the research design, research approaches, data collection and data analysis methods.

Chapter 4: Findings

This chapter presents the findings in the research study**.**

Chapter 5: Discussion

This chapter provides the discussion of the findings presented in Chapter 4.

Chapter 6: Implications

This chapter outlines the implications of the study and recommendations for further study.

1.11 CONCLUSION

This chapter gave the rationale for the research study and the context in which the study is based on. The research problem and research questions are highlighted.

This chapter is followed by literature review which highlights the theoretical framework and relevant literature that underpins the study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The previous chapter introduced an overview of the study. This chapter scrutinizes the existing literature on examining the influence of co-curricular activities on learner attitudes towards Physical Sciences, the state of Science education nationally and internationally as well as the theories underpinning the study. The main objective of this chapter is to reveal the path of previous studies and how this investigation is related to them. Boote and Beile (2005) pointed out that a complimentary review is the one which helps the researcher to learn from other scholars and inspire or kindle innovative ideas. As alluded by Boote and Beile (2005) this research study undertook to find the literature that aligns with it.

2.2 THEORETICAL FRAMEWORK

This study is underpinned by the constructivist theory

2.2.1 Constructivism

According to Piaget (1976) constructivism refers to learning as the construction of new meanings (knowledge) by the learner him/herself. The constructivist theory explains learning as an active process of formulating meaning of the world around us. As opposed to behaviorism and critical theory propositions, constructivist theory assumes that learning is more active and self-directed. Accommodation and assimilation categorizes constructivism into two; with the main emphasis on teacher being a mediator who is scaffolding, mentors and give guidance to the learner; and a learner being an active participant (Piaget, 1976).

Assimilation occurs when a learner perceives new objects or events in terms of existing schemas or operations. Piaget (1976) emphasizes the functional quality of assimilation, where learners tend to apply any mental structure that is available to assimilate a new event, and actively seek to use this newly acquired mental structure, whereas accommodation refers to the process of changing internal mental structures to provide consistency with external reality. It occurs when existing schemas or operations must be modified, or new schemas are created to account for a new experience. Obviously, accommodation influences assimilation, and vice versa. As reality is assimilated, structures are accommodated. Piaget's assimilation and accommodation relate to this research study in that learners reason, infer, hypothesize, process information and draw up conclusions based on what they already know and understand.

In agreement to what Piaget proposed, Vygotsky (1978) cited that during construction of meaning, a learner uses two developmental steps called Zone of Proximal Development (ZPD) and More Knowledgeable Other (MKO). According to Vygotsky (1978), the ZPD is the distance between the *"actual developmental level as determined by independent problem solving and the level of potential development",* as determined through problem solving under adult guidance or in collaboration with more capable peers. MKO refers to someone who has a better understanding or a higher ability level than the learner, with respect to a task, process, or concept. This research study therefore applied both ZPD and MKO steps, because the learners could explore their environment and surroundings through project development using problem-solving skills with the help and guidance of the teacher, where necessary.

Many researchers argue that constructivism is divided into radical and social constructivism. Radical constructivist approach is attributed from the works of Piaget and social constructivism is based on the writings of Vygotsky (O'Loughlin, 1992, Osborne, 1996, Piaget, 1951 & Staver, 1997). They further explain that in a radical constructivist approach, knowledge is developed when knowledge about the world is true, the person believes the knowledge and there is a reasonable belief that the knowledge is true, whereas social constructivism emphasizes the influence of culture and social contexts in which knowledge is developed and how can it influence learning. Social constructivism refers to learning as the result of the active participation in a 'community', where new meanings are co-constructed by the learner and his/her 'community', and knowledge is the result of consensus (Gruender, 1996, Savery & Duffy, 1995 in Brown, 2006).
The elements on which social constructivism is based are reality, knowledge and learning. Kukla (2000) points out that reality is constructed through human activity where members of a society

together invent the properties of the world and reality cannot be discovered: it does not exist prior to its social invention. Several researchers (Ernest, 1999; Gredler, 1997; Pratt & Floden, 1994) concur that knowledge is a human product, and is socially and culturally constructed. Individuals create meaning through their interactions with each other and with the environment they live in. Furthermore, social constructivists' view is that learning is a social process which does not take place only within an individual, nor a passive development of behaviors that are shaped by external forces, and that meaningful learning occurs when individuals are engaged in social activities (McMahon, 1997). Similarly, the learners in this research study were given an opportunity to indulge with their Science-rich environment in the form of a Science-Exposition (Expo) which is a co-curricular activity in order to access knowledge from reality in an educational learning process.

This research study was based on social constructivism approach which suggests that learners should construct their own understanding and knowledge of the world, through undergoing experiences, and reflecting on those experiences.

2.2.2. Studies on constructivism

Gilbert, Osborne and Fensham (1982) argues that children are not passive learners, and the way they make sense and scientific meaning of their experiences leads to the development of an intuitive knowledge known as "children's Science". Duit & Treagust (2003) further posited that findings from many research studies over the past three decades show that students do not come into Science instruction without any pre-instructional knowledge in the form of informal education or beliefs about the Science phenomena and concepts taught at school. The researcher therefore holds a belief that learners understand Science concepts and phenomena learnt at home in a unique way from what is learnt at school. They do not link everyday knowledge with school knowledge. Rather, they treat these two bodies of knowledge as different entities; thus, there is a dire need for this research study to help learners harmonize ideas, concepts and phenomena learnt from the environment at home with those learnt at school.

Constructivist ideas are developed by merging various cognitive approaches with a focus on viewing knowledge as being constructed through the Piagetian interplay of assimilation and accommodation, Kuhnian ideas of theory change in the history of Science and the radical constructivist ideas of people like von Glasersfeld (1989). Contrary to their research, there are limitations of the Constructivist ideas of the 1980s and early 1990s which led to their merger with social constructivist and social cultural orientations. More recently these resulted in recommendations to employ multi-perspective epistemological frameworks in order to adequately address the complex process of learning (Duit & Treagust, 1998).

Leach & Scott (1998) concur with writers in the European didactic tradition (e.g., Viennot & Rainson, 1999; Lijnse, 1995, 2000; Tiberghien & Le Marechal, 2000) that the fundamental contribution that research in Science education can make is in clarifying the objectives of Science teaching by careful analysis of the knowledge to be taught, and learners' preinstructional knowledge. In their view, they state that an important test of the perspective is provided by the extent to which it can illuminate learning demands that can be utilized as teaching objectives and provide insights about the role of the teacher in implementing teaching that successfully addresses those objectives. They furthermore argue and concur with Lijnse (1995) that there is some modest evidence that instructional approaches that are designed based on insights about students' prior knowledge are more effective than 'conventional' teaching approaches. Moreover, research in Science education has some considerable way to go if its aim is to produce a body of knowledge about Science teaching that can be drawn upon in a systematic way to improve students' learning. Social environment should be taken into consideration as learners draw scientific ideas from it. Vosniadou & Ioannides (1998) explain that individual views on Science learning are a result of influence of social environment and conceptual structures can change because of learner's observations of cultural context. They further point out that learner's representations of earth are a product of their attempts to link and integrate experiences of living on earth with the cultural image of earth as spherical.

The researcher fully agrees with the studies made by all the researchers mentioned above because constructivism suggests that, in the classroom learners should use active techniques like experiments, real world problem solving (e.g. engaging in Science Clubs, Science conferences, Science Expos, etc.) to enrich their knowledge. Constructivism highlights that a learner's curiosity should be triggered, and learners should be allowed to construct knowledge based on their individual experiences and hypotheses of the environment. Learners do not engage in teaching and learning process as tabula rasa (clean slates) but construct meaning of scientific phenomena by inferring and referring to what they already know and have drawn from their environment.

Leach & Scott (1998) portray Science learning as a gradual and complex affair during which information that comes in through observation and/or instruction is used to enrich, replace or restructure existing beliefs and presuppositions. The researcher concurs with this view because learners come to school with a certain understanding of certain concepts based on their surroundings, which is the base for teaching and learning. In agreement with Leach & Scott (1998), the IsiXhosa speaking learners grasp the concept of lightning as created by witchdoctors (izangoma) because they extracted that from their surroundings. The role of teachers in such cases is to restructure the information learners have, by fusing in Physical Sciences concepts and driving them to scientific meaning of lightning (lightning is caused by buildup of charges in atmosphere). In a nutshell, Physical Sciences concepts, Science learning, scientific knowledge acquisition and scientific perceptions are a result of social transmission, culture and social observations as well as integration of scientific language and teacher-learner support material to construct new scientific meaning and understanding.

Von Glasersfeld, (1996) in radical constructivism argues that all learning starts from already existing knowledge, and the teacher, therefore, must start always with students' pre-existing knowledge to facilitate construction processes in the direction of the acknowledged instructional goal of transmitting book and scientific knowledge. As already alluded by von Glasersfeld, (1996), the learner's prior knowledge must be directed towards the desired goal, so that it is not extensive but scientific. Roth & Roychoudhury (1994) claim that constructivism didactics is clearly dominated by moderate positions whose influence grows in proportion to the extent to which they pursue concrete research and practical projects, not just programmatic arguments. Only a moderate position can open, systematically and practically, the possibility and legitimacy of an activity like teaching—an attempt to promote learners' learning as a construction process, to accompany it, and to support it, and, thereby, give a constructivist-didactic thinking in the first place. Roth & Roychoudhury (1994) research fits well with this research study because it suggests that learners' prior knowledge must be positioned in the scientific world, and given scientific meaning per scientific theories and principles that already exist.

Rubeck (1992) and Rubeck & Enochs (1991) maintain that teachers who are capable of teaching via inquiry/constructivist formats tend to be those who have positive attitudes toward Physical Sciences and Science teaching, tend to be measured as effective teachers of science, and have learners who are successful in learning Physical Sciences. They further argue that the perceptions developed and held by these teachers' learners about Science and scientists, are often believed to be more positive than are the perceptions held by learners taught via more expository, authoritative approaches. Finson (2002) highlights that the consequence of these differential beliefs is that the former learner groups tend to have more positive perceptions of scientists than do learners from the latter group, and their images of scientists tend to be less stereotypical. Finson (2002) further alludes that, such learners are more likely to see themselves in the role of scientists and view such a role as being more positive than negative.

Fleury & Bentley (1991) view the way Science knowledge is gathered as the infrastructure of scientific knowledge and argue that if the infrastructure is faulty, then any understanding constructed on it will be fallible. The researcher therefore concurs with this statement because unless learners can construct scientific meaning from the interaction with the environment and social life, then there would be no challenges Science learnt at school. Brush (1989) notes that generally teachers are not aware of construction of scientific thought from social and environmental interaction; this research study then tried to vector teachers towards using environment-linked lessons in the teaching of Physical Sciences. Various researchers in agreement with Fleury and Bentley (1991) suggest that Physical Sciences teachers should allow their learners to spend more time in independent discovery-based activities in an environment which is inviting, challenging and motivating, with a variety of learning materials so that they can interact with the materials using all their senses (Berk, 2006 :152; DeWitt, 2009:13; Shaffer & Kipp, 2007 :288).

Furthermore, Trowbridge, Bybee and Powell (2004) highlighted that Science teaching and learning must be characterized by an emphasis on active learning, whereby the learners are seen to be active in scientific investigations in a classroom environment full of varied materials and activities not familiar to them. In a nutshell, Trowbridge, et al. depicts that students learn better when indulging and exploring new material. Shaffer & Kipp (2007) & Kramer (2002) argued that Science learners should, therefore, be presented with problems that provide them with opportunities to engage in thinking, insights and problem solving as an integral part of their Science lessons. They further noted that social learning strongly asserts that human cognitive development is inherently socio-cultural, such that it is influenced by beliefs, values and tools of intellectual adaptation passed to individuals by their culture and environment. They also believe that children's mental, language and social development is supported by and enhanced through such social interactions.

Research has also shown that the learner's concept of his physical world is a function of the special and unique interaction between the learner himself, the teacher, others, the environment, experiences, needs and ideals (De Witt, 2000; Morrison, Craig, Jiang, Pan, Cameron & DesMeules 2009). Shaffer and Kipp (2007) suggest that Science teachers should create positive social-culture environments by arranging cooperative and collaborative learning tasks in which learners are encouraged to assist each other to perform scientific activities. All in all the idea here, is that less competent learners in the team are likely to benefit from the instructions they receive from their more skillful peers, who also benefit by playing the role of their teacher, thus enabling collaborative learning.

Chi-Kin Le e (2000) points out that the importance of environmental education should be emphasized by its integration in the formal school curriculum in many countries. MICOA (1996); Chapani & Daibem (2003) and Sanchez - DelBarrio, Messeguer, Rozas, J. & Rozas, R. (2003) further state that in Mozambique there is an understanding that environmental education at a school level is needed for the preservation of the environment, and that the acquisition of knowledge is necessary to improve peoples' quality of life. Therefore, environmental education must be incorporated with the curriculum in South African schools through co-curricular activities, with emphasis of societal involvement in the education of their children. MICOA (2002) suggests that environmental education should be understood in an unsophisticated way as being a permanent process of educating (i) about the environment (share knowledge, information, experiences and values); (ii) in the environment (practical activities in the field; in contact with the environment) and; (iii) for the environment (actions to achieve sustainable development).

The Ministry of Education (MINED, 2003), recognizing the role of schools in promoting environmental awareness of children, youth and adults in Mozambique, decided that environmental education should be part of the compulsory school subjects and since then environmental related topics are integrated into several subjects at primary and secondary school levels. As alluded by MINED, scientific knowledge must be introduced to learners during their early years of schooling, so that they develop scientific meaning and reasoning around phenomena. Hsu (2004) argues that recent studies about classroom environmental education intervention indicate that its effectiveness should be measured, and more emphasis should be placed on investigation of environmental issues, and the cultivation of environmental actions. In agreement with Hsu, teaching and learning should be structured such that learners explore their environment and apply Physical Sciences they learn at school in their everyday life.

Chapani and Daibem (2003) argue that environmental education in public schools should help learners develop coherent attitudes towards school subjects in order to construct a socially and ecologically equilibrated world. According to these researchers, the teaching and learning process of Science and Technology is fundamental to consider pedagogical practices which can be used in the promotion of positive attitudes to better the performance of learners in school subjects. Chi-Kin Lee (2000) and McCaw (1980) argue that although the constructivist conceptions have a cognitive origin, they can be extrapolated to an attitudinal scope, and an active involvement of the learners is a fundamental condition for the development of positive attitudes towards environment. Furthermore, Chi-Kin Lee (2000) and McCaw (1980) regard the teachers' perceptions as being a key catalyst in the engine for the change of attitudes towards environmental problems. This will be only possible if the curriculum innovations contemplate the issues on teachers' attitudes as the main implementer of the curriculum in the classroom, and the agent to better learner attitudes towards Science. Kim and Fortner (2006) as well as Goussia and Abiliotis (2004) argue that the weak pedagogical practice of the teachers in approaching the environmental related issues in Science learning and Science education is not only due the lack of positive attitudes by the teachers, but teachers are usually confronted with many external factors which form barriers to an effective implantation of innovations, one example being a lack of enough time to approach environment issues in a meaningful way when teaching. The researcher concurs with Kim and Fortner argument to a certain extent, because the present Curriculum and Assessment Policy Statement (CAPS) of Physical Sciences has a restricted contact time stipulated for teaching and learning, which is four hours per week and forty weeks as reflected in CAPS policy document.

Therefore, there is an intriguing need for school teachers to reflect on their pedagogical practices in collaboration with environmental studies through in-service training activities, and for teachers to consolidate their pedagogical practices to preserve the environment. Furthermore, it is important to produce the Learner-Teacher Support Material (LTSM) addressing specific topics in Physical Sciences as way of linking school Science theory and knowledge to the daily life practices. Wandersee, Mintzes and Novak (1996) argue that the basis or the centerpiece of constructivism lies on the evidence-documented claim that learners gather a range of alternative conceptions about objects and events when they enter formal instruction in Science. The researcher therefore suggests that the Physical Sciences teacher has a duty of categorizing that information and directing it to scientific meanings and phenomena.

Constructivism theory is a learning theory more so than a teaching method, but it plays a vital role in the teaching process such that various researchers such as Confrey (1990); Brooks & Brooks, (1993) and Fosnot, (1996) made the following recommendations which are fundamental constructivist principles of learning:

1. Learners should be encouraged to raise questions; generate hypotheses and test their validity.

2. Learners should be challenged by ideas and experiences that generate inner cognitive conflict or disequilibrium. Students' errors should be viewed positively as opportunities for learners and teachers to explore conceptual understanding.

3. Learners should be given time to engage in reflection through journal writing, drawing, modeling and discussion. Learning occurs through reflective abstraction.

4. The learning environment should provide ample opportunities for dialogue and the classroom should be seen as a "community of discourse engaged in activity, reflection, and conversation" (Fosnot, 1989).

5. In a community of learners, it is the students themselves who must communicate their ideas to others; defend and justify them.

6. Learners should work with grandiose ideas, central organizing principles that have the power to generalize across experiences and disciplines.

From these principles, it can be deduced that the key role of a teacher is to challenge the thinking of learners through real-world application tasks and interest-arousing teaching approaches.

2.3. STUDIES ON CO-CURRICULAR ACTIVITIES AND THEIR IMPACT ON LEARNER ATTITUDES AND SCIENCE EDUCATION.

The purpose of this research study was to expose learners to various co-curricular activities like Science Expos, Science Clubs and debates, Science journals, Science memorial sites, Science magazines like "QUEST MAGAZINE", to improve learners' attitudes towards Physical Sciences, to develop problem solving skills, scientific inquiry, synthesizing, critical thinking, data handling and analysis. The introduction of co-curricular activities was used to inquire how to develop scientific reasoning, cognitive reasoning and application of Science learnt at school in real-life situations. This study aimed to explore measures to alleviate poor performance in Further Education and Training (FET) Physical Sciences. Fraser (1982) suggests that much of the generalized concern and interest in attitudes towards school Science is based on a somewhat simplistic notion that 'the best milk comes from contented cows'. Concisely, if learners have a positive attitude they are likely to perform better.

Trivedi (2013) points out three curriculum development stages in Science learning:

Primary level: At this stage, the basic objective of Science teaching is to arouse curiosity and exploration of the world using cognitive and psychomotor skills. At this stage, Science and social science should be integrated as environment studies.

Upper Primary Level: the level which suggests that a child should be engaged in learning principles of Science through familiar experiences working with hands to design simple technological units and modules.

Secondary Level: At this stage, learners should be engaged in learning Science as a composite discipline and systematic experimentation, viewing the subject as a tool to discover / verify theoretical principles. In light of Trivedi's work, the poor performance in FET Physical Sciences in South Africa suggests that learners did not reach all the developmental stages necessary to acquire the scientific skills that would influence them to develop a positive attitude towards Physical Sciences.

It is highlighted by the Baden Analine and Soda Factory (BASF) (2013) chemistry company that: *"Getting next generations excited about chemistry is important for humankind's future. That's why we've created kid's lab in 15 countries, where the young ones can learn about Chemistry and Science in a fun, hands-on way. Little students and test tubes finally getting along? At BASF, we create chemistry."* (www.basf.com/chemistry (2013). If the passion for Physical Science can be developed at an early age as cited by BASF, there would be no diverse attitudes towards Physical Sciences.

Only one in five black students choose physics and mathematics in high school level, and tertiary level according to *"News Online",* (2008). This may be attributed to their upbringing where they were not exposed to a Science-positive environment during their early years of life. In a study by Bouvier (2011), over 200 elementary teachers from four districts were trained in this curriculum, which uses hands-on, inquiry-based experiences to encourage learning in STEM (Science, Technology, Engineering and Mathematics) subjects, particularly engineering and technology. Bouvier (2011) confirms that when teachers are trained in hands-on activities, they disseminate the information down to learners. When learners are exposed to hands-on activities, they develop the skills and methods for scientific inquiry and become intrinsically motivated. Bouvier (2011) further states that Saturday conferences can provide middle school learners with STEM career information and inspire interest in STEM. Each conference includes a large group keynote address or panel discussion in which one or more professionals share how and why they became employed in STEM, and the challenges and rewards they encountered. The students can be rotated through small-group workshops delivered by STEM professionals, who interact with students and offer hands-on activities related to their work.

The main cause of varied attitudes towards Physical Sciences is the misunderstanding and misconceptions about the nature of Science. Occasionally, the everyday knowledge learnt from cultural heritage is not linked to scientific knowledge learnt at school. In some cases, people have different attitudes for certain aspects due to “cultural” meanings assigned to them, as well as the way the learners understand scientific concepts according to their cultural context. As stated in section 2.2.2 above, the IsiXhosa speaking people believe that lightning can be “caused by witch doctors”, while Science explains that lightning is caused by the build-up of electrical charges in the clouds. Therefore, the IsiXhosa learners will take time to understand the scientific origin of lightning due to the cultural believe that is embedded in his/her mind. It needs a teacher to patiently redirect the learners towards the scientific meaning of existing concepts.

Professional development in technology can help improve teaching strategies and learner comprehension. A number of studies point out that teachers’ attitudes towards computers are a major factor in accepting ICT in the classroom (Koohang, 1989; Selwyn 1997; Kluever, Lam, Hoffman, Green and Swearinges, 1994). This suggests that studies at the early stages of technology implementation should focus on the end-user’s attitudes. Positive attitudes often encourage less technologically-capable teachers to learn the skills necessary for the implementation of ICT activities in the classroom (Bullock & Cliff, 2004; Kersaint, 2003; Horton, Wyatt, Allison, Donoghue & Kearney, 2003 and Stol & Garofalo, 2003). Use of ICT teaching approaches can arouse learners’ interests in Physical Sciences, as suggested by Bullock & Cliff (2004). Learner-centred teaching approaches encourage learners to be interrogative, to interact with each other, hypothesize, think critically and draw up conclusions, thus emphasizing process approach and promoting a positive attitude towards Physical Sciences (Polly & Hannafin, 2007). Historically, teaching innovations have been dominated by two instructional perspectives; traditional and process approaches. However, traditional-oriented approaches seem to be inadequate when it comes to communicating vital Science content to learners, because it focuses only on the learning of scientific knowledge (facts, concepts, laws and theories).

In comparison, the process approach stresses the use of hands-on activities and/or laboratory experiments to develop an understanding of the mechanics of how scientists gain knowledge, that in turn serves as a framework for learning about Science through experience (Polly &

Hannafin, 2007). The National Curriculum Statement (NCS) requires learner-centered approaches and is outcomes-based to arouse learners' interests. Learner-centeredness requires change in the way that teachers think and the choices they make regarding content and teaching methods (Randler & Hulde, 2007; Walczyk & Ramsey, 2003). Such changes result in transformed classrooms, shifting authority and power in the classroom away from the teacher and allowing learners to engage more deeply in the content.

As learner-centered classes become more flexible, to encourage greater learner participation, there is a consequent increase in teacher risk as they loosen their hold over learner behavior. Learner-centered approaches strengthen learners' intrinsic motivation, promote peer communication through group work and discussions. This helps better achieve the goals of each lesson, namely to develop critical thinking and problem-solving skills of learners, thus creating a positive learning environment which includes an inclusive learning space, encouraging learner involvement, discipline and diversity. Learners need to be exposed to Science activities such as reading of Science magazines and other Science-related journals, Science Expos, Science Festivals, National Science Weeks, Science Clubs and career exhibitions in the Science field, so that their attitudes are changed for the better. These activities will help them develop problem-solving skills and scientific inquiry skills that they can use when solving higher order questions.

Motivation of learners through certificates, merit tags, trophies and medals, appraisals and bursaries to arouse their interest towards Science. Teachers should use teaching approaches that will stimulate the interest of learners, such as the use of experiments, overhead projectors, computers and on-line boards. Learner-centered approaches that are based on learners working independently will boost their confidence in Science. Daron (2009), Mwamwenda (1995) and Sternberg (2003) declare that the role of the environmental stimuli in teaching and learning that produces changes in observable behavior should be strongly emphasized through a reward system determined by the teacher. They also claim that the reward system plays a vital role in improving learner attitudes, observing that a learner who experiences recognition through acceptance learns more easily than the one who has had to learn without acknowledgement.

De Witt (2009) also concurred that approval and rewards by the Science teacher may be regarded as methods of reinforcement of most of the learner's behavior in class. However, the magnitude of the reward should vary from situation to situation. The situations may range from a fleeting smile by the Science teacher through a simple nod of the head, praise for good work, bringing the good work of a learner to the attention of others, or a written statement on the learner's paper/workbook to a good grade. By doing so, the confidence and attitude of the learner towards Science improves and impacts the performance of the learner positively. For example, a Physical Science teacher can acknowledge a learner by taking the reading correctly from the scientific apparatus during a group activity and praise the learner or support the learner through probing questions in a stimulating, challenging and curiosity-arousing manner.

This research proposed that learners' attitudes towards Science improve when they are motivated, coached and guided towards the right direction with the use of scientific language and exposure to the Science world. This opinion about change in learner attitudes through motivation is supported by several researchers, including Donald (2006) and Fenstermacher & Soltis (2004). These researchers hold the view that rewarding, and appraisal are useful for training and shaping skill performance in Science because improved consequences, results or behavior can be increased where a learner experiences positive reinforcement. Daron (2013) and De Witt (2009) add that if a reward or reinforcement immediately follows the response, stimulus retention also becomes greater, and a similarly positive response becomes more probable in future. In addition, Fenstermacher & Soltis (2004) argued that an effective Science teacher is the one who produces powerful gains in learner achievements by bringing about learning, as a result of knowing precisely when and how to reward learners for behaviors that assist them in reaching the goals set for them.

However, Harlen and Deakin (2003) argue that not everyone agrees completely with the idea of reinforcement, since it is believed to have some negative impact in other circumstances in class. For example, some negative comments or behaviour on behalf of the teacher tends to impact the general trend of the learners' performance negatively. Take for instance, a case where the Science teacher consistently discourages a learner from participating in a debate, or avoids picking him/her to participate, because on a particular occasion the same learner failed to do the Physical Sciences homework. In such a case, the learner may develop an inferiority complex, become withdrawn in Physical Sciences class or participating in Physical Sciences activities, and eventually fail Physical Sciences. In such a case, the learner has been reinforced negatively and will lose interest in Physical Sciences, and will feel discouraged from partaking in Physical Sciences activities, viewing himself/herself as having little or nothing to contribute as far as Physical Science tasks are concerned.

Trowbridge (2004) concludes that the Physical Sciences teacher's decision to motivate or reward the good performance of learners, or to negatively reinforce or discourage learners, influences learners' achievement. Furthermore, Harlen and Deakin (2003) augment this idea with the theory that the classroom organization in which learners are grouped by ability during scientific activities leads learners to label themselves. Therefore, the Physical Sciences teachers should use mixed-ability groups, and attempt to build up self-confidence in such learners so that there is always motivation among members of the group, and a willingness to try. The researcher embraces a view that learners need to be exposed to learning methods that will nurture their problem-solving skills, scientific thinking and assimilation skills, and that by doing so their cognitive scientific reasoning will be developed. Berk (2006) and Shaffer & Kipp (2007) agree that learning results in cognitive development which involves qualitative changes in thinking, as well as quantitative changes such as increased knowledge and ability, and that such adjustments make positive changes in behavior possible. Sternberg (2003) further claims that learners are inquisitive explorers who are actively involved in learning and discovering new principles. Additionally, Van Loggerenberg-Hattingh (2003) conducted research to examine learning achievement through the experiences of Science learners in a problem-based learning environment and discovered that problem-based learning influences the learners' thinking more than information that was read or told them. Furthermore, he maintains that problem-based learning has the potential to involve learners more, and makes them more accountable for their own learning, in that they had real understanding only of conclusions to which they arrived at themselves.

Charlesworth & Lind (2003) also propose that once adults interfere with children's learning, they keep them (children) from inventing and re-inventing things for themselves. Berk (2006), De Witt (2009) and Shaffer & Kipp (2007) declare that Science teachers should allow their learners to spend more time in independent discovery-based activities in an environment which is inviting, challenging and motivating, with a variety of learner-teacher support material so that they can interact with the materials, using all their senses. As indicated by this research; Science teaching and learning should be marked by learner-centered activities in the form of projects, investigations, practical work, journal writing, Science debates and Science expositions, in which the teacher is a facilitator who gives guidance, thus acts as the scaffolding.

According to Trowbridge (2004), an environment full of various teaching materials and unfamiliar activities allows learners to not waste time attending to completely familiar activities. Therefore, Physical Sciences learners should be presented with problems that provide learners with opportunities to engage in thinking, insights and problem-solving as an integral part of their Science lessons. Norms, values, beliefs, tools, scientific language, cognitive development, scientific reasoning and intellectual adaptation are strongly dependent on social learning and social interactions as well as culture (Shaffer & Kipp, 2007 & Kramer, 2002). Per Morrison (2009), children seek out adults for social interactions from birth, and he states that a variety of developmental processes occur through these interactions. Likewise, Mwamwenda (1995) and Shaffer & Kipp (2007) argue that social interactions with parents, peers and teachers is a radical and dynamic view of learning, emphasizing that through these social interactions, children learn and develop new ideas, skills, values and attitudes, which they use in solving scientific problems. They further explained that the social interaction advocates guided learner participations in Science class, suggesting that the effective Science teacher organizes and structures the learning activities, provides helpful hints and offers clear guidelines or instructions while he monitors and supervises the learner progress, performance and achievement.

Charlesworth & Lind (2003), De Witt (2009) and Trowbridge (2004) hold the same view that, to assimilate and accommodate the effects of constant change at each stage of development, the Science learners need continued mentoring, accompaniment and assurance from the Science teacher. Dori & Hameiri (2003) affirm that for learners to be in a position to understand and write symbols that are used in chemistry, learners should be able to understand symbols that are used in real life situations. Chew and Andrews (2010) assert that teacher pedagogical leadership facilitates and communicates learning and enables schools to tackle and transcend barriers; and helps cultivate and nurture a culture of success - a culture that was undermined by the apartheid, Reform of teaching and learning effects of the past is a prime concern of education in South

Africa. A social justice teacher development perspective should increase awareness of the social dimension of mathematics and Science education; and target the most disadvantaged groups with a view to reduce historically entrenched gaps of exclusion (Gates & Jorgensen, 2009 and Langley, Moen, Nolan, K., Nolan, T., Norman, & Provost, 2009).

The real-life application of Physical Sciences learnt in class will make learners associate themselves positively with a Science-rich environment. Such an association with their environment will enhance their love and understanding of Science. Teachers need to be highly equipped with skills that will enable them to develop problem solving skills for the learners. Teachers will attain these skills through in-service training, teacher interactions, curriculum support material and proper support by subject advisors and MSTE (Mathematics, Science, technology Education) co-coordinators. Findings by Bennet (1956) indicate that most learners' opinions about participating in co-curricular activities, a Science Club in his case, were very positive, confirming that learners have a clearer picture of scientists' and engineers' scientific worlds, well-developed self-confidence, logical and critical thinking skills, scientific reasoning and interest in pursuing careers in science-related fields.

Hartley (2010) mentions that learners who participate in co-curricular activities gain methodological and intellectual skills for tackling Physical Sciences assessment tasks. Hartley (2010) also states that Science Clubs can be an important vehicle for teachers entering the profession, as it can establish them as respected teachers among their learners and fellow teachers. It is important as a teacher to involve learners in teaching Science, rather than be theoretical. He further emphasizes that, in a Science Club, everybody (teachers and learners) must be professional and show that their hands are full of strategies to make the learner understand Science clearly.

According to Van Aalderen-Smeets, Walma van der Molen & Asma (2012), attitude is a complex concept, and different studies use a multitude of definitions which need to be kindled by co-curricular activities. On that score, Giroux (2004) cites that co-curricular activities in school can reduce anxiety surrounding the subject and stimulate the interest of learners. Therefore, the researcher encouraged learners to use indigenous knowledge in Science activities with the aim of linking the world outside school and school knowledge. Ordinarily, existing knowledge learnt from cultural heritage is not linked to scientific knowledge learnt at school, which accounts for varying attitudes around certain subjects that may conflict with embedded "cultural" meanings assigned to them. The nature of Science is fluid and dynamic, and the extent to which schools of thought are prioritized depends heavily on cultural context, and this cultural context can change over time.

Kincheloe (2005) and McLaren (2015) agree that practical work empowers and allows learners to be at the center of learning, while creating space for cognition. Lunetta, Hofstein, & Clough (2007) posit that *'practical and inquiry skills'*, *'practical and investigative activities'*, *'independent enquiry'*, *'experimental work'*, and *'learning experiences in which learners interact with material or with secondary sources of data help them to observe and understand the natural world'*. Kahn (2003) argues that in line with the redress agenda, resources were concentrated on a set of schools – rather than all the schools – that would become quality sites of Science and mathematics teaching. In contrast with what Kahn (2003) is pointing out, if all FET Physical Sciences' learners can engage in co-curricular activities, all schools can be quality sites, as learners will be developing interrogative skills, investigative skills thus better understand the nature of Science. Lederman (1992) points out that science teaching is based on scientific method and Science processes. Lederman's study aligns with this research study which sought to advocate the use of scientific method in all South African schools in the teaching of Physical Sciences, to better the achievement of learners and develop a passion for Physical Sciences.

Hodson (1991) concurs with Lederman in that understanding scientific method is more vital than acquisition of scientific knowledge. Similar trends were found by Hartley (2014), with teachers and learners participating in Science clubs in South Africa, as outlined below.

The following section highlights the findings of an outreach project to establish Science clubs at rural schools in South Africa:

- Four to five teachers worked alongside practicing scientists as part of their research groups.
- Each teacher facilitated a Science Club with 10-15 learners, who by extension were members of the scientists' research groups. In their findings, they presented case studies of

teachers who were mentored by a research professor, and how they in turn mentored the learners.

- They found that that in less than one academic year, the teachers could gain the knowledge and skills to facilitate the children's participation in authentic scientific research.
- The results of their study are also supported by the findings of researchers who used a similar approach in training and mentoring teachers to cascade their knowledge and skills towards learners in Science clubs at their schools.

The September issue of Afterschool Alliance (2011) summarized the evaluation reports from afterschool STEM programs across the United States; and identified common trends and strengths that afterschool learning brought to STEM education. Most of the programs evaluated were specifically designed to provide services to underrepresented populations in STEM fields, with many also focusing on providing female learners with exposure to Science and female role models. An analysis of the evaluations yielded STEM-specific benefits that can be categorized under three broad areas namely (i) improved attitudes towards STEM fields and careers; (ii) improved STEM knowledge and skills; and (iii) a greater likelihood of graduation and pursuing a STEM career. These three areas were also highlighted by Mkandawire (2009) in his study on Physical Sciences activities and skills development in the Namibian curriculum. This view was also supported Shadreck and Isaac (2012), who elicited learners' views on teachers' scientific knowledge in Zimbabwe. They reported that learners expressed a need for Science teachers who made teaching Science fun and interesting.

Tytler and Osborne (2012) claim that the choice of Science-related careers at Tertiary level depends solely on school attitudes towards Science. In agreement to Tytler's claim, Barmby, Kind & Jones (2008) allege that there are number of attitudes to be considered, namely: attitudes towards Science in society; attitudes towards school Science as well as a career in Science, which all influence university students when it comes to making decisions on career choices at Tertiary level. Tytler and Osborne (2012) further insist that it is the perceptions and attitudes towards school Science that are likely to be most significant in determining students' decisions about whether to proceed with further study of Science beyond compulsory courses.

Viegas (2004), Twillman (2006) and Coldwell (2008) agree with Bonnet (1956) that co-curricular activities serve as a vehicle for developing scientific interest in learners, in that these activities help learners to understand some Physical Sciences topics better. Moore-Hart, Liggit and Daisy (2004) allude that the Science club they established at different schools initiated a change in attitude towards Sciences. This improved attitude towards Science is also cited by Twillman (2006), who found that most activities require teamwork, club members' communication and leadership skills, which made learners interact with each other and better equipped them to work independently. She also points out that schools that missed science-orientated events faced challenges concerning learner attitudes towards Physical Sciences. A research study by Feldman & Pirog (2011) and Twillman (2006) in elementary schools in the United States points out challenges reflected in the South African context, namely that learners experience social difficulty when it comes to Science achievement and enthusiasm; and tend to envy peers who performed better in the group. A study by Kim and Song (2009) examined the relationships between attitudes and conceptual understanding of physics in Japanese high school learners using a structural equation modeling methodology. They found that Grade 10 students' attitudes towards school Science and interest in Science subject matter, as opposed to how important students perceived Science is to society, was exclusively influenced by students' conceptual understanding of physics. Furthermore, they also found that through 'reluctant persuasion', students might 'temporarily' accept the importance of Science in society, and 'superficially' learn concepts while they study Science in high school.

According to Pike and Dunne (2014), the learners' reflections and responses globally indicate the importance of secondary school experiences in shaping how they identified with curriculum subjects, such as Science and Mathematics, and whether they considered these subjects as part of their future careers and future. They further state that traditional pedagogies and teaching approaches used in Science classes, and the perception by students of a lack of relevance of Science subject matter, resulted in Science being unpopular with the students. They also noted that students also put mathematics and Science at the top of what the researchers referred to as a 'subject hierarchy' of difficulty, assessed and categorized themselves as either capable or not capable of further studies of Science.

Maltese & Tai (2010) conducted an interview study for scientists and graduate students where they found that about 65% of participants disclosed that interest and zeal in Science began in the middle school or earlier, depending on the level of motivation that was exposed to them. Furthermore, Maltese & Tai (2010) state that interest in Science for 40% of participants was attributed to their experience(s) at school, such as teacher demonstrations or projects, or participation in educational events related to Science, which resulted in an interest in pursuing a science-related career. Barmby, Eisenhardt, Brodwin, Gonzalez, Stanford, Stern & Galametz (2008) and Bolstad & Hipkins (2008) in their study with 932 English students, argued that their attitudes towards Science in general declined as they progressed through secondary school. Moreover, they also found that the decline in interest towards Science as a subject had a strong negative impact on students' attitudes towards learning Science at school. Through linear regression, they found that as students graduate through school, the development of attitudes toward learning Science at school had greater influence on their attitudes toward Science in general.

The role of parents and their level of education are vital when it comes to influencing learners in their subject and career choices. A research study by Adamuti-Trache and Andres (2008) in Canada used longitudinal data over 10 years with 1,055 respondents and found that learners with university-educated parents were more likely to complete Science courses in high school and had earlier plans to continue post-secondary education. Adamuti-Trache and Andres (2008) emphasize that the level of education of parents is a key determining factor on learner attitudes towards Physical Sciences.

Young and Freedman (2008) argues that the differentiation of the curriculum in many countries over the past 25 years to include subjects that are more 'context driven, problem focused, and interdisciplinary' compared with the traditional disciplinary mode that is 'academic, investigator initiated and discipline-based' was misplaced. According to Young and Freedman (2008) school subjects need to be classified according to their content and context, so that from pilot stages of learning, a learner is directed towards the right direction, and his/her interest is developed from an early age as possible. According to Rennie (2007), Stocklmayer (2010) and Bar-Tal (2012), students can learn about and develop attitudes toward Science through informal learning contexts such as Science centres, museums, community organizations and the mass media.

This statement then aligns with the objective of this research study, which aims at exposing learners to various co-curricular activities to improve learner attitudes towards Physical Sciences.

Rennie (2007) further posits that compared with formal, school environments, learning in informal or 'out-of-school' contexts are usually learner-led, and intrinsically motivated, and informal Science programs are usually voluntary, with students are often given choices as to the direction and content. In other words, Rennie suggests scaffolding for learners where a teacher gives guidance to learners and let them work at their own pace, and develop scientific understanding and meaning of work at their disposal. In agreement, Bar-Tal (2012) and Wellington (1990) further suggest that such programs are not assessed, and be delivered to students of a range of ages and abilities. Osborne and Dillon (2007) conclude that the quantity of research that investigates Science learning and the development of attitudes toward Science in informal contexts, are considerably less than that conducted in formal school settings, but that positive results of co-curricular activities to support learners is seen within a very short space of time.

Research conducted by Hackling and Garnett (1985) within Australia suggests that outreach programs offered by Science centres and other providers, improved students' interest and skills and benefited students and teachers by demonstrating new teaching and learning approaches, content and Science concepts, use of techniques and resources available to them. In contrast Rennie (2007) states that while participants are generally positive about the experience, it is a paradox that it is unlikely that the potential of these incursions into schools are fully realized in terms of student learning of Science. Lucas (2004) refers to one informal program that was provided by Questacon, called 'Smart Moves', which aims to raise the awareness of secondary school students in regional and rural Australia concerning innovative Australian Science and technology and emerging career opportunities through participation in co-curricular activities. Findings of the study suggest that the Smart Moves program is effective in raising or confirming pre-existing interest of a minority of students in pursuing careers in Science and/or technology. Interest also is aroused in other students attending the presentation but, for most, this dissipates rapidly after the presentation in the absence of appropriate supporting activities.

Based on Lucas' research, one concludes there should be continuous support after learners have been exposed to co-curricular activities, so that the developed interests do not evaporate after the fact. Thomas (1986) and Kovaleva & Lipscomb (2007) unanimously agree that the factors surrounding cultivating students' interests in Science through co-curricular activities yield satisfactory results in Science assessment tasks, therefore their argument aligns with this research study. Sheldon & Epstein (2005), Sirin (2005) and Simpkins (2005) argue that economic background, family support systems and poverty are proportional to academic performance and level of interest in participating in co-curricular activities across the racial or ethnic groups. Students from affluent families with good family support systems that partake in co-curricular activities tend to perform better than their counterparts, who come from low economic backgrounds and have no support or interest in participating in co-curricular activities, which results in poor performance. Contrary to what these researchers predict, this study suggests that Physical Sciences teachers should intervene and encourage the interest of learners, irrespective of socio-economic status and poverty status, by forming Science clubs, to make up for the lack of support.

Costa (2000) points out that the teacher's role is to convert learners' scientific knowledge into meaningful representations, thus transforming the nonfigurative sciences into Physical Sciences. Zembylas (2004) reported that the emotional states of Science learners are strongly affected by teachers' emotional states, which in turn has an impact on the performance of learners. Matthews (2002), also notes that learners' emotional and social skills improve relative to teacher's level of Science enthusiasm. In the light of these studies the researcher suggested that the teachers should use teaching methodologies and approaches that trigger positive scientific emotions to him/her, which can be transferred to learners thus promoting the diffusion of scientific emotions (DOSE).

According to Shakespeare (2003), the use of different questions to create cognitive conflict is a good method that leads to correct scientific view. Shakespeare emphasized the strengthening of scientific cognitive and intellectual skills of learners and developing interrogative, hypothesizing, assimilation and analyzing, and interpretation skills. An extract from Africa's On-

Line Science Magazine (2008), revealed that South Africa has low levels of scientific literacy and is marked by a decline in numbers of learners taking Mathematics and Physical Sciences at the FET band, and engineering and technology studies at tertiary level. Science expositions, Science clubs and debates then can help alleviate the challenge faced by South Africa as the learners can have an opportunity to explore and indulge in Science and develop problem-solving skills, intrinsic motivation, confidence and effective communication skills. These co-curricular activities play a vital role as they challenge the logical thinking of gifted learners while building confidence and motivation to the struggling one.
Establishment of co-curricular activities can help schools form partnerships with universities, industries, research institutes and Science councils. Roberts (2002) also held a view that pupils are turning away from studying Science, technology, engineering and mathematics result in employers struggling to recruiting candidates with appropriate Science and engineering skills. He also identified several issues that need to be addressed to alleviate the decline in progression rates, including shortages in human resources such as Mathematics and Science teachers, outdated Science laboratories and equipment, the inability of courses to inspire and interest students as well as ineffective career guidance.

Roberts further recommended enhancing and enriching the curriculum both inside and outside the classroom to motivate students towards Science, technology and engineering, improving the quality of mentoring and guidance offered by both teachers and parents about Science careers, as well as improving the quality of practical work in Science, infrastructure and delivery mechanisms. Mentoring of learners towards subject choice and grouping, and encouraging participation in co-curricular activities can serve as a vehicle to improve learner attitudes towards Physical Sciences and Science-related careers. He cites team work as pivotal in successful Science learning.

Klopfer (1971) made a prominent contribution towards Science education, consequently classifying a collection of sentimental behaviors in Science education as:

_ *The manifestation of favourable attitudes towards Science and scientists;*

_ *The acceptance of scientific enquiry as a way of thought;*

_ *The adoption of 'scientific attitudes';*

_ *The enjoyment of Science learning experiences;*

_ *The development of interests in Science and science-related activities; and*

_ *The development of an interest in pursuing a career in Science or Science-related work.* Consequently, from Klopfer's research it is crystal clear that the core of Science teaching and learning is powerfully affected by learner attitudes.

Additionally, studies by many researchers such as Breakwell and Beardsell (1992), Brown (1976), Crawley & Black (1992), Gardner (1975), Haladyna, Olsen & Shaughnessy (1982), Keys (1987), Koballa Jr. (1995), Oliver & Simpson (1988), Simpson, Koballa, Oliver & Cranley (1994) hold a view that the Science education literature contains hundreds, if not thousands, of reports of interventions designed to change attitudes. Therefore, development of programs to influence the likelihood of certain Science-related attitudes is important because it is assumed that changes in attitude will result in changes in behavior. Because of these researchers' findings, the researcher asserts that curriculum features play a vital role in influencing learner attitudes towards Physical Sciences. It is therefore essential that curriculum planners bear learner attitudes in mind. Woolnough (1994) found that, for a small minority of academic pupils (usually boys), interest and enthusiasm for Science was stimulated by the challenge presented by the abstract and mathematical aspects of Science, particularly physics, and the desire to explore the subject in more depth. He further states that a Science curriculum that relates to students' interests and life-world experiences produce a more positive attitude in both boys and girls to school Science. Science-focused studies, science-effective teaching, Science teaching approaches; teacher grounding and level of aptitude in Science are the determinant factors to simulate interest in learners.

Crawley & Black (1992), Havard (1996) and Hendley (1996) have identified students' perception of Science as a difficult subject and as being a determinant of subject choice. In fact, Havard's investigation of the uptake of Sciences at A-level, points to the perceived difficulty of Science as *the major* factor inhibiting uptake. Furthering the impression that Physical Sciences is perceived as being challenging is provided by the recent analysis of the data collected in the UK on the youth cohort for 1989, 1990 and 1991 using sample sizes of approximately 14,000 learners for each year (Cheng,1995). The perception that Physical Sciences is a tough subject is a worldwide belief, hence this study tried to prove that notion wrong. This research study tried to oppose that stereotype by fusing co-curricular activities into the 'normal' curriculum to better the attitudes of learners towards Physical Sciences, thus leading to improved performance in Physical Sciences. Subsequently, Science understanding and appreciation, as summarized above, rests upon attitude, confidence building, role of parents and community in molding and shaping learners towards Science orientated goals, which concurs with this study.

2.5 CONCLUSION

The international, national and provincial, as well as local literature, have revealed that there is a relationship between learner attitudes and performance. Other determining factors include environmental and social interactions by learners; socioeconomic status; competency of teachers and the role parents play in the education of their children. Literature has further shown that there is a drastic decline in number of learners choosing career paths in Science at Tertiary institutions, which calls for intervention to trigger the interest of learners towards FET Physical Sciences and Science-related careers. Scientific public–relations value needs to be linked with scientific educational value, thus linking everyday knowledge with school knowledge to entrench problem solving skills, nature of Science, scientific meaning in learners' minds. This research study contributes to existing literature by providing a current investigation on examining the influence of co-curricular activities on learner attitudes towards Physical Sciences. This research study has also tried to bridge the gap using the case study and developed research instruments. The succeeding chapter discusses and provides motivation for the use of a specific research design, research methods and related deliberations employed to answer the research question.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The previous chapter outlined the theoretical framework and the research literature that underpins this study. This chapter outlines and describes the various methods and techniques used in the collection of the data.

3.2 RESEARCH QUESTION

This research study is directed at answering the following research question:

What is the influence of co-curricular activities on learners' attitudes and achievement in Physical Sciences?

3.3 RESEARCH DESIGN

This research study made use of a mixed method approach, consisting of both qualitative and quantitative approaches to collect data. According to Tashakkori and Teddlie (2003) a mixed-method research design involves the mixing of quantitative and qualitative methods or paradigm characteristics.

3.3.1 Advantages of a mixed method approach

Johnson and Turner (2003) state that, by combining research methods with different strengths and weaknesses in a study, it is less likely that you will miss something that is important or make a mistake. The researcher can answer a broader and more complete range of research questions because the researcher is not confined to a single method or research approach. [deleted as repetitive]

The researcher can use the strengths of an additional method to overcome the weakness in another method by using both in a research study which is a principle of non-overlapping weaknesses. A mixed-method approach combining qualitative and quantitative research produces integral knowledge that best informs theory and practice. As quantified by Johnson and Turner (2003), more reliable and valid data is obtained through this research method, as the instruments used complement each other. The information that was not covered in one instrument, was covered by another instrument which resulted to a trustworthy data.

3.4 SAMPLE

Franfort-Niechimas & Leon-Guerrero (2009) define a sample as the collection of people who are selected for a given research study. The research study made use of purposive sampling consisting of 35 out 120 learners who were selected according to their academic performance in a previous monthly test, to have a broad range of learners towards FET Physical Sciences. The purposive sampling assisted the researcher to have an overall view of the school population's perceptions of and performance in Physical Sciences by generalizing the results of the research study. Johnson & Gray (2010) maintain that in purposive or judgmental sampling, the researcher specifies characteristics of the population of interest, and locates individuals with those characteristics. The research study took place at the school where the researcher was teaching. Two classes took part in this research study, one each from Grades 10 and 11. Table 2 below shows a summary of the sample to be used in the research.

Table 2: Sample for the research

Participants	Population	Technique	Criteria
Learners Grade 10 Grade 11	 20 out of 54 15 out of 66	Purposive	Learners were taking Physical Sciences as one of their Subjects in grade 10 & 11. Learners selected were ranging from poor performers, mediocre and bright sparks and selected using achievement scores as they were depicted in the schedule.
Teachers	3 out of 4 teachers	Purposive	Teachers have a minimum of 5 years teaching experience.

The school is situated in a deep rural, previously and presently disadvantaged area in the Butterworth district in the Eastern Cape. The population of learners taking Physical Sciences in Grades 10 and 11 consisted of 120 learners from which the researcher had to sample. Henry

(1990) stated that a population or target group is a large group from which a researcher wants to generalize the sample results. The elements of the sampling frame were Grade 10 and 11 Physical Sciences learners. The learners were between the ages of 15 and 16 years, and taking Physical Sciences as one of their subjects. The Physical Sciences teachers sampled for this research study had a minimum of five years teaching experience.

3.5 THE CASE STUDY

The research study was conducted in the form of a case study at the selected school. Yin (1993) identified some specific types of case studies, namely *exploratory and explanatory*. *Exploratory* cases are sometimes considered as a prelude to social research. *Explanatory* case studies may be used for doing investigations. Stake (1995) included three other forms of case studies namely, *Intrinsic* - when the researcher has an interest in the case; *Instrumental* - when the case is used to understand more than what is obvious to the observer; *Collective* - when a group of cases is studied. As viewed by Stake (1995), Intrinsic case study helped learners develop an in-depth understanding of Physical Sciences, the nature of Science and scientific phenomena.

According to the above descriptions, this study is both Exploratory and Intrinsic, because the learners were exposed to co-curricular activities (Science Expos, Science clubs, Science debates). The learners' attitudes towards Physical Sciences; and their way of handling higher order questions were measured. Furthermore, the research study was a case study because it involved only one school. It involved research that was aimed at providing a detailed account on how to use co-curricular activities to change abstract concepts into scientific meaning, thus improving learner performance on handling higher order questions in the same school.

3.5.1 Advantages of a case study

According to Yin (1993) case studies tend to be selective, focusing on one or two issues that are fundamental to understanding the system being examined. Case studies are multi-perspectival analyses. This means that the researcher considers not just the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them. This one aspect is a salient point in the characteristic that case studies possess. Case studies give a voice to the powerless and voiceless.

Yin (1993) further presented at least four applications for a case study model:

1. To explicate multifaceted causal links in factual interventions
2. To designate the real-life context in which the intervention has happened
3. To define the intervention itself
4. To explore those situations in which the intervention being evaluated has no clear set of outcomes. These studies can be holistic or embedded, the latter occurring when the same case study involves more than one unit of analysis. Multiple-case studies follow replication logic. This is not to be confused with sampling logic, where a selection is made from a population, for inclusion in the study. As already alluded to by Yin (1993), as much as this case study explored the impact of leaner attitudes towards Physicals Sciences as it also addressed the status of Science education internationally, nationally and locally, therefore it has been multipurpose study.

3.5.2 Disadvantages of a case study

- The research is limited only in one case
- The sample size does not represent the greater population in an area

3.6 DATA COLLECTION PROCESS

The case study was conducted at a school where the researcher is teaching, and it was conducted as part of an after-school program so that it did not interfere with tuition time. The data was collected using questionnaires, observations and interviews as explained in four steps below, and an outline of the data collection plan can be found in Table 3 below.

Table 3 - METHODOLOGICAL FRAMEWORK

Research question	Research Methodology	Instrument	Respondents	Analysis
How can participation of learners in co-curricular activities help change attitudes towards Physical Sciences?				
Step 1	Pre–attitude test	Attitude questionnaire (appendix A)	35 learners	Excel spread sheet, coding for trends
Step 2	Expose learners to co-curricular activities Video-recording of activities	Observation check list (Appendix B)	35 learners	Scan and code the data. Provide thick descriptions Audio recording Transcribe data verbatim word for word and re read it, translate where necessary
Step 3	Post attitude test	Questionnaire (appendix A)	35 learners	Excel spread sheet, coding for trends
Step 4	Teacher Interviews Focus group interviews for learners	Interview schedule for teachers (appendix C) Interview schedule for learners	3 teachers Two focus group interviews, one for Grade 10 and 11 respectively	Audio recording Transcribe data verbatim word for word and re- read it Translate where necessary
Focus group interviews for both teachers and learners will be abbreviated as indicated in the study	FI, L- Focus group interview for learners e.g. FI, L_{10} means Focus group interview learner 10 II, T- Individual Interview for teachers e.g. II, T_1 means Individual Interview Teacher 1			

3.6.1 Step 1: Attitude test questionnaire (ATQ) for learners before participating in co-curricular activities

A questionnaire was used as a pre- and post-test. A questionnaire is a self–report data-collection instrument that each research participants fills out as part of the research study (Johnson & Gray, 2010). In this study, the questionnaire is called an *Attitude Test Questionnaire* (ATQ) - which can be found in appendix A - was used.

3.6.1.1 Development of the *Attitude Test Questionnaire* (ATQ)

Interests and Perceptions in Physical Sciences were some of the scales through which the ATQ was developed from the Test of Science Related Attitudes (TOSRA) developed by Fraser (1982).

The ATQ consisted of five scales; each scale is defined by 3 items. Each item in the questionnaire required a response that was presented on a Likert scale. The options on the Likert scale are: strongly disagree (1), disagree (2), neither agree or disagree (3), agree (4), and strongly agree (5). The items were categorized into the following five scales: interest in Physical Sciences; relevance and Importance of school work; application to real life situation; teaching approaches and level of confidence in Physical Sciences as they appear in Appendix A. The scales from TOSRA were mediated and adapted according to the context of the research school, while other scales were developed based on the findings of term one (1) performance of learners.

3.6.1.2 Advantages and disadvantages of a questionnaire

(i) Advantages

The advantages of questionnaires are their practicality. The researcher can collect copious amounts of information from many people in a short period and at a relatively low cost. The results of the questionnaire can be quickly and easily quantified and analyzed, even more scientifically. It can be used to compare and contrast other research, and may be used to measure change (Popper, 1959). The wording was kept simple, with no ambiguity, allowing respondents to choose categories that fit their situations. The questionnaire was designed to cover a lot of information from many people within a brief period of time. The questionnaire served as a pre-and post-survey method to assess the learners' attitudes and perceptions of Physical Sciences before and after exposing them to a Science exposition.

Advantages of Questionnaire summarized according to Creswell (1994)

- Provides estimates of populations at large.
- Indicates the extensiveness of attitudes held by people.
- Allows for statistical comparison between various groups.
- Provides results which can be condensed to statistics.
- Has precision, is definitive and standardized.
- Can answer such questions as "How many?" and "How often?"
- Measures level of occurrence, actions, trends, etc.

It was easy to collect data from participants within a very short space of time using a questionnaire as proposed by Creswell (1994).

(ii) Disadvantages as per Creswell (1994) study

- If mailed, response rate is low. Often requires follow up.
- May take a long time to receive sufficient responses.
- Respondents self-select (potential bias).
- If used for material pretest, exposure to materials is not controlled.
- May not be appropriate if audience has limited writing skills.

3.6.2 Step 2: Exposing learners to co-curricular activities: The qualitative observation

Qualitative observation according to Johnson & Gray (2010), involves observing all relevant phenomena and taking extensive field notes without specifying in advance exactly what is to be observed, and is done for exploratory purposes. The type of observation that was used in the research study is qualitative, since the study is exploratory. All 35 sample learners were exposed to co-curricular activities.

3.6.2.1 Observation of learners in Science project

The learners were asked to identify a problem in their community and try to solve that particular problem by designing a Science project (refer to Appendix B for the Project Instruction Sheet). The purpose of the project was to make them interact with their environment, and deal with higher order challenges. This project is directed at problem solving skills, scientific enquiry and the application of scientific knowledge.

The project activity enabled the learners to partake in the district Science Expo, Science debates and provincial Science essay-writing competition. Kuh & George (1995) argue that students become involved in co-curricular activities not only for entertainment, social, and enjoyment purposes, but most importantly, to gain and improve skills. The learners were video-recorded and the following observed: how they interacted with each other and with their environment; how they applied problem solving skills and used the principles of scientific inquiry. Learners' involvement in co-curricular activities was video-recorded for later analysis, coding and descriptions.

3.6.2.2 Observation of learners in Science Expo, debates and essay-writing

Science Expo

In preparation for the Science Expo, the participants were guided to use Science learner support material (SLSM) such as Science journals, Science magazines, Science websites, Science media centers, Science memorial centers, etc. This was a hands-on project with real-life context and relevance, which included parental involvement, in that learners could ask for assistance from their parents where necessary. This activity brought opportunities for collaborative work as they competed in district eliminations with their projects. The aim was to boost learners' confidence and leave them as independent individuals. The learners prepared journals, also known as Science diaries, where they wrote each step they took towards designing a project, and the researcher gave guidance where necessary.

They also prepared posters with all the steps that were employed in their project investigation, namely; the problem, background information, investigative question, hypothesis & variables under consideration, precautions to be taken when conducting the investigation process, data collection, data analysis, conclusion and relevance in real-life situations. At school level, there was an exposition show where all learners displayed their projects. There was also a gala walk where learners had an opportunity to see each other's projects and interrogate each other. The learners were granted marks using an observation schedule (appendix B) and scientific explanation was given to them where they seemed to lose scientific grasp.

Science debates

Participants were asked to bring to class a series of topics that were areas of concern in their surroundings that could be solved scientifically. Learners were arranged in small groups of fives, where other groups argued for the topic and others against the topic. The debates took place on Friday afternoons, taking a maximum of two topics per day until everybody participated. A score sheet was used which addressed the scientific language used, traced the research that was undertaken, measured the relevance to Science and whether their methods solved the problem it was meant to.

Essay writing

Learners were given related topics where they had to write about five pages on *'How to save water, as South Africa is faced with drought threats, pollution of water reservoirs and underground water using scientific methods'*. The essay structure had to include the following: introduction and background, body (suggested ways of water saving methods, socioeconomic and environmental impacts of water usage, international, national and local research and sustainable development measures on water usage) and a conclusion. A rubric was prepared to check the appropriate length of the essay, the accepted structure, scientific value and language and viability of the hypothesis and investigative questions used, and to draw up conclusions and scientific implications. Having participated in all these co-curricular activities at school level, learners proceeded to district eliminations in preparation for regional Eskom Expo competitions.

3.6.3 Step 3: Post-test Questionnaire

The ATQ that was given in Step 1 was re-administered to learners as a post-test to measure their attitudes after they were exposed to the Science Expo.

3.6.4 Step 4: Interviews

Three Physical Sciences teachers and learners were interviewed based on the performance of learners after engaging in the Science Expo. An interview schedule was prepared, and the interviewees were provided with copies of the schedule. According to Fontana and Frey (2000), a sound atmosphere should be created for the respondents to feel free during the interview. The questions were posed in a relaxed manner, rephrased and translated where it was necessary.

The interviews were semi structured in the sense that the key questions were prepared but deviations were catered for. In some instances, probing took place to get the relevant responses for the correct data. A welcoming atmosphere was designed for the interviewees to feel comfortable during the interview session, and the school computer lab was used as an interview venue.

3.7 PILOT STUDY

According to Johnson and Gray (2010) a pilot study is a preliminary test of research instruments prior the research study. To make certain that reliability is maintained, three instruments used in this study were piloted. The interview schedule and the questionnaire were given to non-participants to ascertain that the questions were simple, appropriate, straightforward and not confusing. Where necessary, the questions were rephrased. The observation schedule was given to Grade 12 teachers. The non-participants that tested the instruments were Grade 10 and 11 Physical Sciences learners, and two teachers from a neighboring rural FET school. The instruments were also taken to the researcher's supervisor for an expert validation. The pilot test was used as a diagnostic tool, which assisted the researcher to address length of the instruments, misunderstandings and misconceptions on the instruments, before they were administered for the actual research study.

3.8 DATA ANALYSIS

3.8.1 Interview

According to Marshall (1997:65), once the data has been collected and summarized, the researcher needs to make sense of the data by beginning the process of analyzing the data. With qualitative data, researchers generally utilize a process of inductive coding, which can be easily influenced by researcher subjectivities (Bryman, 1989). The interviews in this research study were audio taped, transcribed and translated where necessary. While the questionnaire generally took participants approximately 20 minutes to complete, the interviews usually lasted for about an hour, giving more time to expose the variabilities and inconsistencies within human thinking (Marton & Pong, 2005; Parajes & Miller 1994 and Parajes 2004). The data was cleaned by removing the information that was not relevant to the study. The data was coded using categories and themes that emanated from the interviews. The responses that fell under the same category were coded with the same colour, for instance the positive responses were coded red and the negative responses were coded in green.

3.8.2 Questionnaire

The data was captured on an Excel spread sheet. In agreement with Stemler (2004) and Marton et al. (2005), the data was analyzed and represented visually in graphs and tables using the Excel program.

3.8.3 Qualitative observation

Leech & Onwuegbuzie (2011) suggest that comparative analysis can be used to analyze observation. The data was categorized into themes and coded according to themes which helped the researcher to have a broad understanding of the impact of co-curricular activities on learners' critical thinking and interpretation of Science knowledge. This was also aided by thorough manipulation of resources derived from the learners' environment and the role of their surroundings on their scientific point of view. During the observation, learners were monitored for active participation and interaction with each other, making informed decisions and drawing of relevant conclusions.

3.9 RELIABILITY

Rudner and Schafer (2001) argue that the best way to view reliability is the extent to which test measurements are the result of properties of those individuals being measured. For example, reliability has been defined as "*the degree to which test scores for a group of test takers are consistent over repeated applications of a measurement procedure and hence are inferred to be dependable and repeatable for an individual test taker*" (Berkowitz, Wolfowitz, Fitch & Kopriva, 2000). As confirmed by the literature above, reliability is the extent to which an instrument produces constant and reliable results. To make certain that reliability was maintained, both instruments were piloted; the interview schedule and the questionnaire by giving them to non-participants to ascertain that the questions were simple, straightforward and not confusing, and where necessary the questions were rephrased. The respondents' names remained anonymous on their Instruments. To avoid bias, two of the researcher's colleagues were requested to conduct the interviews on her behalf. Also, the questions were designed in such a way that they did not favor the researcher.

3.9 VALIDITY

Validity is concerned with the meaningfulness of research components. When researchers measure behaviors, they are concerned with whether they are measuring what they intended to measure (Bollen, 1989). Validity refers to how well the test assesses that which it is supposed to assess. To ensure that the instruments were valid, the researcher ensured that the objectives of the research aligned with the research questions, and chose the relevant model of sample size of respondents as cited by Bollen. The instruments, the questionnaire and interview schedule were validated by experts in research, who ensured that they were excellent tools to conduct the research. Interviews and questionnaires were used for triangulation. Triangulation occurs when the results of two instruments are merged together to get more authentic data as sighted by Trochim, (2006).

3.10 ETHICAL CONSIDERATIONS

Permission to conduct the research was requested from the respondents, and they participated in the research on a voluntary basis. Permission letters were forwarded to each respondent before the research was conducted. When the research was conducted, the respondents were aware of how and when the research was taking place. The researcher made sure that there were no respondents that were harmed in any form during the research study. Dignity, integrity of the participants was not violated, and anonymity as well as confidentiality was respected.

The research was conducted in such a way that no favouritism was practiced, and it was free from prejudice. The respondents were granted permission to withdraw from research at any stage when they felt like doing so. During the research, a sound atmosphere was created so that the respondents felt comfortable. The research was conducted at convenient time for each participant. Respondents were unique individuals, because inclusive education demands diversity, and that each learner's circumstances and barriers to learning are to be taken into consideration. The clearance letters for Eastern Cape Department of Education and UWC Faculty of Education; permission letter for school and consent letters for participants can be found in appendices 1, 2, 3, 4 and 5 respectively. The contact sessions were discussed and arranged with respondents' prior the research study.

3.11 CONCLUSION

This chapter addressed the research design and methodology used in the research study, as well as the motive for the selection of research methods, approaches and instruments employed. The following chapter will present the findings of the research study.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

The previous chapter outlined the methodology on how the research study was harmonized. Chapter 3 provides comprehensive information on how the instruments were administered, the sampling technique used and the research design, as well as the approach of the research study. This chapter addresses the detailed results of the data that were collected after applying the research methodology.

4.2. DETERMINING LEARNERS' ATTITUDES TOWARDS PHYSICAL SCIENCES

Learners were randomly interviewed after performing badly in the first term assessment, and below are the samples of their responses. The researcher tried to find out their challenges through discussion with the learners. Most learners indicated that they were forced by their parents and/or family members to choose Physical Sciences as one of their subjects; only a few indicated that they voluntarily chose the subject.

> Learner 1: *If it was not for my parents' demand, I would have changed to another stream as I absolutely have no interest in Physical Sciences and science related careers. My parents are forcing me to take Mathematics and Physical Sciences, but they cannot assist me with my school work. They keep on saying it is easy to find jobs with Mathematics and Physical Sciences.*

> Learner 2: *Physical Sciences' statements are lengthy with difficult English which I don't understand, that is why I don't like that nasty subject which has nothing to do with what I do in life.*

These responses were the foundation for the research study, as learners showed various attitudes towards Physical Sciences. As an initial attempt to deal with the challenges and attitudes the learners had towards Physical Sciences, a pre-Attitude Test Questionnaire was given to a sample of 35 learners. As discussed in section 3.6.1.1 above, the pre-attitude test questionnaire (ATQ) was developed and given to a sample of 20 learners selected from Grade 10 (20 out of 54) and 15 from Grade 11 (15 out of 66).

The questionnaires were taken from the safety box that was sealed so that they do not leak before being administered. The sealed box was then taken to the school hall where learners were waiting to answer the questionnaire. The aim of gathering the learners was to administer the questionnaire at the same time under controlled conditions, but in a friendly environment where the researcher could monitor them. Participants answered the questionnaire without any assistance from the researcher. Since the instrument was piloted, the questions were clear without any ambiguity.

After the learners finished writing, the questionnaires were collected for analysis. The data in Table 3 was captured on an Excel spreadsheet and was analyzed. Table 3 below depicts a summary of responses on the Attitude Test Questionnaire (ATQ) which was used as a pre-test and contained three themes with five items each, namely: **Interest in Physical Sciences, Perceptions about Science and Use of scientific language.**

4.2.1 Interest in Physical Sciences

Based on the responses of the 35 participants in the pre-Attitude Test Questionnaires (ATQ) (see appendix A) that was administered in the first step of the research study, the following was ascertained:

In question 1.5, most learners i.e. 60% (which is 21 out of 35 participants) saw no need for conducting practical work to improve their performance. 4% of learners (1 participant) disagreed and 56% (20 participants) strongly disagreed that practical work makes Science concepts clear. 70% of learners (25 participants out of 35) did not find Science stimulating. Only 13% (5 participants out of 35) were not sure, and 17% (6 participants) of learners agreed that Physical Sciences are thought–provoking (question 1.1). 44% (15 participants) disagreed, and 26% (9 participants) strongly disagreed that Physical Sciences is interesting and fascinating.

Table 3: Learners' responses to the Pre-ATQ

Items	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1 Interests in Physical Sciences. 1.1 I find Physical Sciences is interesting and fascinating.	**12%**	**5%**	**13%**	**44%**	**26%**
1.2. Science debates are fun	**13%**	**12%**	**23%**	**27%**	**25%**
1.3. I feel like studying Physical Sciences everyday	**19%**	**4%**	**20%**	**17%**	**40%**
1.4 Physical Sciences lessons are a base for my future career	**14%**	**9%**	**6%**	**57%**	**0**
1.5 Practical work makes Physical Sciences concepts clear	**18%**	**22%**	**0**	**4%**	**56%**
2. Perceptions about Science 2.1 My family sees me furthering in Science	**4%**	**21%**	**19%**	**31%**	**25%**
2.2. My parents think Physical Sciences is a difficult subject	**16%**	**35%**	**8%**	**31%**	**10%**
2.3. My friends see Physical Sciences as an easy subject	**13%**	**17%**	**7%**	**40%**	**23%**
2.4. I think it is important to do well in Physical Sciences at school	**2%**	**8%**	**2%**	**30%**	**58%**
2.5 I feel confident when doing Physical Sciences class works and homework	**13%**	**9%**	**22%**	**16%**	**40%**

Items	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
3. Use of scientific language and application 3.1. I understand better, when my teacher uses different teaching approaches.	**9%**	**16%**	**13%**	**27%**	**36%**
3.2**.** I can link knowledge learnt in Physical Sciences in other subjects.	**5%**	**7%**	**18%**	**24%**	**45%**
3.3 I understand the language used in Physical Sciences very well.	**24%**	**9%**	**5%**	**22%**	**40%**
3.4. I easily learn Physical Sciences topics through practical work.	**7%**	**7%**	**15%**	**9%**	**62%**
3.5 I can apply Physical Sciences laws and principles in everyday life	**5%**	**9%**	**9%**	**27%**	**50%**

Only 25% (9 participants) of responses highlighted that Science debates are exciting, with 23%uncertain and 52% (18 respondents) agreeing that Science debates were boring (question 1.2). 27% (9 participants) disagreed and 25% (9 participants) strongly disagreed that Science debates are fun. A minority of learners, 23% (8 respondents) of learners felt that studying Physical Sciences was fun, with 20% (7 respondents) being unclear, and 57% (20 respondents) certain that they were stuck with studying Physical Sciences (question 1.3). 17% (6 participants) disagreed, and 40% (14 participants) strongly disagreed that they have passion for Physical Sciences. One learner (3%) did not respond in question 1.4 while 57% (20 respondents) of learners did not see Physical Sciences as the foundation of their future studies, as they disagreed that Science lessons are a base for their future career. However, 40% of the respondents agreed with the latter question (1.4). This is the second theme in the Attitude Test Questionnaire (ATQ) (see Table 3 and Figure 4) with five items, and the data on it confirmed that 56 % (20 respondents) of responses disagreed that their families see them furthering in Physical Sciences, while 25% (9 respondents) agreed, and 19% (6 respondents) were uncertain about the status of their families concerning Physical Sciences (question 2.1).

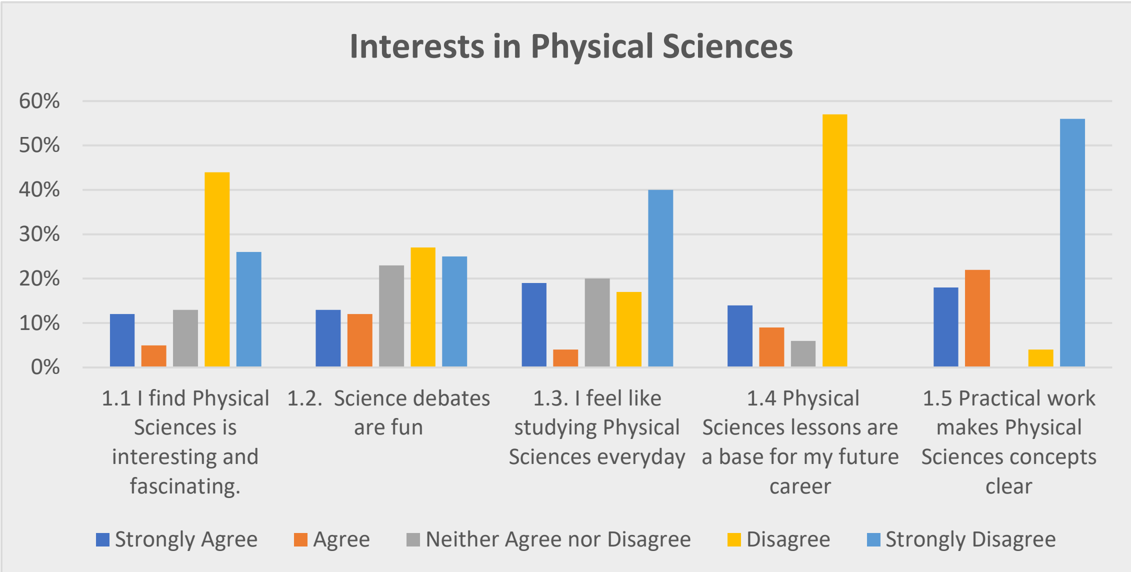

Figure 2: Graph of learners' responses to interests in Physical Sciences category of the ATQ

4.2.2. Perceptions about Physical Sciences

The bulk (51%) of respondents i.e. 18 learners agreed in question 2.2 that their parents think Science is a difficult subject whereas 8% (3 respondents) neither agreed nor disagreed and 41% (14 respondents) disagreed. In question 2.3, (22 learners) 63% of respondents disagreed that their friends see Physical Sciences as an easy subject, while (11 learners) 30% of respondents agreed that their peers see Physical Sciences as an easy subject, and 7% (2 learners) were not sure about their friends' perception about the difficulty of Physical Sciences.

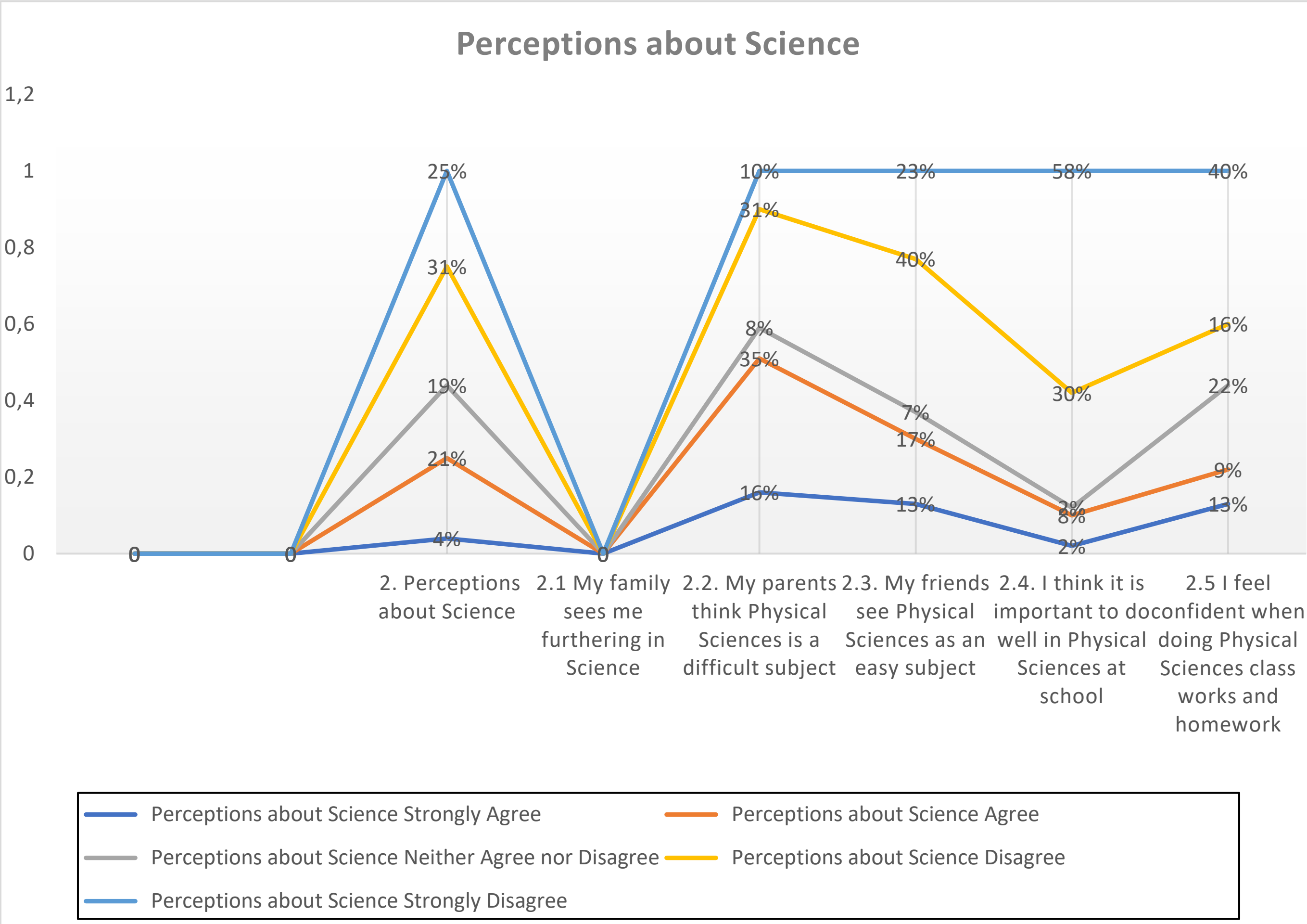

Figure 3: Perceptions about Science

On the fourth item, **I think it is important to do well in science at school**: 88% (31 learners) totally disagreed that they take their Physical Sciences schoolwork seriously, whereas 10% (3 learners) saw the need to commit to their schoolwork but 2% (1 learner) were in doubt. In item 2.5: **I feel confident when doing Physical Sciences class work and homework,** the popular option was "disagree" with 56% (20 learners); the unpopular ones were: agree with 22% (8 learners) and 22% (8 learners) neither agree nor disagree.

4.2.3 Use of scientific language and application

The third theme in the questionnaire is the **use of scientific language** represented in Table 3 and Figure 5. 63% (22 learners) of respondents disagreed that they understood better when their teacher used different teaching approaches, while 25% (9 learners) of respondents agreed, and 13% (5 learners) of respondents were uncertain. In question 3.1. only 12% (4 learners) of respondents agreed that they could link knowledge learnt in Physical Sciences to other subjects, while 18% (6 learners) were undecided, and 69% (24 learners) of learners disagreed in question 3.2.

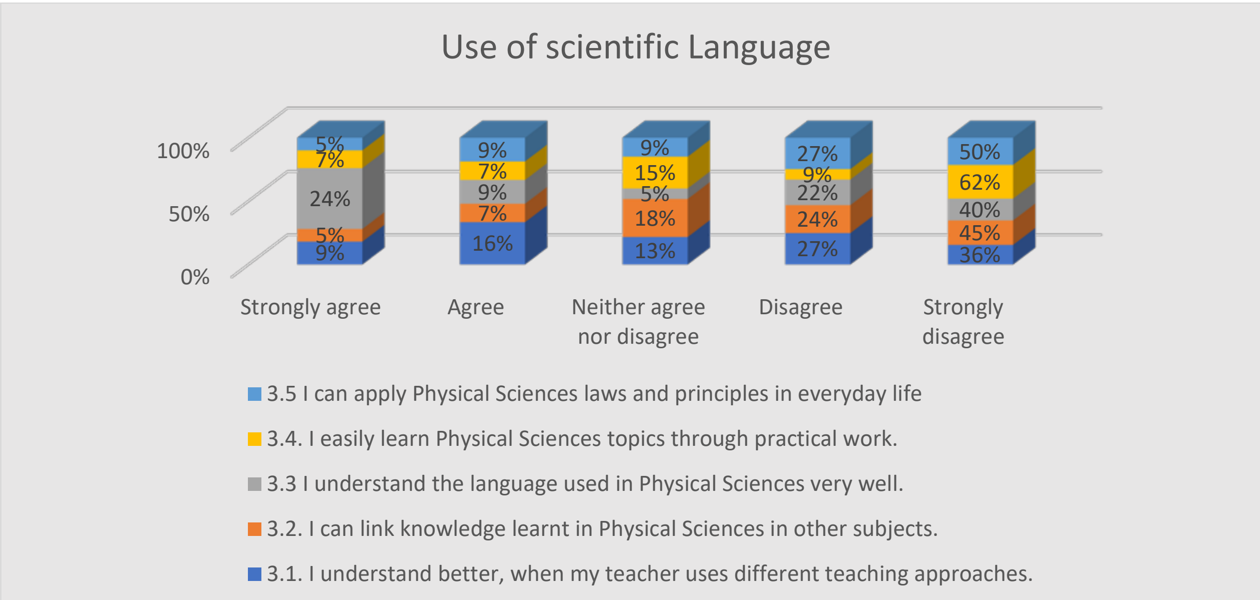

Figure 4: Use of scientific language

A total of 62% (22 learners) of respondents indicated that they did not understand the language used in Physical Sciences, whereas 33% (12 learners) agreed, and 5% (1 learner) of respondents was uncertain about question 3.3. About 71% (25 learners) of respondents disagreed on item 3.4, **I understand the language used in Physical Sciences very well,** but 14% (5) agreed and 15% of respondents (5 learners) were undecided. Most respondents (77%), i.e. 27 learners disagreed with question 3.5, **I can apply Physical Sciences' laws and principles in everyday life,** while 14% of respondents (5 learners) agreed and 9% (3) were unsure.

Following the pre-Attitude Test Questionnaire, the learners were introduced to co-curricular activities as an intervention to deal with the challenges that learners were experiencing with Physical Sciences, as well as various attitudes they were showing towards Physical Sciences.

4.3 LEARNERS' INVOLVEMENT IN CO-CURRICULAR ACTIVITIES

4.3.1 Min Quiz

Learners from the research school participated in the Physical Sciences MinTek Minquiz competition which was held on 19 May 2016 at Walter Sisulu University (WSU), as indicated in the invitation letter in Appendix 8. MinTek Minquiz is South Africa's premier annual science competition for learners which is organized by MinTek, a National Science Council specializing in mineral and metallurgical technology. Participating learners take an individual multiple-choice test, followed by competing as a team during a live, on-stage oral multiple-choice quiz. The Quiz cover sections in Physical Sciences, Mathematics and Technology curriculum. A group of three learners from the sample of 10 out of 35 learners managed to reach to the finals of the Min Quiz, while others (6 learners) managed to reach the semi-finals. The learners could answer higher order questions in the Min Quiz, the quiz consisting of questions from cognitive level 1 to cognitive level 4. Cognitive levels range from recall (CL_1), comprehension (CL_2), analysis & application (CL_3) and evaluation (CL_4). The learners in the written quiz category was in the top 5 out of 50 schools.

For example, one of the learners pointed out that:

> *"The MINQUIZ assisted me to think broadly especially in applying laws and principles in Physical Sciences, especially that we were top 5 out of 50 schools"* [FI L_{28}]

The learners' participation and reaching the finals made them confident when tackling Physical Sciences activities in the classroom. They also added that they did not view Physical Sciences as difficult a subject as they did before, thus their perception changed for the better towards Physical Sciences. The Min Quiz was based on Chemistry and this enhanced the learners' ability to strengthen their observation, problem-solving, hypothesizing and decision–making skills. Learners were interviewed after the Min Quiz exposure, and the interview was a focus group interview. Learners confirmed that they sat for mid-year exams with confidence owing to the experience they gained from the competition.

To prove the learners' level of confidence, one learner alluded that:

> *"After being exposed to Min Quiz competition; I managed to answer questions in chemistry in the mid-year examinations which was a nightmare during term 1 examinations, I was also very confident when answering the questions."* [FI, L_6]

Both teachers and learners reported that after participating in the Min Quiz competition, the performance and passion for Physical Sciences gradually improved, and they gained scientific writing skills. These learners also highlighted that they understood the scientific language used in the Min Quiz questions, hence they made it to the top. The teachers and learners also mentioned that they wanted to participate in more than one co-curricular activity to improve their performance. Having participated in the Minquiz, a post-Attitude Test Questionnaire was administered to learners, and the results are represented in the graph below:

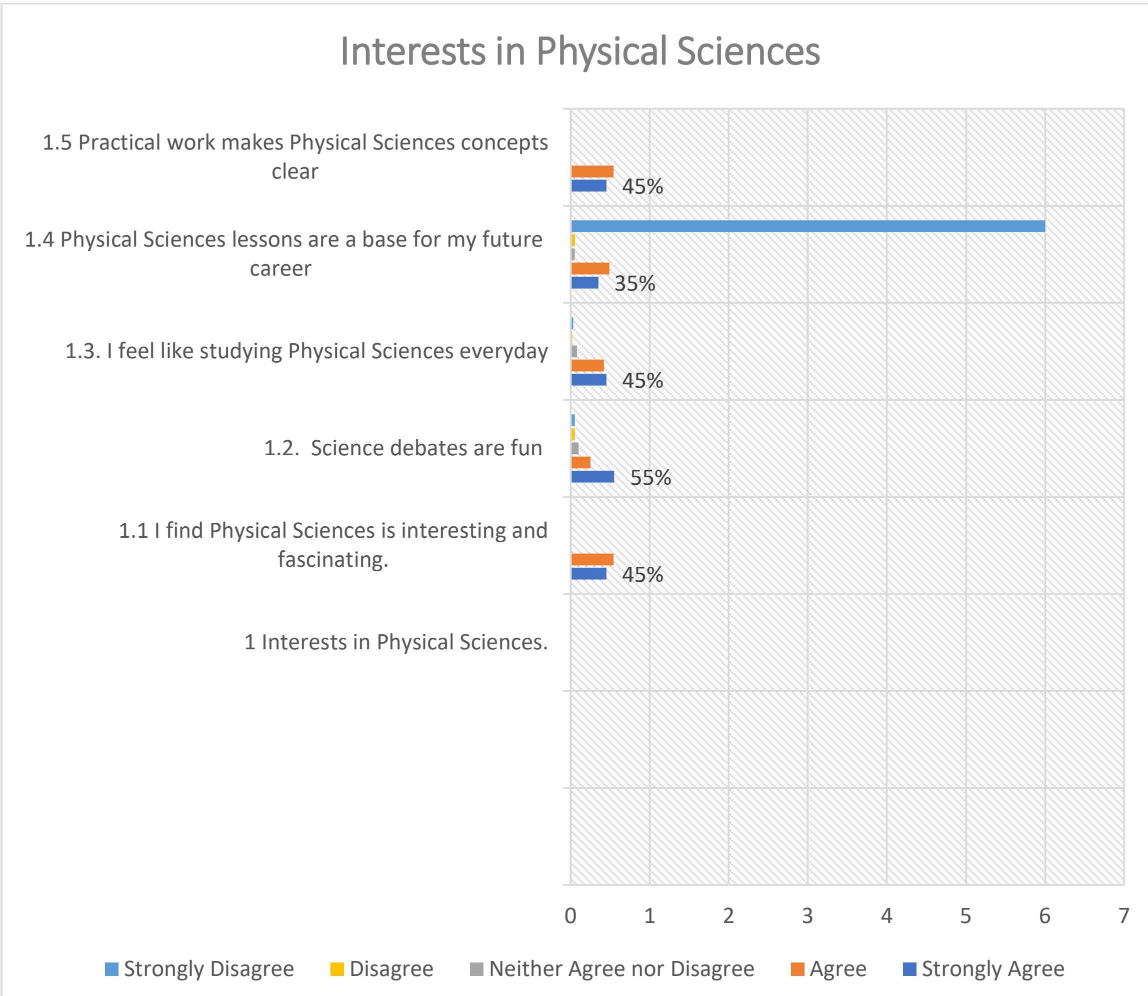

Figure 5: Interest of learners towards Science after participating in Min Quiz

The graph analysis depicts that participation of learners in the MIN QUIZ intrigued their interest in Physical Sciences, especially in the Chemistry section.

4.3.2 Essay writing and Science debates

Before participating in a Physical Sciences debate, all 35 participants wrote an essay to qualify for entry in the debate**.** The following topic for both debates and essay writing was used**: Why alternate fuel sources are important in South Africa?** The competition was conducted from the 14-28 May 2016. The respondents entered the second stage of the competition with other schools. The essay writing was intended to equip participants with research skills. It also assisted them with better understanding of the concepts and phenomena of the topic. This essay writing also improved the writing and communication language and skills, which helped them in structuring their debate topic. Apart from the acquired skills, the essay writing gave the participants a chance for short-listing purposes to proceed to the next level of Science debate.

The learners qualified to proceed to the level of the debate, where 10 learners out of 35 participated. Out of 10 learners, 5 learners formed a proposing team, and another 5 formed an opposing team.

The same topic - **Why alternative fuel sources are important in South Africa** - that was used for essay writing was used for debate competitions. When debating about the topic participants had to include the impact of alternative fuel on the human needs, economy of the country, culture, politics and its sustainability. These subtopics opened opportunities for learners to dig deeper as far as research is concerned. The teams competed at district level, and then to regional level in Mtata, and finally to Queenstown for Provincial eliminations, where they came second and did not advance to the championship victory.

4.3.3 Administering of ATQ after essay writing and Science debate

After the essay writing and debating, the post-Attitude Test Questionnaire was given to learners for completion. Essay writing strengthened the confidence of learners in the use and application of scientific language; structuring of essay type questions; comparing and contrasting ideas and drawing up conclusions, as well as making recommendations. The results are represented in the graph below (see fig7).

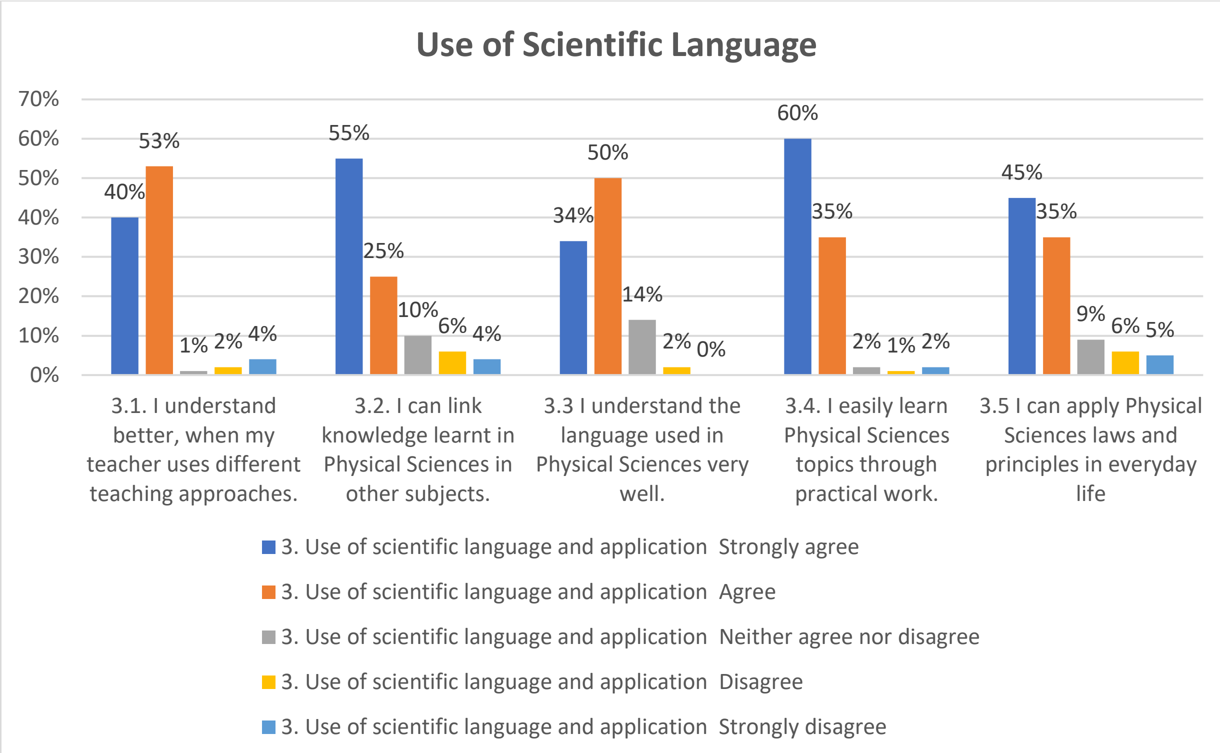

Figure 6: Use of scientific language after essay writing

The graph results portray that the bulk of learners indicate that participation in essay writing and science debates helped them to understand the language used in Physical Sciences. The understanding of scientific language helped learners to easily learn Physical Sciences.

4.3.4 The National Science Week

On the 7th August 2016, the National Science Week was launched at Walter Sisulu University (WSU) and ran until 12 August 2016. The learners from various schools, including the 35 participants in this study, were exposed to various activities like experiments and demonstrations, as well as career opportunities in the Mathematics, Science and Technology (MST) field. There was also a mini Career Expo, where learners were exposed to Science career paths to follow Matriculation. The Armaments Corporation of South Africa (ARMSCOR) bursary forms were issued to motivate learners to study MST fields at a Tertiary level. Having attended and participated in the National Science Week, when interviewed, learners indicated interest in further studies in Physical Sciences at Tertiary level. Their confidence in class was strengthened so that their performance in term 3 showed improvement.

4.3.5 Launch of Science clubs

Participants attended the launch of Provincial Science Clubs, held in East London on 24 and 25 August 2016. The purpose of the launch was to encourage more school to establish Science Clubs, especially in the General Education and Training (GET) band. The launch of Science Clubs was mainly characterized by Science demonstrations and practical activities, resulting in most learners being keen to establish Science Clubs at their own schools after they were exposed to science demonstrations and experiments.

4.3.6 Science Expo

In getting ready for the Science Expo, learners designed projects for interschool competitions where they proceeded to the Regional eliminations in Umtata. All 35 participants prepared the projects and entered the competitions at school, but only 15 made it to the Regional eliminations. The categories were divided into: Pure Science, Applied Science, Technology, Computer Science, Mathematical Science, Theoretical Science and Engineering projects. The participants' projects fell under the Theoretical and Engineering Science categories. The participants explained their preliminary designs, listed the materials used in their projects and explained how they built their projects. They kept project journals, which contained all the information about the project from day one of starting the project. They further gave a brief description on how they tested their prototype (sample) of the project.

Table 4: Learners' responses to the Post ATQ

Items	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1 Interests in Physical sciences. 1.1 I find Physical Sciences interesting and fascinating.	**28%**	**44%**	**11%**	**4%**	**12%**
1.2. Science debates are fun	**13%**	**25%**	**23%**	**27%**	**12%**
1.3. I feel like studying Physical Sciences everyday	**19%**	**40%**	**19%**	**17%**	**4%**

1.4 Physical Sciences lessons are a base for my future career	**47%**	**41%**	**8%**	**4%**	**0%**
1.5 Practical work makes Physical Sciences concepts clear	**56%**	**36%**	**4%**	**4%**	**0%**
2. Perceptions about science 2.1 My family sees me furthering in Science	**31%**	**45%**	**19%**	**3%**	**2%**
2.2. My parents think Physical Sciences is a difficult subject	**35%**	**25%**	**15%**	**15%**	**10%**
2.3. My friends see Physical Sciences as an easy subject	**13%**	**17%**	**8%**	**40%**	**23%**
2.4. I think it is important to do well in Physical Sciences at school	**30%**	**50%**	**2%**	**10%**	**8%**
2.5 I feel confident when doing Physical Sciences class works and homework	**70%**	**19%**	**8%**	**2%**	**1%**
3. Use of scientific language and application 3.1. I understand better, when my teacher uses different teaching approaches	**40%**	**53%**	**4%**	**3%**	**0%**
3.2**.** I can link knowledge learnt in Physical Sciences in other subjects	**55%**	**25%**	**10 %**	**6%**	**4%**
3.3 I understand the language used in Physical Sciences very well	**34%**	**50%**	**4%**	**6%**	**0%**
3.4. I easily learn Physical Sciences topics through practical work	**60%**	**35%**	**3%**	**2%**	**1%**
3.5 I can apply Physical Sciences laws and principles in everyday life	**45%**	**35%**	**9%**	**6%**	**5%**

Learners were afforded the opportunity to present their projects using the project report file, which had the information about each section of the project. The project file was divided into:

the plagiarism pledge;

the research plan with abstract, introduction, problem or aim of the project;

the hypothesis which clearly indicated the variables that were addressed in the projects;

the procedure to be followed when designing the project;

the results in the form of tables and graphs;

analysis and discussion with errors (what went wrong in the project) and modifications (what could be improved in the project);

the conclusion (which was an answer to the project question) and list of references that were used when the project was developed, as well as acknowledgements (the people who assisted, and how they offered their assistance in the project development).

The learners were also allowed to take a gala walk to view other learners' projects. The gala walk was followed by interviews, where judges posed questions to the project designers. The questions were based on scientific reasoning, use of scientific language, testing levels of critical thinking, and relevance of topics to the projects designed. After participating in the regional eliminations of the Science Expo in Mtata, both teachers and learners were interviewed using the interview schedules (Appendix C). Below outlines the response rate and samples of participants' responses on each question in the interview schedule for participants (both learners and teachers). The interview was held in the school computer laboratory of the research school and was conducted by the researcher of this study. The interview schedule for learners consisted of 8 questions, and the teacher's schedule had about 10 questions.

4.4. GRAPHICAL REPRESENTATION OF POST-ATQ THEMES

4.4.1. Interest in Physical Sciences

A total of 92% of participants agreed that **practical work** and hands-on activities make Physical Sciences concepts and phenomena clear, while 4% of learners neither agreed nor disagreed and 4% disagreed. 72% of participants declared that **Physical Sciences is interesting** and thought-provoking, with 11% that neither agreeing nor disagreeing, and 16% disagreeing.

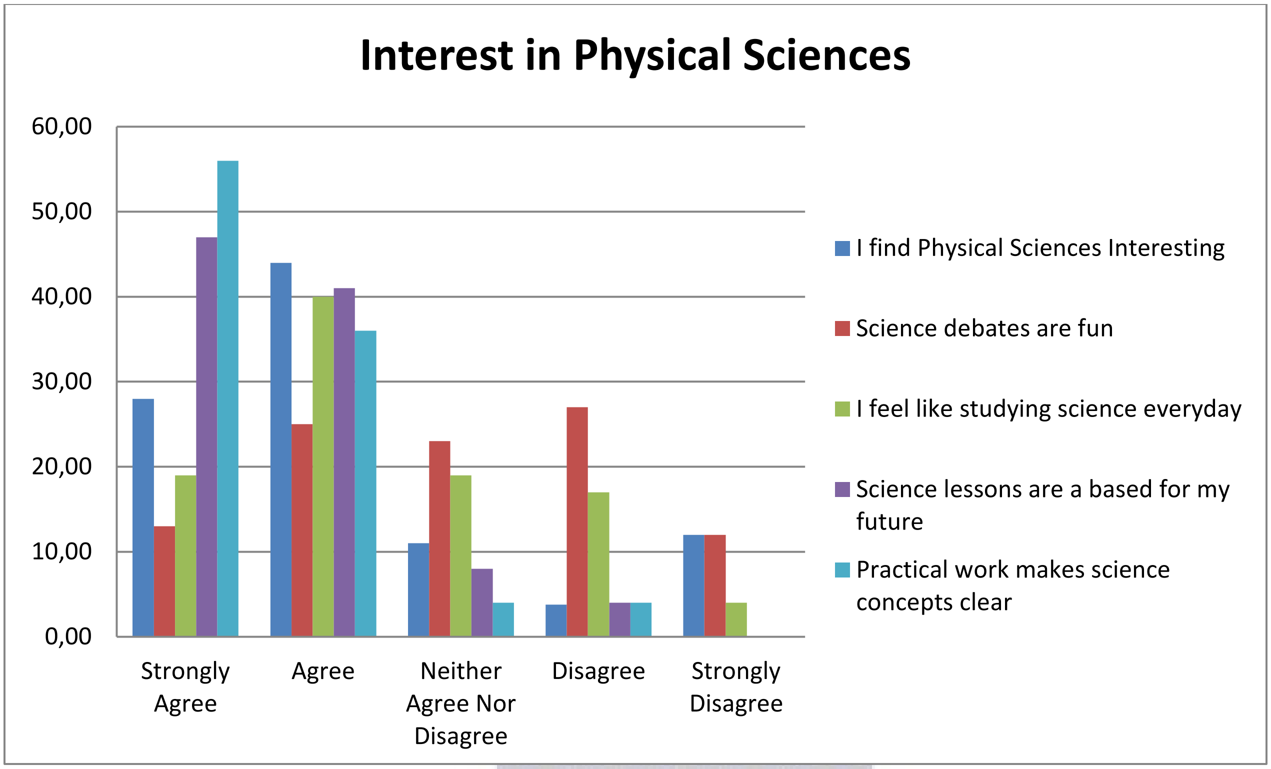

Figure 7: interest in Physical Sciences after participating in Expo

Figure 7 above depicts the results of change of interests in Physical Sciences after learners were exposed to the Science Expo. From the graph, it can be deduced that learners found Physical Sciences fascinating, and felt like studying Physical Sciences every day.

4.4.2. Perceptions towards Physical Sciences

89% of participants agreed that they are confident when doing Physical Sciences classwork and homework, whereas 8% neither agreed nor disagreed, and 3% disagreed. 80% of learners indicated that it is important to do well in Physical Sciences at school. Figure 8 below shows the results of perceptions on Physical Sciences after the ATQ was administered to learners.

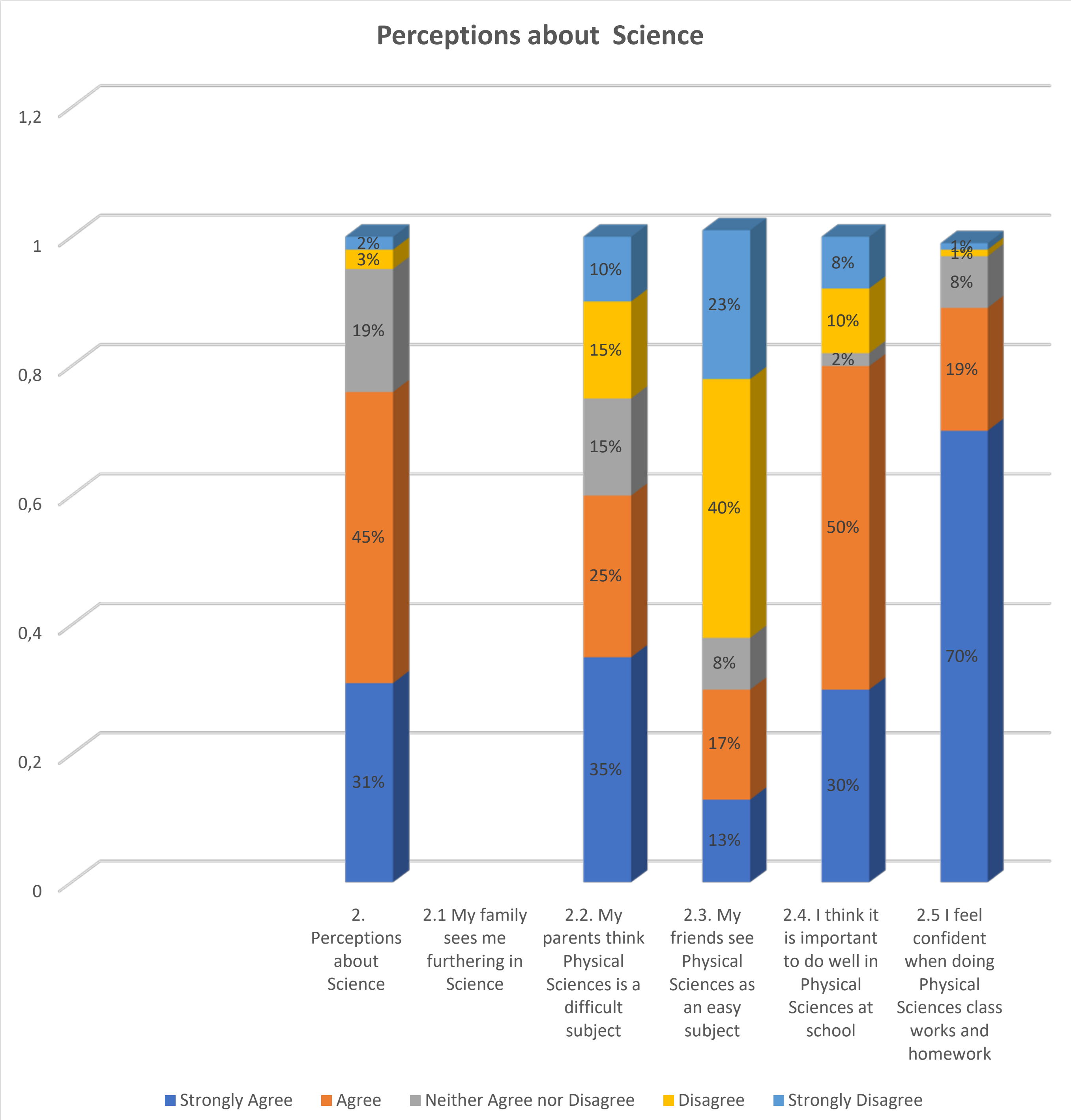

Figure 8: Perception of learners towards Physical Sciences after participating in co-curricular activities

Only 30% of participants agreed **that their friends see Physical Sciences as an easy subject,** while 8% of learners neither agreed nor disagreed, and 62% disagreed. 60% of participants indicated that **their parents see Physical Sciences as a difficult subject,** while 15% were confused, and 25% disagreed. 76% of learners highlighted that **their families see them furthering in Physical Sciences,** but 19% were not sure and 5% disagreed.

4.4.3. Use of scientific language

The explanation of the results given in this section is summarized in figure 9 below**.** The analysis of results depicted by the graph above indicate that 80% of learners indicated that they can **apply Physical Sciences' laws and principles in everyday life,** although 9% were uncertain and 11% disagreed. 95% of participants cited that **they easily learn Physical Sciences topics through practical work,** however 3% were unsure and 2% disagreed. 84% of participants highlighted that **they understand the language used in Physical Sciences very well,** although 14% were uncertain and 2% disagreed. 80% of participants pointed out that **they could link knowledge learnt in Physical Sciences with other subjects,** but 10% were uncertain, and another 10% disagreed. 93% of participants posited that **they understand better when the teacher used different teaching approaches,** although 4% were uncertain and 13% disagreed.

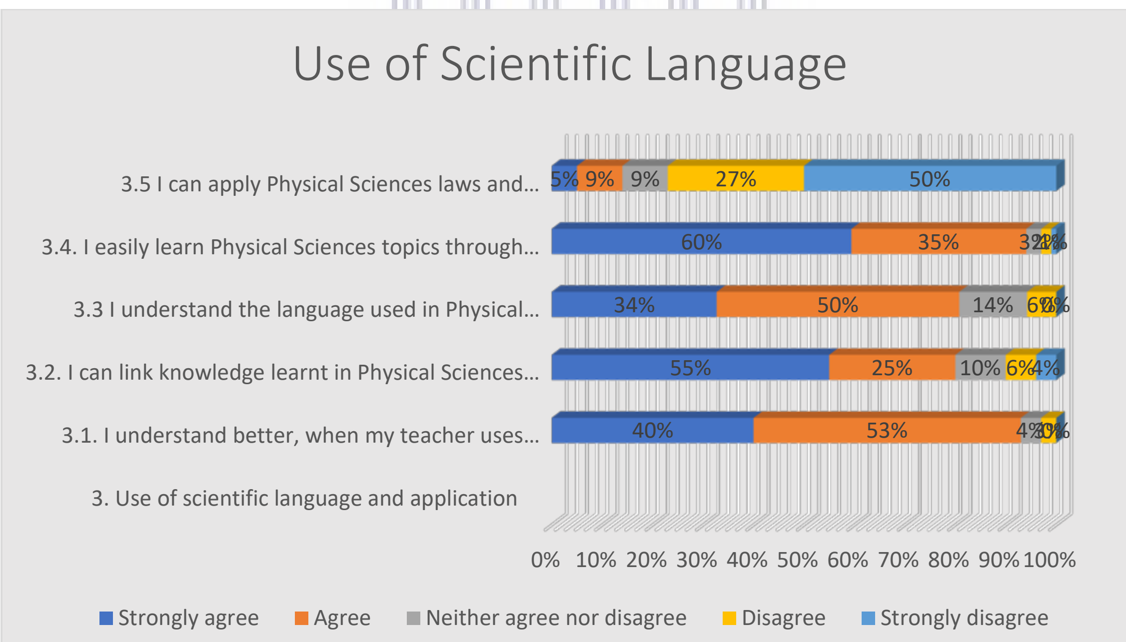

Figure 9: Use of scientific language after participating in Science Expo

4.5. RESPONSES OF LEARNERS ON INTERVIEWS

A total of 70% of participants confirmed that Physical Sciences is not difficult. They also indicated that they designed projects for the Science Expo after interacting with the environment while preparing for their research projects. For example, the following learners reported that:

> *"The exposure to and mingling with learners from other schools as well as seeing their projects in the science expo made him to understand different sections in Physical Sciences better."* [FI, L_{18}]

> *"I found Physical Sciences interesting after engaging in hands-on activity. Yes, it is an easy subject especially when it is collaborated with practical work."* [FI, L_{23}]

Some learners indicated that being involved in practical activities helped and motivated them to do better in Physical Sciences. For example, some learners said:

> *"My engagement in practical activity through practical work in science expo made me motivated internally towards Physical Sciences."* [FI, L_{15}]

> *"If you are not motivated from within you cannot study Physical Sciences."* [FI, L_{21}]

One student highlighted the importance of hands-on activities and connecting the curriculum to real-life situations. She indicated that:

> *"After participating in the expo, I found Physical Sciences as an easy subject especially if it is taught using hands-on activities and should not be separated from real life situations."* [FI, L_4]

90% of learners indicated that after participating in co-curricular activities like essay writing, the Min Quiz and the Science Expo, they developed an in-depth understanding of Scientific concepts and phenomena such as the laws and principles involved in Physical Sciences.

One of the learners agreed that she could comprehend the phenomena in Physical Sciences explained by concepts, and she gave the example of a thunderstorm.

She explained that:

“Thunderstorms occur when charges collide, and the build-up of charges results in thunderstorm.” [FI, L_{32}]

“Another learner further explained how electrostatics can be experienced using an inflated balloon which can be rubbed with cotton and being moved certain centimeters on top of papers.” [FI, L_{18}]

As a catalyst on what Learner 15 was saying, learner 28 further explained that:

“By rubbing the plastic ruler on hair, you are removing electrons from the ruler therefore you are making it to be positive hence it attracts the small pieces of paper.”

[FI, L_{18}]

One learner cited that the expo helped her to use scientific language like use of words like hypothesis, variables, aim, conclusion, analysis and data collection. [FI, L_7]

80% of the participants were confident that they could tackle Physical Sciences problems without asking for any kind of assistance from the teacher or classmates.

To confirm the level of confidence one learner explained that they only ask for assistance from the teacher when they are starting a new chapter before the teacher teaches that chapter.

They drive themselves to study Physical Sciences due to the passion they have on the subject. Generally, they do not ask for any assistance from the teacher. [FI, T_1]

Another learner indicated that:

Leaners are the ones who are assisting the teacher with his work, because when the teacher was attending district meetings or workshops and left a task for them to do in his absence, they did the task. After finishing it, they would start a new chapter in his absence.

She further explained that they also assisted other learners in the new sections.

[FI, L_{33}]

Another learner added that:

After participating in the Science Expo, learners developed their own methods to understand the work that was given to them as well as the work that was not taught to them. She also alluded that they had developed a passion for Physical Sciences, hence they could study on their own.

[FI, L_{12}]

Learners' participation in the Science Expo made them confident enough to aim for 100% in their final examinations.

One learner further explained that:

The Science Expo had made her develop self-confidence and had helped her acquire debating skills to argue about matters around her. [FI, L_{10}]

Another learner highlighted that she understood better in class, and she could work independently, without asking for any assistance from the teacher. She further said she could rate her level of confidence as 10/10. [FI, L_{18}]

80 % of the participants agreed that their involvement in project development made them develop research skills after following the steps engaged in project development.

One learner highlighted that:

The Science Expo helped her to share the information to other learners who were not part of the Expo, because as she spread the information to others, her understanding of Physical Sciences was strengthened in the process. Additionally, she alleged that the Science Expo has developed a new person in her; she is born again as she finds Physical Sciences fascinating.

[FI, L_{25}]

78% of learners agreed that they could integrate the scientific knowledge learnt at school with the knowledge they get from their Science-rich environment. In the light of understanding scientific language one learner mentioned that:

> She links and applies the information learnt at school with what she does at home daily. Even when making tea, she knows that she is making a solution. [FI, L_{12}]

Another learner indicated that:

> The water vapor that is released during cooking could be used to generate electricity. He even indicated that he want to pursue a career in the STEMI field, and made mention of the following fields: soil scientist, an engineer, climatologist, Zoologist, botanist, and lecturers in the field of science. [FI, L_{19}]

90% of learners indicated that they were confident enough to be peer tutors and present some topics to their classmates as they gathered the presentation skills from the expo and pointed out the topics they can present to their peers.

> Learners concluded that they could teach their peers acids and bases; electric current and electric components as well as chemical change. [FI, L_3] [FI, L_{18}] [FI, L_{18}]

85% of learners showed that they had a deeper understanding of Physical Sciences, as they learnt about scientific language, hypothesizing, manipulating variables, data collection & handling, and drawing up conclusions. One of the learners indicated that he could present the topic on waves and electromagnetic radiation, as he researched waves in his project.

> One of the learners indicated that she can explain Newton's laws, electricity and properties of waves, as she understood those topics more deeply with the help of the project that she prepared for the Expo.
> [FI, L_{22}]

Other learners indicated that:

"I can explain Coulomb's law; electricity and I understand the topics very well." [FI, L_{10}]

"I can explain the topic of van der Waals forces by using the household resources like methylated spirits, water, glycerin and cooking oil." [FI, L_{14}]

"It is easy to understand in class when a lesson is taught using practical work as I have seen that the project I made provided the practical part and application of what I learnt in class." [FI, L_{17}]

"My project was about generating electricity using turbines and trapping energy from the ocean so I would teach electricity using practical work and use the scientific language and research skills I obtained while doing my project." [FI, L_{23}]

"My project was about voice tech which involves recording the teacher while teaching which can assist the learners during revision. This device uses sound waves which are directed by the wind. The project made me understand how waves work as I researched about waves from where I am staying. I also learnt from others' projects which led me to understand Physical Sciences better and deeper than before." [FI, L_{18}]

76% of learners indicated that they developed interrogative skills through debates, which helped them answer the questions, compare variables and justify their arguments, assisting them in answering higher order questions in assessment tasks. 80 % of participants indicated that essay writing assisted with discussion and structuring of explanation skills, which helped them with questions which needed explanations. 82% of participants indicated that from the Science Expo, they learnt concept formation, deeper understanding of science phenomena, as well as the application of laws and principles learnt at school in real-life situations, and this helped them handle high order questions.

Some learners highlighted that:

"In my project, I did a lot of research, trying to understand the velocities, impact, time, location, GPRSs, forces that are engaged when a calculator falls. In the process, I have learnt how to compare ideas, how to explain processes, how to collect data and how to draw up conclusions. Being involved in the project gave me skills to tackle higher order questions." [FI, L_{18}]

"The expo has helped me to collect data, analyze the questions, put things in order, start with the basics, and put my work in a chronological order, thinking broadly and how to structure the write up." [FI, L_{35}]

In most of their responses, learners specified that they developed a lot of skills such as concept development (defining and describing concepts), higher order reasoning (applying laws and principles in real life situations), integrating (linking topics within Physical Sciences and other subjects) and problem-solving skills (embarking upon simple and challenging calculations).

4.6 RESPONSES OF TEACHERS IN AN INTERVIEW AFTER LEARNERS PARTICIPATED IN CO-CURRICULAR ACTIVITIES

Two out of three teachers unanimously agreed that after the learners engaged in co-curricular activities, they have noticed a remarkable difference in their performance, attitude as well as discipline. They also noted that the learners show leadership qualities, as they keep the classes in order in their absence and presented topics to their peers. They further indicated that most learners showed an in-depth understanding of scientific language and scientific method, which helps them to be more confident when answering higher order questions.

Moreover, they mentioned that learners have developed a passion for Physical Sciences, and their attitude towards it has changed positively. Additionally, they highlighted that learners can apply scientific laws and principles to real-life scenarios. The third teacher saw no difference in learner performance after participating in the Science Expo. Below are the views of teachers concerning the participation of learners in various co-curricular activities.

"'Learners view Physical Sciences as an easy subject and they show a positive attitude towards it. They pass it and can work in groups and assist each other after participating in co-curricular activities." [II, T_2]

"Yes, because whenever a new topic is introduced they try to conduct practical work and persuade me to use experiments when teaching as it helps them to have better understanding of concepts." [II, T_2]

"My learners can argue over some concepts, they are no longer reserved and shy they are confident, inquisitive and inquiring. They make my class to be active and vibrant because of the influence of expo learners."
[II, T_1]

"Their curiosity about Physical Sciences makes them to ask time and again and when they encounter a problem but generally, they work on their own." [II, T_2]

After learners were interviewed, a Post-Attitude Questionnaire was administered to them.

4.7. EXAMINING LEARNERS' ATTITUDE TOWARDS PHYSICAL SCIENCES USING A POST- ATTITUDE TEST QUESTIONNAIRE (ATQ)

Most learners in the research study, after participating in co-curricular activities, showed a positive attitude towards Physical Sciences as depicted in the responses of the post-ATQ. Records show that learners wanted practical work to be included in Physical Sciences lessons. The participants alleged that participating in co-curricular activities such as Science debates and essay writing, the MinTek Minquiz and the Science Expo made them understand Science better. The majority of participants found Physical Sciences useful in their day to day lives, and not only for school examination and assessment purposes.

4.8. LEARNERS' PERCEPTIONS OF CO-CURRICULAR ACTIVITIES

When learners were interviewed after being exposed to various co-curricular activities, it was found that most of them wanted to pursue careers in science at a Tertiary level. For example, learners indicated that they will link the everyday science knowledge with school Physical Sciences knowledge using the skills and information they gained while participating in debates, expos, MinTek Minquiz as well as essay writing. They also highlighted that they did not get any form of assistance from family members, hence they showed various attitudes towards Physical Sciences. Their exposure to co-curricular activities made them more confident in doing their formal and informal assessments.

4.9 TEACHERS' PERCEPTIONS OF CO-CURRICULAR ACTIVITIES

Based on the interviews that were conducted, the teachers indicated that the learners who participated in co-curricular activities did no longer view Physical Sciences as a challenging subject, but an easy subject as their performance in assessment tasks improved. The teachers further cited that the learners could analyze and handle higher order questions, as well as applying Physical Sciences laws and principles. The teachers concluded that the curiosity and interest of learners towards Physical Sciences were aroused during Physical Sciences lessons after partaking in co-curricular activities, hence they used practical work and different teaching approaches during teaching and learning process. The teachers added that they constantly gave feedback and guidance to learners, and their classes became learner-centered and vibrant.

4.10 SUMMARY

Most learners indicated that being hands-on in a practical activity, involved in research and interacting with the environment during projects encouraged them to be interested in Physical Sciences, to understand the content, science concepts and scientific language. They also added that they no longer classify Physical Sciences as a difficult subject, especially when teaching is done through practical work. The teachers highlighted that they noticed a remarkable change in learner performance, attitudes and passion for Physical Sciences. The next chapter, chapter 5 will give the analysis of results presented in this chapter.

CHAPTER 5

DISCUSSION

5.1 INTRODUCTION

The discussion chapter presents a clear argument on the findings that were obtained for the study. It also gives a rich answer on the research question: ***What is the influence of co-curricular activities on learners' attitudes and achievement in Physical Sciences?*** The research question will be answered per themes of the pre-and post-ATQ, as well as the interview schedules that were given to both learners and teachers. Discussed below are the themes of the questionnaire and questions on the interview schedule before and after learners were exposed to various co-curricular activities.

5.2 INTERESTS IN PHYSICAL SCIENCES

5.2.1 Use of practical work

Based on the information, data and statistics of the ATQ given in sections 4.2.1 (pre-ATQ) and 4.4 (post-ATQ) above, this research study suggests that learners understood better and the teachers' teaching became efficient when practical work was used during teaching. This led to improvement of attitudes towards and performance in Physical Sciences. The research results of the post-ATQ demonstrated that when learners learn by doing practical work, the attitudes and performance of learners improves. The results of the research study depicted that the percentage of participants who agreed that they understood better when theory is taught in collaboration with practical work, increased from 40% to 92%. Studies conducted by Choi &Cho (2002); Bennett, Lubben, Hogarth and Robinson (2002), determined that only a deviation from a normal teaching style permits learners to achieve the full benefits from a context-based approach, in terms of the improvement of their understanding and acceptance of science concepts, theories and laws.

This research study, together with other studies mentioned by the researchers above, suggest that teachers need to get rid of traditional teaching methods and use CAPS-compliant methods, of which practical work is an integral part, as it weighs about 25% of the exam mark, helping learners to achieve better in Physical Sciences. Social constructivists Gruender, (1996); Savery and Duffy (1995) in Brown (2006) in section 2.2.1 suggested that learners need to construct information, concepts, ideas and indulge in hands-on activities from their environment, which in turn they will apply in school Physical Sciences. Social constructivists, science researchers as well as this study are all in harmony, in suggesting that practical work enhances teaching and learning; and through participation in co-curricular activities arouses the interests of learners thus improving their attitudes towards Physical Sciences. The results of this study recommend that when teachers introduce new topics, they should introduce them using hands-on activities. Teachers substantiate the practical applications with theory. The teachers indicated that learners seem to enjoy the classes more and showed a greater level of interest when they could be involved using a hands-on approach. The teachers pointed out that:

> *"Yes, because whenever a new topic is introduced they try to conduct practical work and persuade me to use experiments when teaching as it helps them to have better understanding of concepts."* [II, T_2]

Learners also highlighted their need to be involved in more practical-oriented approach as they reflected that understanding improved when they were involved in practical activities. Many of them highlighted how their involvement in the co-curricular activities exposed them to a more practical hands-on approach. For example, several learners had the following to say during the interviews:

> *"It is easy to understand in class when a lesson is taught using practical work as I have seen that the project I made provided the practical part and application of what I learnt in class."* [FI, L_{17}]

> *"My project was about generating electricity using turbines and trapping energy from the ocean so I would learn electricity using practical work and use the scientific language and research skills I obtained while doing my project."* [FI, L_{23}]

It appeared that the ATQ data are supported by both teachers and learners during the interviews. There seem to a push coming from the research data to include practical-oriented approaches, such as those were used in the co-curricular activities. Learners' attitudes towards the subject, Physical Sciences, seem to be improved by using the practical approach to teaching.

Considering what the social constructivists submitted, societies, communities and parents should be informed about the importance of practical work in the assessment of learners through seminars and awareness campaigns. These awareness programs should be designed so that that they provide parents and learner guardians with basic training on how to assist learners with household science resources for practical work and be classified per those relevant for both GET and FET bands.

5.2.2. Interest in Physical Sciences

Most learners confirmed that Physical Sciences is intriguing after being exposed to various co-curricular activities. All learners suggested that they should be given a chance to participate in co-curricular activities; this opportunity should be open to all and not be limited to the so-called Mathematics, Science and Technology (MST) grant schools, and former Dinaledi schools. They further mentioned that these activities broaden their thinking, as they provide scientific inquiry, problem solving skills, passion and love for Physical Sciences. Learners also claimed that zeal and intrinsic motivation helped them to improve the performance in examinations especially in the higher order questions. To mention one learner voiced out that:

> *"My project was about voice tech which involves recording the teacher while teaching which can assist the learners during revision. This device uses sound waves which are directed by the wind. The project made me understand how waves work as I researched about waves from where I am staying. I also learnt from others' projects which led me to understand Physical Sciences better and deeper than before."*

[FI, L_{18}]

Teacher 2 confirmed that the learners' interest towards Physical Sciences as well as level of valuing the subject has improved after partaking in co-curricular activities:

"Learners that participated in all these co-curricular activities view Physical Sciences as an important subject and they show a positive attitude towards it. They pass it and are able to work in groups and assist each other." [II, T_2]

Maltese & Tai (2010) in section 2.3 above stated that interest in science is aroused when the teacher performs experiment expositions, allows learners to attend Science excursions and engages in investigation ventures and assignments which are fuel for inspiring careers in science. Maltese & Tai (2010) study is in accord with this research study, because the co-curricular activities stimulated the aspiration and urge of learners to follow careers in science. Additionally, the constructivists Chi-Kin Lee (2000) & McCaw (1980) and Chapani & Daibem (2003) in section 2.2.2 above maintained that concept formation is a combination of intellectual reasoning and attitudinal association of scientific information with surroundings, which yields positive attitudes towards school science, balanced and cost-effective science world thus reinforcing the findings of this study, and Maltese & Tai (2010) propositions.

The results of this study propose that the attitudes of learners became more positive compared to before they engaged in co-curricular activities. When learners are interested and have developed positive attitude in Physical Sciences, the chances of them to registering for Science-related fields at a Tertiary level are higher, therefore It is suggested that the schools should be planned in the model of Science centres, which produce Science-confident and excited learners.

5.2.3. Physical Sciences debates are fun

The percentage of participants who viewed **that science debates are fun,** increased from 25% to 38%, which shows that the Science debates impacted positively on their interest. The research study results indicated that Science debates assisted learners with critical thinking. Despite the percentage of learners who viewed science debates as interesting increased, it still shows that most learners are still encountering problems concerning Science debates, implying that there should be much more exposure to learners. One of the teachers confirmed that:

"My learners can argue over some concepts, they are no longer reserved and shy they are confident, inquisitive and inquiring. They make my class to be active and vibrant and I think

it is because of the influence of the expo." [II, T_1]

This research study suggests that the contact time for Physical Sciences should provide debate sessions once a week to develop interrogative and inquisitive skills in learners. For example, one learner pointed out that:

"The expo has made me develop self-confidence and I have acquired debating skills and I can now discuss and argue about matters around me." [FI, L_{10}]

Various researchers indicate that learners need to be exposed to a lot of mind-training activities to master and develop interest in Physical Sciences. Haussler & Hoffmann (2000) discovered the types of contexts that arouse learners' interest in learning of Physics at German secondary schools. They determined that settings from the socio-scientific and emotional sphere recover attitudes to Physics learning more than settings stressing practical activities, intellectual development, or preparation for future work. As per Haussler & Hoffmann (2000), discovery other than engaging learners in practical work, learners can also be involved in debates on issues in their communities. Additionally, Ausubel's (1968) notion of meaningful learning was supplementary and added significance to Constructivism, as it put forward that recent knowledge should be related to preceding knowledge. Haussler and Hoffmann (2000) suggested that the teacher should seek out means to support learners to bond the data through science debates, which result in understanding of science knowledge. They further argued that when the learners have bonded with data, a positive attitude towards science learning is yielded, thus aligning with this research study and Vygotsky's theory of scaffolding discussed in section 2.2.2.

The topics that were debated in science debates were both context and content-related so that learners could practice the inquiry in class, and apply that information in examinations and real-life situations. The research results indicate that the skills that learners received from science debates helped them tackle higher order questions in both formal and informal assessments.

5.2.4 Physical Sciences lessons are a base for learners' future careers

The percentage of learners who agreed that Physical Science lessons are a base for their future careers increased from 23% to 88%. This variance marks the change in the attitudes of learners which changed for the better. Prior exposure to the Science Expo, only a few learners were interested to further their studies in Science careers after matriculating, because they believed that Physical Sciences is a difficult subject. They claimed that furthering with Physical Sciences was going to create some problems in their careers. To sanction that, co-curricular activities helped learners to rate Physical Sciences as a subject that could elevate their future careers. One learner detailed that:

> *"The water vapor that is released during cooking can be used to generate electricity. With information like this I want to pursue careers in the STEM field such as soil scientist, an engineer, climatologist, zoologist, botanist, and lecturer in the field of science."* [FI, L_{19}]

The discovery method, data handling, data analysis and making deductions from what has been discovered, raised the learners' eagerness to study Physical Sciences at a Tertiary level. Reid and Skryabina (2002) conducted a large-scale attitude survey of students in Scotland offering courses which are context based to various degrees, and found that throughout secondary schooling, context-based learning approaches are interrelated to a higher interest in further Science training and Science-based careers. Conversely, at pre-university level, further study and career choice is linked less prominently to context-based approaches. As stated by Reid and Skryabina (2002), for learners to register and further in Science-related courses, their interest needs to be aroused at High School level, so as to yield positive outcomes at Tertiary institutions. The context-based learning aligns with Constructivism discussed above in section 2.2.2 and with this study, too.

Learners in this research study also revealed that after seeing others obtaining awards and medals in the Regional Expo, they realized that the life of a scientist is a rewarding life, and that is why they decided to perform better in Physical Sciences. It is recommended that learners at all schools should be involved in ongoing projects to familiarize them with research methodology. Redding's & Wallace's research (1996), determined that involvement of students in hands-on activities was triggered by prospects for learners to oversee their learning and superior learner sovereignty.

The conception of learners being responsible for their studies correlates with Constructivism discussed in in section 2.2.2 above as Constructivism requires learners to be the key role players in the teaching and learning process, and aligns with this theme because immediately learners possess their science learning, and the chances of pursuing Science careers are undoubtedly high. Having acquired the research skills, the learners were able to handle higher concept questions, alluded that they were ready to proceed to Tertiary and promised to be quality scientists and independent citizens.

5.2.5. Feeling like doing Physical Sciences everyday

The percentage of participants who reported that they felt like studying Physical Sciences every day increased from 23% to 59% when tracking them from pre-ATQ to post-ATQ. The research results indicate that the Expo encouraged the learners to make it their custom and habit to learn Physical Sciences daily. One learner confessed that:

> *"The expo helped me to share the information to other learners who were not part of the expo because as I spread the information to others, my understanding of Physical Sciences is strengthened in the process. Additionally, I the science expo has developed a new person in me; I am born again as I find Physical Sciences fascinating."* [FI, L_{25}]

Teaching approaches and assessment tasks should be planned so that learners have the desire to become future scientists.

Teacher 2 agreed that:

> *"Yes, because whenever a new topic is introduced they try to conduct practical work and persuade me to use experiments when teaching as it helps them to have better understanding of concepts."* [II, T_2]

The findings of this research study align with Bouvier's (2011) research discussed in section 2.3 of this study, which alluded that if learners are familiarized with practical activities they cultivate scientific inquiry and become innately inspired. For that reason, teaching methods should engage learners through use of puzzles, work sheets, experiments, models, projects, multiple-representation of concepts through simulations, videos, diagrams, picture collage, voice notes, online teaching events, sessions for TV and radio programs as well as telematics centres for all schools.

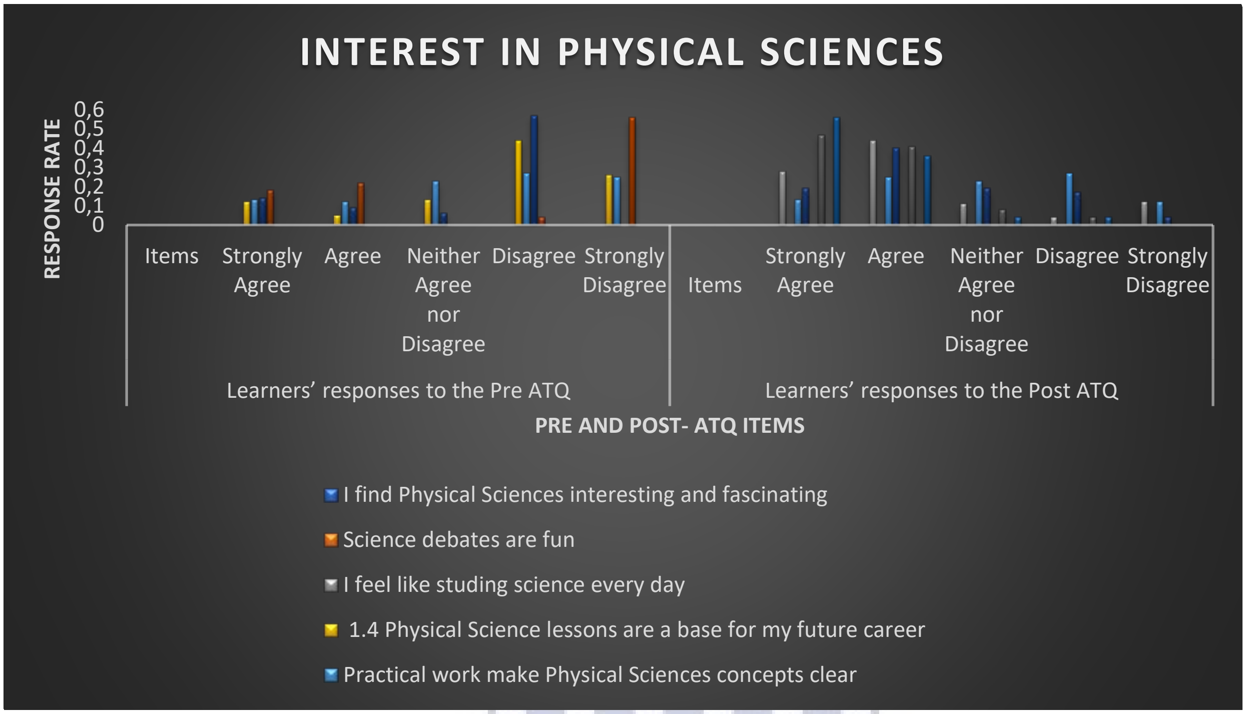

Figure 10: Pre-and posttest ATQ on interests in Physical Sciences

The above graph presents the extensive summary of comparison of the results that were obtained in the Pre-and Post-ATQ on interests in Physical Sciences. The result analysis as portrayed by the graph clearly indicates the interest of learners towards Physical Sciences on learner attitudes prior to and post partaking in the co-curricular activities. The trend of the graph indicates improved interests towards Physical Sciences. The graph is skewed to the right (strongly disagree side) in the Pre-ATQ and skewed to the left (strongly agree side) in the Post-ATQ, which suggests a difference in the response rate, which seems to be positive after intervention as per graph analysis. This graph advocates that there should be a routine teaching where co-curricular activities are in cooperated with theory for all curriculum topics. The inclusion of co-curricular activities to curriculum will improve learner attitudes, build conceptual progression in all Physical Sciences topics and arouse the interest of learners towards Physical Sciences. This research study's results suggest that when learners' interests are aroused through co-curricular activities, the performance and achievement of learners towards Physical Sciences can be improved.

5.3. PERCEPTIONS TOWARDS PHYSICAL SCIENCES

5.3.1 Confidence when doing Physical Sciences classwork and homework

Many learners (80%) highlighted that that they are confident when doing Physical Sciences classwork and homework as compared to 22% demonstrated by the results of the pre-ATQ under this sub-theme**.** Their level of confidence improved after they realized that more of their school work depends solely on them, rather than their teacher. In agreement with these results, Van Loggerenberg-Hattingh (2003) in section 2.3, maintained that challenge-centered knowledge had the possibility to encourage learners more, and made them more liable for their own learning, so that they had real understanding only of that which they formulate themselves.

5.3.2 Learners who are self-assured about doing their informal assessment tasks

The percentage of learners who are self-assured about doing their informal assessment tasks increased from 22% to 80%; this drastic improvement indicates that the attitudes of learners are positive. The optimistic attitude of learners made them to understand the content better, which is the start of their journey as scientists and a stepping stone for them to tackle higher order questions. Viegas (2004), Twillman (2006) and Coldwell (2008) were in consensus with Bonnet, Kessel, Kerrest, and Chapman (1956) that co-curricular activities aid as the means for increasing scientific attentiveness in learners, as the activities made them appreciate some Physical Sciences areas better. These researchers' suggestions concur with the findings of this research study because participants revealed that they comprehended Physical Sciences better after partaking in various co-curricular activities.

5.3.3 The importance of doing well in Physical Sciences at school

Learners should be made aware that classwork and homework are the groundwork of their future studies, and a basic determinant of their studies and best performance. The number of participants who acknowledged the importance of doing well in Physical Sciences at school improved from 10 % to 89%. The exposure of learners to Science careers helped them advance their performance because of the requirements for the entry in each Tertiary faculty. Prerequisite requirements for each course needed to be explained to learners so that they work towards their goals in life.

5.3.4 Participants' friends seeing Physical Sciences as an easy subject

The percentage of the participants' friends seeing Physical Sciences as an easy subject remained at 30%. The reason behind this consistent perception is that most of their friends were not part of the co-curricular activities, which means they were not exposed to science environment. The research study also gathered that they did not have a deeper understanding of Science and how it applied to the world around them. Seminars and mini workshops need to be conducted to expose learners who do not take Science as a subject to the Science world. In agreement with this study, Miller (1997) suggested the establishment of "Citizen Scientists", who would obtain their Science education through Science media such as museums, magazines TV and radio programs. These science sites would boost learners' logical development in Science, as these "Science Citizens" would aid school learners in their daily assessments, thus increasing learners' Science literacy skills.

5.3.5 Parents see Physical Sciences as a difficult subject

The number of participants who indicated that their parents see Physical Sciences as a difficult subject increased from 51% to 60%. The reason for this variance is that most participants' parents could not assist them with their tasks hence they declared it as a difficult subject. Conferences and campaigns can help parents with simple science information which can assist parents with basic skills that will help them to help their children in informal tasks. Lyons (2006) posited, in a three-country relative study he conducted in Australia, Sweden, and the United Kingdom, that attitudes to Science learning are powerfully affected by students' perceptions of "how it is related to the real world and technology and the future".

This research study fully agrees with Lyons's study, because most participants after engaging in co-curricular activities viewed Physical Sciences differently. They further disclosed their interests in continuing or following career paths in Physical Sciences. Another research by Muya and Oguga (2000) stated that the students' attitude towards Science is strongly affected by parental influence and beliefs from one's culture. Muya's study links with the Constructivism theory that underpins this study, which states that learners create meaning of Physical Sciences concepts, theories, laws, principles, assumptions and phenomena from what they see. Learners also learn and apply Science at home, as well as in the social order and atmosphere in which they live.

The graph (figure 11) below presents the responses of participants on perceptions on Physical Sciences in the Pre-and Post-attitude tests. On the Pre-ATQ side, the graph is tilted to the right, whereas on the Post-ATQ the graph is askew to the left. Grounded on the graph outline, this study submits that the participants had a different perception about Physical Sciences after participating in co-curricular activities. This study decides to call this type of different perceptions, Learner-Based Perception (LBP), which assists learners on concept-building, and yielding better understanding on the vitality of Physical Sciences in the future of the learner. This study further advocates that the LBP could have an ability to influence learners on the choice of careers while at FET level. Another perception that has been pinpointed by this research study is the Parent-Based Perception (PBP). The PBP addresses the level of difficulty of Physical Sciences which has not been properly developed by parents. The PBP indicated that parents were not well versed about the processes involved in Physical Sciences. The results of this research study then suggest that the PBP needs to be addressed to equip parents with relevant basic Physical Sciences skills that can help parents to assist their children in daily Physical Sciences informal tasks. The arrangement of the graphs in the Pre-and Post-ATQ designate that the Confidence-Based Perception (CBP) of learners improved after exposure to co-curricular activities. Therefore, the graph with analyzed data proposes an improvement in learner perceptions after co-curricular acquaintance.

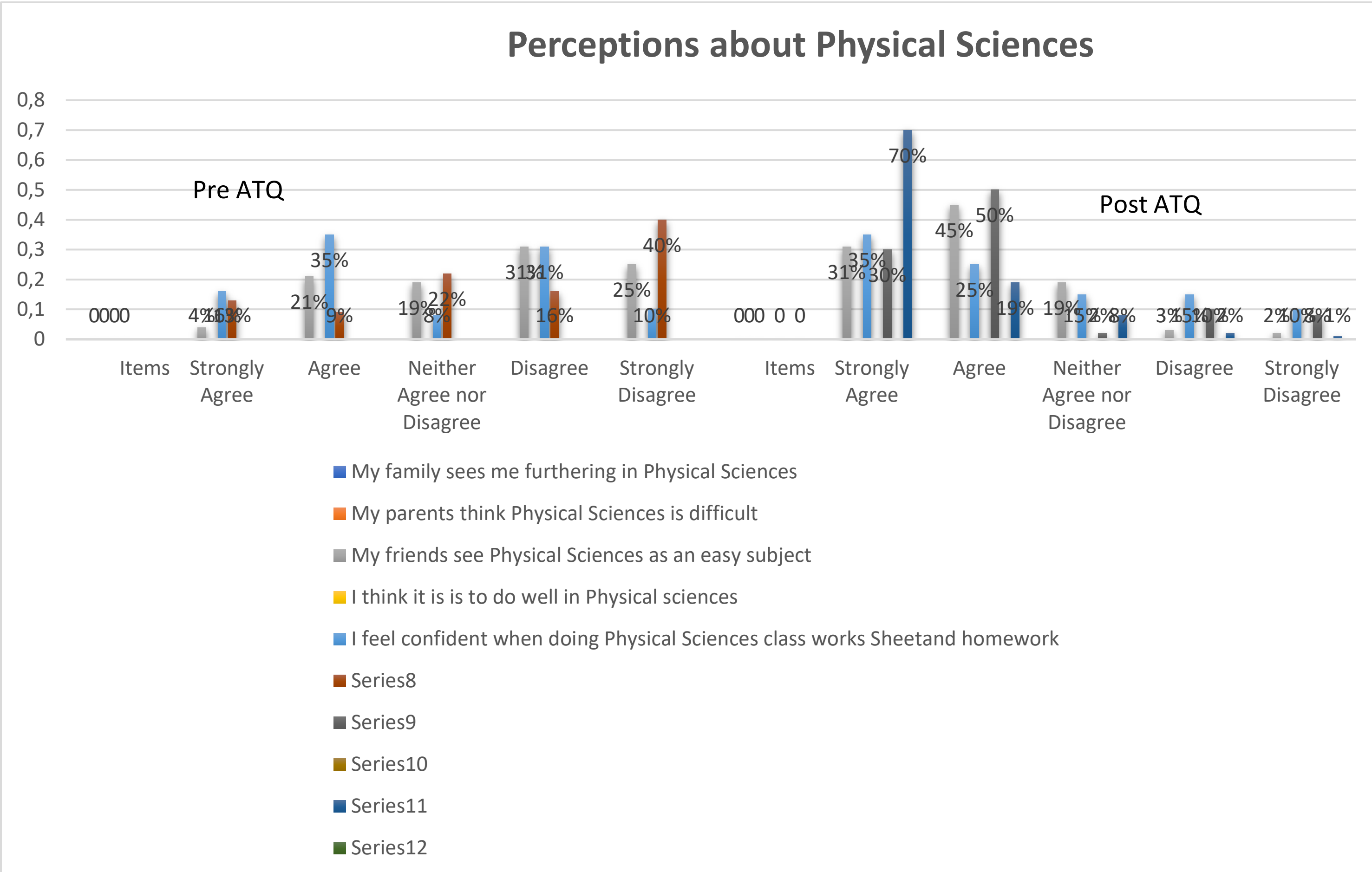

Figure 11: Pre-and Post-ATQ on perceptions about Physical Sciences

5.5 USE OF SCIENTIFIC LANGUAGE

5.5.1 Application of Physical Sciences' laws and principles in everyday life

The number of learners who indicated that they can apply Physical Sciences' laws and principles in everyday life augmented from 14% to 80%. The reason for this increase in percentages is that learners did not only understand Physical Sciences principles but reached a stage of knowing and passion for the subject since they were involved in the research process. Learners need to be provided with tasks that need application of Physical Sciences laws and principles on a daily basis to train them for examination readiness, especially in questions that require synthesis.

5.5.2 Learners easily learn Physical Sciences topics through practical work.

There was a drastic improvement in the number participants (from 14% to 95%) who cited that they easily learn Physical Sciences topics through practical work. The motive for this noticeable change is that participants could confirm what they learnt theoretically through experiments, and they observed all the changes employed in experimentation, and the information was engraved in their minds hence their improvement in performance. The findings of this research study concur with Campbell's (2001) results, which postulated that learners, when asked what they enjoyed most in Science, revealed that conducting experiments and discover current information and phenomena makes Science pleasurable.

Practical work should be used as means to enhance teaching and learning, coupled with other teaching approaches to better the performance of learners in Physical Sciences. Polly and Hannafin (2007) agree with the results of this research study, concluding that learner-centred education tactics make learners more probing, cause them to intermingle with each other, postulate, reason analytically and draw up inferences, and thus stress the route style and endorse optimistic assertiveness towards Physical Sciences (see section 2.2.2 above).

5.5.3 Understanding of the language used in Physical Sciences

The percentage of participants who highlighted that they understand the language used in Physical Sciences very well improved from 33% to 84%. The motivation for this improvement was the scientific language involved in the steps of the project development. These findings correlate with Norris' and Philips' (2003) research, which suggest that scientific knowledge is made up of numerous constituents which include:

- The Information of the utilitarian content of Science and the capability to differentiate from non-science
- Accepting science and its submissions
- Facts of what is regarded as Science
- Unconventionality in learning Science
- capacity to reason scientifically
- Skills to use scientific knowledge in problem solving

- Data needed for intelligent involvement in Science-based concerns
- Appreciating the nature of Science and its association with culture
- Obligation of and ease with Science with its sensation and inquisitiveness
- Understanding of the hazards and profits of Science
- The aptitude to reason analytically about Science and to deal with scientific expertise.

Therefore, this research study advises that the continuous assessment of learners should include fortnightly projects that will train learners and sharpen their minds on the use of scientific language, which in turn will help learners solve higher order questions, thus improving their performance in Physical Sciences. This will result in learners reaching all the stages of Phillips' research expectations. Furthermore, learners will be able to construct information from what they already know thus employing a Constructivism-based learning process. Several studies also confirm the results of this study to be true; Zeidler et al. (1997) stated that their Science literacy development is for the addition of issue–centred or framework–based teaching as a chief force to establish the scientific problem to be scrutinized.

Additionally, Holbrook and Rannikmae (2007) claimed that scientific literacy is developed through the desire to exceed scientific problem solving through incorporating socio-scientific conclusion making. Simultaneously, Roth and Chi-Kin Lee, (2007) viewed scientific literacy as the acknowledgment that scientific literacy permits citizens to meritoriously partake in the real world, and is thus a communal responsibility rather than exclusively an individual consideration. This research study advocates that continuous assessment should be administered to train learners in all Physical Sciences concepts and phenomena.

5.5.4 Ability to link knowledge learnt in Physical Sciences to other subjects

The percentage increased from 12% to 80% of participants who pointed out that they could link knowledge learnt in Physical Sciences in other subjects, such as Agricultural Sciences, Life Sciences and Mathematics. The main cause of the change in learner attitudes is that during the Min Quiz and Science Expo, learners were exposed to Expo categories in which other science subjects fell. Connecting scientific knowledge with ordinary knowledge is in line with Sadler's

(2004) research verdicts, which posit that socio-scientific issues, i.e. everyday contexts, end up incorporating school science into personal science, therefore facilitating the advancement of understanding of scientific concepts. As posited by Sadler, learners could integrate and link information learnt in Physical Sciences within other school subjects and across their surroundings. The topics that overlap in Physical Sciences and other science subjects should be taught at the same time, to allow for integration across subjects and make it easier for learners to grasp the information that is similar, as well as to spot the differences.

5.5.5 Understanding better when the teacher uses different teaching approaches

A remarkable change from 25% to 93% in learner attitudes on understanding better when the teacher uses different teaching approaches. This change was caused by the fact that learners differ in grasping information, and their levels of understanding differ because they are unique and therefore they need different teaching approaches. The study that is related to these findings is the study which was conducted by Henige (2005). In her study, "students' attitudes related responses to inquiry learning in undergraduate kinesiology laboratory instruction", who researched the impact of varying teaching methods, from traditional to investigative inquiry methodology, where learners declared that they enjoyed the different approach.

This research study therefore suggests that teachers should vary the teaching methods to trigger the learner curiosity and strive for mastery of learning for each learner. Furthermore, the suggestions of this research study align with Tschannen-Moran & Hoy's (2007) study, which cited that lively teaching is teaching that is depicted by increased levels of teacher elucidation coupled with demonstrations and active student involvement.

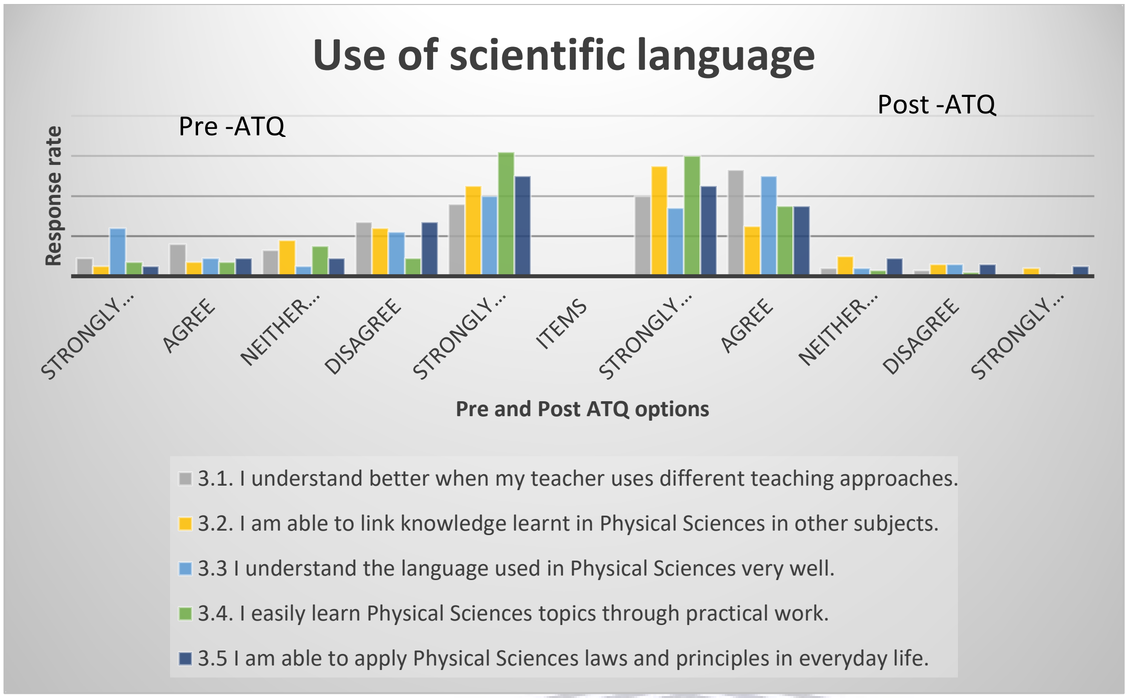

Figure 12: Pre-and Post-ATQ on use of scientific language

Figure 12 shows an evidence-based improvement analysis of data in the pre- and post-attitude tests for the “use of scientific language “ category. The analyzed data in the pretest is sloping towards the “strongly disagree” option, while the post test analysis is slanting towards the “strongly agree” option. The shape of the graph signposts the improved understanding of the language used in Physical Sciences after engaging in co-curricular activities. Under this section, this study acclaims the Scientific Language-Based Improvement (SLBI), which appears to have afforded learners an opportunity to understand Physical Sciences in totality. The SLBI was able to help learners with understanding, progressing from Cognitive level 1 to Cognitive level 4. The understanding phenomena progression as displayed by the graph, helped learners to build information from concepts, theory, application of laws, graphing and application in real life. The graph also illustrates that the foundation in SLBI assisted participants with linked the school Physical Sciences with home Physical Sciences, and with other subjects that have overlapping sections.

The graph patterns further exhibit that the Practical-Based Teaching and Learning (PBTL), which was introduced through co-curricular activities, yielded good results. This can be owed to the fact that the bar and its corresponding value in the graph on the PBLT are greater on “Strongly Agree” in the Post-ATQ. This research therfore suggests the maximum use of scientific language during teaching and learning process. When learners are grounded in scientific language using co-curricular activities as a base, Physical Sciences teaching and learning, the learner performance can be improved leading to quality results.

5.3 INTERVIEWS FOR LEARNERS ON THEIR INVOLVEMENT IN CO-CURRICULAR ACTIVITIES

5.3.1 Min Quiz

The learners revealed that the Min Quiz assisted them with Chemistry, which they had no hope of passing, because they viewed it as difficult compared to Physics. The participants further emphasized the importance of Chemistry in their future studies. Additionally, they confirmed the love of Chemistry, and displayed new-found self-confidence, since most of the practical work they do at school is applicable in their homes. The use of Chemistry concepts and symbols relies on the capacity of learners to transfer from real-life situations to symbolic or representative level, or the other way around, (Dori & Hameiri (2003). Per Dori & Hameiri (2003), the Min Quiz competition assisted learners by simplifying complex Physical Sciences concepts and content into illustrations and symbols, thus providing better understanding, as well as implanting a positive attitude towards Chemistry. Therefore, the results of this research study are in line with Dori & Hameiri’s findings (see section 2.3), and have the same goal - to improve attitudes towards Physical Sciences.

The ability of learners to link Chemistry to real-life situations correlates with Constructivism is clearly explained in section 2.2.1 above. Kukla (2000); Ernest (1999); Gredler (1997); Pratt & Floden (1994) and McMahon, (1997) are social Constructivists, who state that learning is an active environmental progression of making meaning from societal events. Consequently, tasks given to learners should be strategized in such a way that they strengthen the practical skills of learners and how they relate to their environment. This research study therefore proposes that learners need to be informed through career exhibitions that Chemistry is a prerequisite, or Essential for some courses at Tertiary level. It is further suggested by this study that self-confidence of learners should be developed, so that it results in positive attitude towards Physical Sciences. If learners are trained to master Chemistry, and a positive attitude is instilled to them to perform better in that section, they are likely to enjoy the subject, thus developing a positive attitude towards Physical Sciences.

5.3.2 Learner interviews after engaging in co-curricular activities (essay writing, debates, launch of Science Clubs and attending the Science Expo)

After engaging in co-curricular activities, learners were interviewed, revealing that participation in the Expo helped them engage in collaborative work. They further stated that the hands-on activities from co-curricular activities made them to have better understanding of Science and became intrinsically motivated enough to link practical work learnt at school with real-life situations. Learners specified that their interest and in-depth understanding of Physical Sciences' concepts helped them to comprehend phenomena in their environment, and improved understanding of scientific language. It is believed that the change in learners' attitude was caused by their exposure to the science context, which helped integrate science content and context.

Pappas (1993) agrees with the findings of this study, as his research argued that eloquence in scientific language is crucial for triumph in school Science, because achievement in school Science gives rise to opportunities for career paths in Science. Pappas further highlighted that learners arrive at school speaking many languages at various levels; others get to school confident in their communication skills; therefore, there is a vigorous struggle in classrooms to shape description language per contexts. Pappas' (1993) research and this research study are in line with Von Glasersfeld's (1996) study of radical Constructivism discussed in section 2.2.2, which declared that the learning process commences with pre-existing knowledge to achieve the goals of all science lessons taught at school, which leads to the better understanding of scientific knowledge.

This research study proposes that schools should establish scientific context for learners, and expose learners to science vocabulary. They should also allow space for learners to explore using their pre-existing knowledge. The learners also postulated that they became self-driven due to the passion they developed in Physical Sciences, and could compare information. Additionally, learners reflected that they developed the skills to share information with other learners, which sharpened their confidence for examination readiness. They also posited that they could integrate school knowledge with every day knowledge, and were ready to trail careers in science. Learners also cited that they could present new topics that were not covered by their teacher to their peers, since they gathered interrogative skills, problem solving skills, data collection, data handling and data analysis skills.

The results of this research study show that change in learners' attitudes improved since the learners had an opportunity to discover who they were in a scientific context. Learners also revealed that they developed leadership skills, observed the world around them and saw it through the eyes of a scientist. In harmony with these results De Witt (2000) and Morrison (2009) in section 2.2.2 stated that the inherent understanding of what is happening in the learners' surroundings is the responsibility of the individual learner, the teacher, society, environment, capabilities, philosophies and prerequisites to join forces towards nurturing positive attitudes towards Physical Sciences. This notion therefore concurs with the discoveries of this research study, which noted that after learners interacted with their environment with the help of their teachers, their understanding, performance and attitudes towards Physical Sciences improved. In the light of discoveries of this research study, learners should be trained to differentiate between scientific phenomena and cultural phenomena, as well as spotting the similarities between the two.

5.4 INTERVIEWS WITH TEACHERS ON LEARNER INVOLVEMENT IN CO-CURRICULAR ACTIVITIES

Two teachers, teacher 1 and teacher 2, revealed that the learners who participated in co-curricular activities viewed Physical Sciences as an easy subject, showed a positive attitude, were able to work in groups and support each other during teaching and learning. They further stated that their classes are lively with learners who are inquisitive, confident in that they work on their own, inquiring and able to argue over topics and concepts. The teachers also highlighted that learners persuade them to conduct experiments to clarify terms, and they ask time and again and when they encounter a problem and can connect scientific knowledge with evidence based explanations.

Kincheloe (2005) and McLaren (2015) studies discussed in section 2.3 correspond with the findings of this study as they appealed that practical work intends to enable and allow learners to be the primary role players of learning, as well as generating space for cognizance. Accordingly, quality results can be obtained if learners are developed scientifically through exposure to co-curricular activities, as these studies and results relate. The teachers also noted that learners have command of scientific language, because they could justify their arguments and engage in critical arguments, analyze and interpret data, differentiate variables, hypothesize, analyze data, graph results from the data, draw up conclusions and relate what they know with what they learn in the classroom. Teachers further quantified that learners are very well-balanced, advantageous to others during revision time and cultivate a positive attitude in others. They further added that learners can answer questions on all cognitive levels, perform very well in assessment tasks, and are not reluctant to do calculations on the chalkboard since they have developed passion for Physical Sciences. Every time there is no teacher in class, you find them busy practicing and revising question papers. Furthermore, they revealed that learners are more about to think out of the box, and make the intangible Physical Sciences tangible. Moreover, teachers revealed that learners can integrate, argue and justify information, so that in the final exam teachers are expecting level 7's, because they have deeper understanding of science process and language. The findings of this research study tally with Fosnot (1996) principles, which were based on Constructivism in section 2.2.2 above, which state that learners should be encouraged to ask questions, make suppositions and assess their legitimacy, and challenge their inward intellectual encounter or uncertainty.

According to Fosnot (1996), students' blunders should be observed positively, as prospects for both learners and teachers to explore abstract understanding. He further states that students be duty-bound to be given a stage to echo their understanding through journal writing, illustrations, demonstrating and arguing science issues as learning arises through contemplative intellection.

Collaborating the results of this research study and Fosnot (1996) principles, it can be deduced that when learners participate in co-curricular activities their reasoning levels and the way they handle and interpret scientific information improves, and their attitudes towards Physical Sciences become positive. However, teacher 3 had a counter opinion in contrast to other two teachers, stating that the learners were irritating her by asking lots of questions, and interpreted this to be them doubting her qualifications and questioning her teaching. This teacher's challenge was one of personal and professional insecurity, and it may be that she does not have deeper understanding of the subject, while on the other hand the learners are keen and eager to learn. She added that to get information that relates to real-life situations to school work, she yells at her learners.

Teacher 3 does not create a sound environment for her learners to be curious and develop passion for the subject. Zembylas (2004) in section 2.3 reported that the scientific demonstrative traits of learners are intensely impacted by the teacher's own in Science teaching, which consecutively has an influence on the performance of learners. Taking into consideration Zembylas' attributions teacher (T_3) ploughed negativity into her learners, so she reaped negative results. Her negative emotions and lack of confidence in the subject was projected onto most learners in her class, being the primary source information, and was reluctant to allow learners to explore and appreciate the beauty of Physical Sciences everywhere. She further added that letting learners present lessons to other learners was a waste of time. She agreed that her learners did not pass; some did not understand scientific language and she insisted that she is a good teacher.

Several researchers like Moss, Leone, & Dipillo, 1997; Pappas, 1993 and Smolkin & Donovan (2001), agreed that the outline for observing students' Science inscription fundamentally provides teachers with a semantic for the assessment and support of students' scientific language attainment. Its significance lies in the prospective for teachers to use such outline to support the full contribution of all students in the arena of Science. Contrary to what these researchers concluded, teacher 3 did not support her learners to develop scientific language which could assist her to proceed smoothly with her lessons and examinations, because scientific language would no longer be a barrier in their studies.

The teacher (T_3), did not create an atmosphere for learners to explore and discover science around them, and she further stated that some learners were still the same, and they were the barrier for her to get 100% she aimed for. She also added that, what worried her most was that some learners did not even attempt higher order questions. Teacher 3 was determined to produce satisfactory results, but at the same time would not enhance her teaching and own learning, and did not seem to be addressing the challenges learners face. She did not express interest in finding the reasons why learners seemed to be demotivated and no change occurred to them. The actions of teacher 3 were conflicting with Vygotsky's (1978) research discussed in section 2.2.2, which suggested the dissemination of information from the well-informed person to the learner, as means of constructing scientific meaning by the learner.

5.7 TRIANGULATION OF INSTRUMENTS

To avoid bias and misconceptions about the results of each tool, the results of tools were compared to assess the accuracy of each tool against the other so that an informed decision can be drawn on similar and distinct aspects**.** The tools supplemented each other where there were grey areas and gaps in certain themes and aspects. After triangulation of tools it was found that an average of 80% on both the questionnaire and interviews yielded related data on interests towards Physical Sciences, perceptions towards Physical Sciences as well as use of scientific language. Given below is the sample of how triangulation was done to analyze the results.

Table 5: Sample of data triangulation table

Theme	Instrument	Extract from the study	Section

Interests in science	Questionnaire Interviews	1.5 **practical work** make science concepts clear- 92% (56% Strongly agreed &36% agreed) FI, L_{23} indicated that she found Physical Sciences interesting after engaging in hands-on activity and agreed that it is an easy subject especially when it is collaborated with **practical work.**	4.3.5 page 63 4.6.1 Page 67
Perceptions in science	Questionnaire Interviews	2.5 I feel **confident** when doing physics classwork and homework – 89% (70% strongly agreed and 19% agreed) FI, L6 agreed that he can **confidently** present acids and bases to his peers	4.3.5 page 63 4.6.6 page 69
Use of scientific language	Questionnaire Interviews	3.3 I understand the **language** used in physical science very well - 84% (34%strongly agreed& 50% agreed). FI, L7 cited that the Expo helped her to use scientific language like use of words like hypothesis, variables, aim, conclusion, analysis and data collection.	4.3.5 page 63 4.6.2 page 67

5.7.1 SUMMARY OF TRIANGULATION

Use of qualitative (interview schedules) and quantitative (questionnaire) instruments helped to answer the research question because the results showed that the co-curricular activities had a positive impact on the learner attitudes.

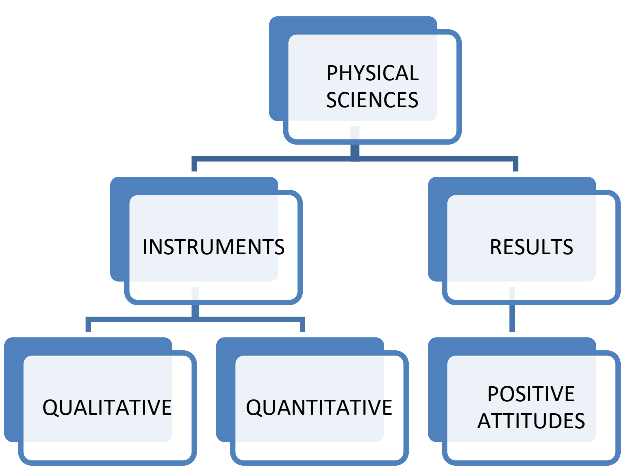

Figure 13: summary of triangulation of instruments

5.8 IMPACT OF CO-CURRICULAR ACTIVITIES ON LEARNER ATTITUDES AND ACHIEVEMENT OF LEARNERS

After triangulating the results of the data that was obtained qualitatively (interviews) and quantitatively (ATQ), it was found that on average 75 % for the overall results showed improved attitudes and better-quality performance, especially in higher order questions. The results were most improved (86%) in the use of scientific language, which is the kernel of understanding of Physical Sciences. Therefore, it can be proposed that the co-curricular activities had a positive influence on learner attitudes and performance. This research study has answered the research question on the influence of co-curricular activities on learner attitudes. The analysis of research results showed that learner attitudes became positive towards Physical Sciences. Furthermore, the learners could answer higher order questions in both formal and informal assessments, and the number of learners interested to pursue careers in science at Tertiary level increased.

5.8 CHAPTER SUMMARY

This chapter has revealed that after the participants engaged in co-curricular activities through experimentation, data handling and evaluation of science information; their attitudes towards Physical Sciences improved so that their teachers claimed that they could handle higher order questions and show confidence when writing informal and formal tasks. From this analysis, it could be projected that more learners will further their studies in Science, thus more may pursue science-related careers. A few learners still maintained that Physical Sciences and their attitudes did not change (results were not 100% positive), and one teacher did not agree with some aspects of the interview schedule and the process of engaging in co-curricular activities, as she saw it as waste of teaching time. Following this chapter is Chapter 6 which will outline the concluding remarks and recommendations of this study.

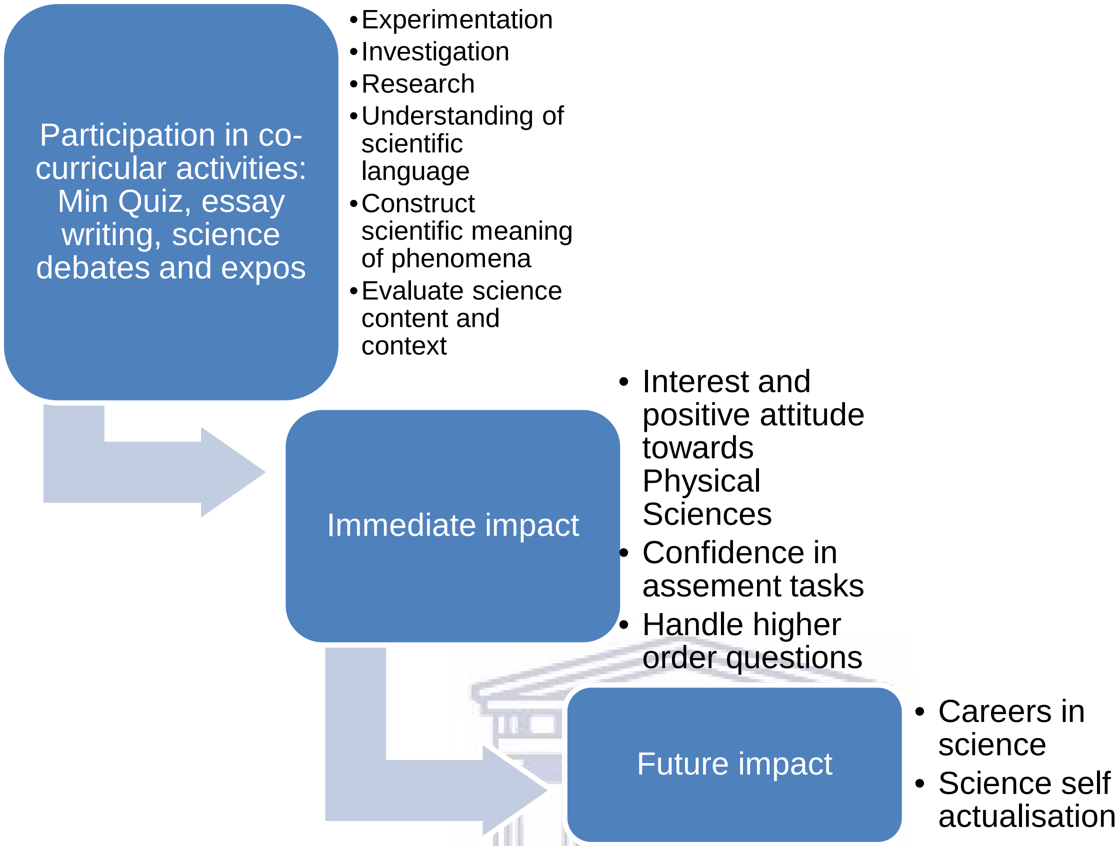

Figure 14**:** Result analysis logic

CHAPTER 6

CONCLUSION

6.1 INTRODUCTION

This chapter will provide conclusions by considering an overview of the study and implications of the study. It highlights the key findings and recommend future areas for research.

6.2 OVERVIEW OF THE SCOPE OF THE STUDY

The introduction of this research study outlined the following aspects: background, context of the study, socioeconomic status of the research community in terms of social class and economic level of the parents and guardians of learners in the community. The background of the study gave a vivid picture of the learner performance in Physical Sciences generally. The background also clearly focused on the learner attainment levels in the research school, with specific focus on term one assessment that was administered. The research study context presented the geographical setting of the school relative to other schools in Butterworth District, in Cluster B, in the Eastern Cape province, in South Africa, as well as its location in the world. The social economic status of parents indicated that learners come from underprivileged homes where most of the community members live below the poverty line. The parents' level of education was below that of their own children, which makes it impossible for parents to assist in learners' school work. Furthermore, economically they cannot support their children with Learner–Teacher Support Material (LTSM), such as scientific calculators, mathematical instrument boxes, learner study guides, graph books and display files. The socioeconomic state of the parents and their levels of illiteracy indicated that there was absolutely no parent involvement in the learning of Physical Sciences, hence learners had difficulty in answering higher order questions. The introduction further revealed the state of Science Education and the interventions which learners were engaging in, before they participated in co-curricular activities. Science education was depicted as having low percentage of learners furthering in Science careers at a Tertiary level when compared against the high percentage of learners registering for Physical Sciences at Matric level. The dwindling number of learners enrolled in Science fields at Tertiary levels is owed to their perception and attitude that Physical Sciences is a difficult subject and a ‘no go’ field after Matriculation.

Chapter 2 provided a detailed literature review on the Constructivism theory underpinning the study, studies on Constructivism, co-curricular activities and chapter conclusion. The chapter gave a clear background of what Constructivism is, and the literature supporting the use of Constructivism in the teaching and learning of Physical Sciences. Additionally, literature on Constructivism and numerous studies on the impact of co-curricular activities on Physical Sciences learning were analyzed and provided as a suitable evidence for literature for this study.

Chapter 3 gave a full description of methodology that was employed in the research study. The research was a case study with a sample of 35 grade 10 to 12 learners and 3 teachers. The study used mixed approach with questionnaire and interview schedules as instruments. The research occurred in three phases: the pretest in the form of a questionnaire, the intervention of exposing participants to co-curricular activities, followed by interviews and the post-test questionnaire. A pilot study to non-participants was done to test the viability of both questions and instruments, as well as testing the depth of measuring the impact of co-curricular activities on learner attitudes towards Physical Sciences. Data from all instruments was thoroughly analyzed, and the results from both instruments were triangulated to ensure that the tools complimented each other. The anonymity, confidentiality and fidelity of participants was kept, and their dignity was maintained throughout the research study.

Chapter 4 gave the written and graphical analysis of results from the data collected from pre-test questionnaire (ATQ) and interviews. The results chapter gave exactly the feeling of participants on each item in the instruments. It also cites the verbatim perceptions and views of participants on each item in the instruments. The response rate of 70% on average in the post-ATQ, indicated positive impact of co-curricular activities on participants’ attitudes towards Physical Sciences. The teachers also revealed how much better the participants understood the Physical Sciences content, and the enthusiasm they showed towards the subject after engaging in co-curricular activities. The participants’ responses disclosed that they did not draw a line between language of teaching and learning (LoLT), and scientific language before the scientific exploration they went through.

Chapter 5 provided a discussion of the findings based on how they responded to the research question. It compared the results of this study with previous studies as expounded on in the literature review of the thesis.

6.3 MAJOR FINDINGS OF THE STUDY

The discoveries of this study were trying to answer the following research question:

What is the influence of Science Expos and other co-curricular activities on learners' attitudes and learner achievement in Physical Sciences?

6.3.1 The outliers

The findings showed that even though most participants indicated the positive impact of co-curricular activities on the teaching and learning of Physical Sciences, there were those who disagreed about the impact of these activities, as they had many reasons for having a different opinion. Their views need to be taken into consideration and they must be regarded as the outliers in the study. One of the outliers was the teacher (one teacher out of 3) who saw no reason for enhancing teaching learning with co-curricular activities, as she just viewed it as time-consuming and found learners who were active in class as disturbances. The possible reasons for this could be that the teacher resists the change, she does not want to translate to new teaching methods and is clinging to her traditional methods. She was not ready to explore, and did not create a sound environment for her learners to enrich their knowledge. Her negative attitude towards participation and the impact of co-currricular activities can be attributed to incompetency and under qualification in Physical Sciences, which resulted in insecurities that were projected onto her students and inhibited their opportunities for learning. The outliers' views open a room for further research as they form part of unintended findings.

6.3.2 Parental or guardian pressure

The low percentage of learners who also saw no influence of co-curricular activities in their learning of Physical Sciences, can be accredited to their slight level of readiness in Physical Sciences learning. Their responses clearly showed that they were pressured by their parents or guardians to learn Physical Sciences. This group of learners had no drive to learn Physical Sciences, and could not be convinced otherwise, hence their inferior performance in the subject. It can therefore be suggested by this research study that handling of higher order questions can also be influenced by the passion for the subject when learners are exposed to the subject in their earlier stages of learning. The incapacity of learners to be passionate about Physical Sciences is mainly caused by parents who pressure learners into taking the subject, but in turn do not have the skills to assist learners with school work, especially the research section.

6.3.3 Teaching approaches

Both the teachers and learners in the research study illustrated that they were not used to learner-centred activities, hence their attitudes towards co-curricular activities and Physical Sciences. This contrasts with what Sternberg (2003) and Van Loggerenberg-Hattingh (2003) argued, where they suggested that learners learn through curiosity, discovery learning, and environmentally-based learning, which sway their level of thinking and how scientifically they perceive things around them. The teacher did not integrate theory with experiments and practical work, which lead to lack of scientific skills by learners to stand higher order questions.

This research study therefore tried to vector the minds and attitudes of both teachers and learners towards scientific evaluation of information through participation in co-curricular activities. The teachers therefore learnt a different teaching approach through observing learners partaking in co-curricular activities. The participation in co-curricular activities then assisted teachers to easily assess learners at all cognitive levels using Bloom’s taxonomy, which in turn enabled learners to respond to all questions presented to them, including higher order questions.

6.3.4 Influence of co-curricular activities on learner attitudes and achievement in Physical Sciences

An average of 80% of the overall results were positive reflection on how the co-curricular activities influenced the use of scientific method and processes, especially in handling and analyzing of higher order questions, and improved attitudes towards Physical Sciences. Scrutinizing the research results, it can be established that learners acquired scientific skills that led them to understand the nature of science, along with its application and implications in their surroundings. Participation in co-curricular activities helped the learners to understand scientific language, which helped them to answer higher order questions - their main challenge before the intervention (research study), and consequently their performance was improved.

Co-curricular activities helped learners to use scientific methods when analyzing scenarios, statements, interpreting flow diagrams and graphs in Physical Sciences. Learner attitudes improved towards the subject and bettered their achievements in assessment tasks. The passion, zeal and attitudes towards Physical Sciences developed because learners were able to think logically and critically after undertaking the research route, which made Physical Sciences simple and understandable. Learners further revealed that they acquired critical skills, creative skills, hypothesizing skills, problem-solving skills, concluding skills, data collection and data handling skills, as well as data analysis skills.

This study therefore recognizes that, when co-curricular activities are used to enhance teaching and learning, Physical Sciences' content and scientific language can be understood by the learners. The excellent quality Matriculation results can be pictured, and for that reason, there will be continuity of Science, because more learners will be interested in taking Science at Tertiary institutions.

6.3.5 Context grounded teaching

This research study found that context teaching through co-curricular activities helped learners to comprehend Physical Sciences better and gave them a chance to indulge in their science-rich environment. They constructed scientific meaning from what they fully understood and appreciated as means of better improvement in class. They related Physical Sciences to the context of their surroundings which helped them to completely grasp principles and laws used in the subject. The learners developed confidence in the learning of Physical Sciences, and became responsible for their learning. Learners referred to their surroundings when giving scientific examples and scenarios, thus contextualizing Physical Sciences.

6.3.6 Societal involvement

This study has exhibited that societal involvement through use of retired science teachers and scholars, policy makers, curriculum planners, curriculum advisors as well as establishment of Professional Learning Communities (PLC's) helped learners to have a better understanding of Physical Sciences. These stakeholders played a prominent role in assisting participants during the research stage in preparation for the Science Expo as one of the co-curricular activities. This study proposes that tertiary institutions should adopt GET and FET schools by engaging them in Science Expositions and establishing Science Clubs with them. Science interns can coach school-going scientists in the learning of Physical Sciences, thus grooming young scientists.

6.4 IMPLICATIONS OF THE STUDY

6.4.1 Learner exposure

The effects of this study showed that exposure to scientific environments prepared learners on concept understanding, data interpretation, scenario analysis, phenomena construction as well as application of Physical Sciences in real-life situations. Accordingly, the results of this research study showed that the extrinsic motivation of learners through co-curricular activities made them to develop a passion for and improved attitudes towards Physical Sciences, thus cultivating their intrinsic motivation. Consequently, exposing all school-going learners to co-curricular activities simplifies the Physical Sciences content and curriculum, and affords learners opportunities to achieve better merits in higher order questions.

6.4.3 Termination of SBA task marks' rejection by DBE and Umalusi

This research study substantiated that when learners fully understand the instructions, content, concepts, terminology and scientific language gained from participating in Olympiads, Expos and other co-curricular activities. The research study also suggested that learners will perform better in qualitative School Based Assessment (SBA) tasks, thus preventing the rejection of SBA marks by DBE (Department of Basic Education) and Umalusi. The SBA assessment tasks are categorized into two classes, namely the formal and informal tasks. The informal assessment comprises of written and oral explanations, classwork, homework, calculations, experiments, question & answer opinions, scientific observations, problem solving exercises. Formal assessment includes structured termly controlled tests, June examinations, preparatory (trial) examinations, prescribed experiments, projects and investigations and final examinations. The Physical Sciences' Curriculum and Assessment Policy Statement (CAPS) document classifies the weighting order in the examinations across the FET band as follows: 15 % of recall questions, 35% and 40% of comprehension questions in paper 1 and paper 2 respectively; 35% and 40 % of analysis & application in paper 1 and paper 2 respectively; and 10% of evaluation and synthesis in both papers.

This research study therefore suggests that offering learners an opportunity to partake in co-curricular activities will grant them an ample opportunity to answer questions at all levels of the weighting order, as per CAPS prescripts through scientific process gained in these activities. When learners perform at the same standard in both informal and formal SBA tasks, the marks will be approved by Umalusi and DBE assessment bodies. The approval of SBA marks by these assessment bodies minimizes the chances of failure rate, because the learner's final examination mark will match the continuous assessment mark. The learner's final examination marks will not be lowered relative to SBA marks, that will lead to eradication of underperformance. The learners' challenges in higher order questions will have been addressed through participation in co-curricular activities. This research study proposes that co-curricular activities should be used as a tool to protect learner marks from being lowered by assessment bodies.

6.4.3 Establishment of fully equipped Science Learning Centres

Another aspect that has been pointed out by this research study is the establishment of Science Learning Centres, which will make the Primary and High School learning of Physical Sciences sustainable. Resourced Physical Sciences media centres as a means of enhancing teaching and learning, coupled with co-curricular activities, can also benefit the learner performance. The science learning centres will provide Physical Sciences environment where high school learners can mimic the science activities dealt with at Tertiary institutions. This research study proposes that, when learners are grounded in Physical Sciences in their early years of schooling there will be more learners registered for STEM careers at Tertiary level. An intensification of number of learners passing Physical Sciences supports the South African policies like Action plan 2025, Chapter 9 of National Development Plan (NDP), action plan 2030 and National Strategy for Learner Attainment (NSLA). These policies are campaigning for an increase in the number of learners passing STEM subjects from grade R to grade 12. The Science learning centres can also provide co-curricular activities' in-service training (CCAIT) for teachers, thus empowering them and providing continuous professional teacher development programs (CPTDP). The teachers will in turn cascade the information to learners, thus fully supporting the implementation of CAPS curriculum. The launch of science learning centres will add value to texture and quality of Grade 12 learners passing Matric, and bridge the divide between well-resourced and under resourced schools.

6.4.4 Curriculum Reforms

This research study is also suitable for all curriculum reforms, as it seeks to promote the scientific process, which encourages learners to read, analyze, interpret scientific transcripts, pinpoint and resolve problems and make scientific write ups. The research study also suggests that this will increase learner's ability to make scientifically informed decisions, independently and in groups. On decision making, learners will be using critical, reasonable thinking and connecting situations leading to the formation of scientific phenomena. Through participation in co-curricular activities, learners will be able to visualize, understand representational phenomena and develop scientific language skills. Research study fits well with all curriculum reforms, systems, nationalities and structures, as well as national and international education systems.

6.4.5 Scientific method integrated with technology

Theoretical scientific method can be technologically translated to give precise meaning of Physical Sciences curriculum therefore all schools should be provided with technological facilities that will fully compliment the theory. The scientific research method and process gained from co-curricular activities will offer learners an opportunity to integrate the information accessed from the environment with technology as means of multi–representation of scientific concepts to make the facts clearer and understandable. The scientific concepts and data retrieved from the surroundings can be technologically represented in the form of virtual reality, videos and diagrams which will aid the learners in understanding and evaluating higher order information when writing assessment tasks and examination. Learners having understood and linked the school Physical Sciences facts with environmental evidence will perform better in examination, and underperformance will be substantially lessened.

6.4.6 Positive diagnostic reports

Having the bulk of learners partaking in co-curricular activities will transform ordinary learners to extraordinary science-grounded learners, therefore the diagnostic report and chief marker's report will chant an excellent performance song as the learners will be studying in a scientific environment created for them to understand scientific context; deficient performance and progressed learner policies will shall have passed. Victory will be the new song and Physical Sciences will no longer be a killer subject but a healer subject, Eastern Cape's performance will improve in the matric results.

6.4.7. Educational Recreation

The participation of learners in co-curricular activities will occupy them, and reduce the faction fights that are happening in most areas of the country. Additionally, the co-curricular activities will act as recreation activities, thus eliminating the abuse of drugs and alcohol by school-going kids, vectoring learners to Science careers at Tertiary level.

6.4.8 Economic Value

When learners perform better in the FET band by incorporating theory and research through co-curricular activities, the country's economy will be safeguarded. There will be less interventions required for Matriculation failures, such as supplementary exams, incubation classes, vacation and weekend classes. The number of progressed learners will be minimized, because the engagement of learners in practical, hands-on activities will complete the curriculum. The province of the Eastern Cape, department of education to mention, will save money due to spending less on these interventions. An injection of STEM graduates into the economy, relieving struggling state entities such as Eskom, may also be of benefit to the economy.

6.5 LIMITATIONS OF THE RESEARCH STUDY

The researcher having to change schools posed a challenge, because the participants had to change, and the learners with highest marks in term 1 examinations achieved results far below the learners in school A. They were in the mediocre level compared to school A. The need for intervention was highly needed in school B. Teachers did not want to take part in the study at the beginning, because they feared that the research may interrupt or reflect negatively on their work. Time was also a challenge, because the researcher had to let the participants complete all stages of the research process in each co-curricular activity.

Language used to reach the learners was a serious challenge. The researcher ended up verbally translating and rephrasing some questions. Focus group interviews were used instead of individual questions due to time constraints.

6.6 RECOMMENDATIONS OF THE RESEARCH STUDY

6.6.1 Approving future research

This research study allows room for future research in a broader spectrum of schools, starting from lower grades in Primary Schools (GET band) up to Secondary Schools (FET band), countrywide as well as internationally, using bigger samples than those that were used. Different clusters of schools (urban, rural, single racial and multiracial) can be used as samples, and their results compared with the main purpose of changing the attitudes of learners towards Physical Sciences to eradicate the underperformance in the subject.

6.6.2 Incorporating co-curricular activities in the GET and FET curricula

Further research on engaging learners in co-curricular activities from grade R to grade 12, and a pilot study on including co-curricular activities as part of curriculum (at least two hours per week), should be food for thought for curriculum planners. The annual teaching plans, work schedules and pace-setters should clearly indicate when and how much time should be catered for co-curricular actives.

6.6.3 Effecting in-service training for teachers on co-curricular activities

All Physical Sciences teachers should be provided with proper training on how to engage learners in co-curricular activities as part of a continuous professional teacher development programme, as well as a vehicle through which to enhance the teaching and learning of Physical Sciences. The lesson plans should be designed so that they clearly show which co-curricular activity matches a section or topic in Physical Sciences. Assessment policy should be designed so that co-curricular activities considered as vital aspects of the policy and be included in assessment plans in all stages of the Department of Education. The weighting of co-curricular activities should be 15% in formal assessment, which will assist all learners to manage higher order questions.

6.6.4 Development of supervision policy and plan for co-curricular activities

The office based Mathematics, Science & Technology Education (MSTE) coordinators and curriculum advisors should design a supervision policy and a plan for co-curricular activities for all schools. The policy and plan should be disseminated to all SMT's (School Management Teams) for implementation purposes and proper supervision at school level.

6.6.5 Adjustment of school time-tabling

School time-tabling should officially cater to Physical Sciences co-curricular activities, science tutorials and science days on a weekly basis, to develop scientific mind and reasoning in all learners taking Physical Sciences.

6.6.6 Annexation of co-curricular activities in SBA and CASS

The SBA moderations should include co-curricular activities, and the activities should contribute 15% of continuous assessment (CASS) marks, where each learner should keep a journal showing all the stages that were employed when engaging in a specific co-curricular activity.

6.6.7 Advocacy of pre-reading and lesson planning

Learners should be exposed to pre-reading of topics to be covered, so that they don't perceive the concepts to be introduced as foreign, thus preparing their minds for scientific reasoning. Curriculum planners and advisors should integrate curriculums with co-curricular activities and develop lesson plans that allow learners to indulge in the environment, and formulate concepts learnt at school and drawn from their environments. Numerous studies conducted by Lyons (2006) in Australia, Sweden and the United States prove that attitudes towards Physical Sciences learning are powerfully influenced by the way the learners perceive the scientific information at their disposal. Therefore, counting on Lyons (2006) study, lesson plans should reflect scientific perception, and intend to encourage learners to reason scientifically.

6.6.8 Exposure of learners to scientific process

Therefore, the primary recommendation of this research study is that learners must be exposed to co-curricular activities that will assist them to visualize and interpret the given information in a scientific manner. The major emphasis should be on the understanding of scientific content and use of scientific language, coupled with exposure to technology, as well as the manipulation and connection of the scientific data to the learners' environment. This approach will help learners develop a passion for Physical Sciences and yield positive attitudes towards the subject, resulting in sustainably high learner performances.

6.6.9 Requisitioning of resources and scientific teaching approach

It is further recommended that when teachers introduce new topics, they should introduce them using hands-on activities. The school heads and management teams should requisition laboratory equipment the same way they order textbooks and other Learner-Teacher Support Material (LTSM), so that all schools across the districts, provinces and South Africa at large have the equipment to enhance teaching and learning of Physical Sciences. The district curriculum advisors should be provided with Physical Sciences kits, so that they can provide basic training in experiments to all teachers who will propagate the information down to learners.

6.6.10 Developing the work book for practical work and co-curricular activities

Furthermore, curriculum planners should design experimental work for all topics with the intention of clarifying Science concepts rather than providing only recommended and prescribed experiments as it is the case currently. The practical work should align with the co-curricular activity for each topic. A workbook with worksheets which address co-curricular activities and experiments for each topic should be designed. The workbooks should be designed so as to require learners to complete set tasks on a weekly basis and be dated with subtopics which build up on each, other thus building the groundwork for regular scientific conceptualization.

6.7 CONCLUDING REMARKS

6.7.1 Authorization of co-curricular activities for all learners

Introduction of compulsory co-curricular activities as a formal part of the curriculum from as early as Grade R up to Grade 12 can encourage learner familiarity with scientific concepts, scientific processes and synthesis of scientific data and information, thus integrating scientific reasoning into learners' environments from an early age.

6.7.2 Integrating LoLT (Language of Learning and Teaching) with Scientific language should be mandatory for all schools

LoLT should be incorporated with scientific language during lesson presentations and during informal assessments to prepare learners for formal assessments, so they are able to solve higher order questions, resulting in and improved learner performance in Physical Sciences.

6.7.3 Channeling co-curricular activities in all schools

In South Africa, co-curricular activities need to be navigated in all schools, with the main concentration in the Eastern Cape Province, the intention being to pull the province out of its current pit of underperformance. The introduction of co-curricular activities will also help in increasing the number of learners passing Physical Sciences with good merits.

6.7.4 Improving attitudes of learners towards Physical Sciences

When learner attitudes are improved, confidence, grounding and passion for Physical Sciences develops automatically, yielding outstanding performance in assessment tasks. Scientific zeal, buoyancy and optimism are a lifetime investment that *can* be established in young scientists. Investing in young scientists is investing in a self-sufficient nation, building a self-sufficient nation helps grow the economy, growing the economy in turn helps alleviate poverty and enables further education and quality of life for its citizens and future learners. Having more– students entering into STEM careers can solve current crises – for example, Eskom not having enough engineers, needing state bail-outs, employing overseas experts, water shortages in the country, advanced means to control drug intake by youth, technological ways of applying to tertiary institutions. The positive legacy of a nation that invests in Science education will be enjoyed long into the future.

6.7.5 Sustainability of Science education

This study associates itself with all the policies that are aimed at increasing number of learners passing Physical Sciences at grade 12 (policies like NSLA, NDP, Action Plan 2025) and aligns with programs that are intended to beef up the number of learners registering at Universities, Technicons and colleges in the field of MST courses. The fundamental purpose of this research study is to keep Science education sustainable, improved and accessible to generations to come.

6.8 CONCLUSION

The results of this research study exposed that the intervention of using co-curricular activities acted as a vehicle to fuel up learner performance and improved achievement in Physical Sciences tasks. Furthermore, the research process helped the learners to enrich their knowledge and understanding of Physical Sciences. The perceptions they had about Physical Sciences before participating in Physical Sciences co-currricular activities upgraded to a positive attitude towards the scientific language, and the mastering of higher order questions. The interest in furthering MST careers was perfected, and learners reclaimed their first love for Physical Sciences which they had when they were enrolling for Physical Sciences for the first time. The research process tried to answer the research question: ***Examining the influence of co-curricular activities on learner attitudes and achievement in Physical Sciences.*** A comprehensive follow-up research is therefore recommended for other researchers.

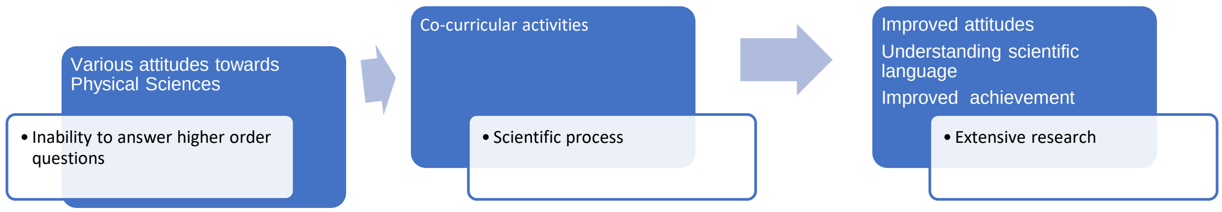

Figure 15: Conclusion logic

References

Adamuti-Trache, M., & Andres, L. (2008). Embarking on and persisting in scientific fields of study:Cultural capital, gender, and curriculum along the science pipeline. *International Journal of Science Education, 30(12)*, 1557-1584.

Africa's First On-line Science Magazine. (2008, march). *scienceclubs.htm.* Retrieved from www.scienceinafrica.co.za: http:/www.scienceinafrica.co.za/2008/march/scienceclubs.htm.

Afterschool Alliance. (2011). *STEM learning in afterschool: An analysis of impact and outcomes.* Retrieved from www.afterschoolalliance.org: www.afterschoolalliance.org/STEM-learning-in-afterschool

Asmal, K . (2002). *Speeches of Minister of Education, Prof Kader Asmal.* Pretoria: Department of Education.

Ausubel, D. P. (1968). *The Psychology of Meaningful Learning; an Introduction to School Learning.* New York: Grune and Stratton.

Baden Analine and Soda Factory (BASF) . (2013). *BASF.* Retrieved from www.basf.com: www.basf.com/chemistry

Baker, R., & Jones, A. T. (2005). How can international studies such as the International Mathematics and Science Study and the Programme for International Student Assessment be used to inform practice, policy and future research in science education in New Zealand? *International Journal of Science Education, 27(2)*, 145-157.

Barmby, P., & Eisenhardt, P. R., Brodwin, M., Gonzalez, A. H., Stanford, S. A., Stern, D., Galametz, A. (2008). Clusters of Galaxies in the First Half of the Universe from the IRAC Shallow Survey. *The Astrophysical Journal, 684(2)*, 905.

Barmby, P., Kind, P. M., & Jones, K . (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education, 30(8)*, 1075-1093.

Bar-Tal, D. (2012). *Group beliefs: A conception for analyzing group structure, processes, and behavior.* New York: Springer Science & Business Media.

Bennet, M.G. (1956). *United Nations Educational Scientific and Cultural Organization (UNESCO):Science Clubs Activities in the United Kingdom. .* Paris, France: UNESCO.

Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: a synthesis of the research evidence on effects of context-based and STS approaches to science teaching. *Science Education, 91 (3)*, 347-370.

Berk, S. G., Gunderson, J. H., Newsome, A. L., Farone, A. L., Hayes, B. J., Redding, K. S. & Reid, A. (2006). Occurrence of infected amoebae in cooling towers compared with natural aquatic environments: implications for emerging pathogens. *Environmental Science & Technology, 40(23)*, 7440-7444.

Berkowitz, D., Wolkowitz, B., Fitch, R. & Kopriva, R. (2000). *The use of tests as part of high-stakes decision-making for students: a resource guide for educators and policy makers.* Washington, DC: US Department for Education.

Bollen, K. A. (1989). *Structural Equations with Latent Variables*. New York:John Wiley & Sons.

Bonnet, D. D., Kessel, J. F., Kerrest, J., & Chapman, H. (1956). Mosquito Collections and Dissections for Evaluating Transmission of Filariasis in Polynesia (Tahiti) 1. *The American Journal of Tropical Medicine and Hygiene*, 5(6), 1093-1102. Immigration to the Metallurgical Districts of Lorraine. *Journal of Social History*, 123-155.

Bolstad, R., & Hipkins, R. (2008). *Seeing Yourself in Science: The Importance of the Middle School Years: Report* prepared for the Royal Society of New Zealand. New Zealand Council for Educational Research.

Boote, D.N. & Beile, P. (2005). Scholars-Before-Researchers, *Educational Researchers* 2005; 34; 3 DOI: 10.3102/0013189X034006003.

Bouvier, S (2011), *MPH Research Analyst/Coordinator*. University of Massachusetts Donahue Institute.

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science*, 1, 183–197.

Brooks, J.G. & Brooks, M.G. (1994). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development

Brown, S. (1976). *Attitude goals in secondary school science Collaborative research newsletter.* Edinburgh: University of Edinburgh).

Brown R.B. (2006). Doing Your Dissertation in Business and Management: *The Reality of Research and Writing*. New Jersey: Sage Publications.

Brush, S. G. (1989). History of science and science education. *Interchange*, 20(2), 60-70.

Bullock, S., & Cliff, D. (2004). Complexity and emergent behaviour in ICT systems.

Bryman, A. (1989). *Research Methods and Organization Studies* (1st ed.). London: Routledge

Campbell, D.E. (2006). *Incentives: Motivation and the economics of information.* Cambridge: University Press.

Carnoy, M., Chisholm, L., & Chilisa, B., (2012). The low achievement trap: Comparing schooling in Botswana and South Africa. Pretoria: HSRC Press. Centre for Educational Sociology (1978). *Collaborative research newsletter* Edinburgh: University of Edinburgh.

Carnoy, M., Chisholm, L., Addy, N., Arends, F., Baloyi, H., Irving, M., Raab, E., (2011). *The process of learning in South Africa: The quality of mathematics teaching in North West Province.* Technical report 11th June 2011. Pretoria: HSRC.

Chapani, D. T., & Daibem, A. M. (2003*). Educação ambiental. Acção-reflexão-acção no Quotidiano de uma Escola Pública.* Escritura Editora, São Paulo, Brasil.

Charlesworth R., & Lind K. K. (2003). *Math and science for young children*. Albany, NY: Delmar.

Cheng, Y., Payne, J., & Witherspoon, S. (1995). *Science and mathematics in full-time education after 16: England and Wales Youth Cohort Study (*London: Department for Education and Employment).

Chew, J. O. A., & Andrews, D. (2010). Enabling teachers to become pedagogical leaders: Case studies of two IDEAS schools in Singapore and Australia. *Educational Research for Policy and Practice, 9(1),* 59-74.

Chi-Kin Lee, J. (2000). Teacher receptivity to curriculum change in the implementation stage: The case of environmental education in Hong Kong. *Journal of Curriculum Studies,32(1)*, 95-115.

Chisholm, L., & Chilisa, B. (2012). Contexts of educational policy change in Botswana and South Africa. *Prospects*, 42, 371–388.

Chisholm, L., (2000). *Report of the Review Committee on Curriculum 2005*. Pretoria: DBE.

Choi, K., & Cho, H.H. (2002). Effects of teaching ethical issues on Korean school student's attitudes towards science. *Journal of Biological Education, 37(1),* 26-30.

Christie, P. (2008). *The right to learn*. Johannesburg: Pan Macmillan South Africa.

Coldwell, B. C. (2008). Evolution of the Peruvian subduction margin at 9° S: evidence from geochemistry, experimental petrology and melt inclusion studies on adakite-like ignimbrites (Doctoral dissertation, Kingston University).

Confrey, J. (1990). What constructivism implies for teaching. In R.B. Davis, C.A. Maher & N. Noddings (Eds.). *Constructivist views of the teaching and learning of mathematics* Reston, VA: National Council of Teachers of Mathematics.

Costa, L.D.F.D, &Ceser Jr, R.M. (2000). *Shape Analysis and Classification: Theory and Practice* Press, Inc.

Crawley, F. E., & Black, C. B. (1992). Causal modeling of secondary science student's intentions to enroll in physics. *Journal of Research in Science Teaching*, (29) 585–599.

Creswell, J.W. (1994). Research Design: Qualitative & Quantitative Approaches, London: SAGE Publications.

Daron, J. D., & Stainforth, D. A. (2013). On predicting climate under climate change. *Environmental Research Letters, 8(3),* 034021.

DBSA, (2009). *Education roadmap narrative report. Johannesburg: DBSA*

Department of Basic Education (2008). *2007 Grade 3 Systemic Evaluations.* Pretoria: DBE.

Department of Basic Education. (2011). *Curriculum and Assessment Policy Statement Intermediate Phase Grades 4–6*. Pretoria: DBE.

Department of Basic Education. (2012). *Report on the Annual National Assessments*. Pretoria: DBE.

Department of Basic Education. (2012b). *Technical Report on the 2012 National Senior Certificate Examination*. Pretoria: Government Printer.

DeWitt, J. C. (2009). Environmental risk factors for autism.

De Witt, D. E., Cox, R. G., & McCoy, P. (2000). U.S. Patent No. 6,104,866. Washington, DC: U.S. Patent and Trademark Office.

De Witt, D. L., Smith, W. L., & Garavito, R. M. (2000). Cyclooxygenases: structural, cellular, and molecular biology. *Annual review of biochemistry, 69(1),* 145-182.

Dori, Y.J., & Hameiri, M. (2003). Multidimensional analysis system for quantitative chemistry problems: Symbol, micro and process aspects. *Journal of Research in Science Teaching,* 40, 278-302.

Duit, R., & Treagust, D.F. (2003). Conceptual change: a powerful framework for improving science teaching and learning. *International Journal of Science Education,*25(6):671- 688.

Ernest, P. (199a). Forms of knowledge in mathematics and mathematics education: Philosophical and Rhetorical Perspectives. *Educational Studies in Mathematics*, 38 (1-3), 67- 83.

Ernest, P. (1999). *Forms of knowledge in mathematics and mathematics education: Philosophical and rhetorical perspectives. In Forms of mathematical knowledge*. Springer Netherlands.

Fenstermacher, G. D. & Soltis, J. F. (2004). *Approaches to teaching: Thinking about education series*. (4th ed.). New York: Teachers College Press.

Feldman, A., & Pirog, K. (2011). Authentic science research in elementary school after-school science clubs. *Journal of Science Education and Technology 20: 494-507.*

Finson, J. W. (2002). Nineteenth-century music: the western classical tradition. Pearson College Div.

Fleury, S. C., & Bentley, M. L. (1991). Educating elementary science teachers: Alternative conceptions of the nature of science. *Teaching Education, 3(2),* 57-67. 12.

Fontana, A. & Frey, J. H. 1993. 'The group interview in social research', in D. Morgan (ed.), *Successful focus group: advancing the state of the art*. Newbury Park: Sage Publications.

Fosnot, C.T. (1989). Constructivism: A psychological theory of learning. In C.T. Fosnot (Ed.), *Constructivism: Theory, Perspectives, and Practice*. New York: Teachers College Press

Fosnot, C.T. (1996). Constructivism: A psychological theory of learning. In C.T. Fosnot (Ed.), *Constructivism: Theory, Perspectives, and Practice*. New York: Teachers College Press.

Fraser, B. J. (1982). How strongly are attitude and achievement related? *School Science Review, 63*, (557–559).

Fraser, B.J., & Butts, W.L. (1982). Relationship Between Percieved Levels of classroom Individualization and Science Related Attitudes. *Journal of research in Science teaching.* 19 (2), 143-154.

Frankfort- Niechimias, C., & Leon Guerrero, A. (2009). *Social Statistics for diverse society.* (5th Ed). Thousand Oaks, CA: Sage.

Gardner, P. L. (1975). Attitudes to Science. *Studies in Science Education*, *2*, 1-4.
Hackling M. W. & Garnett P. J. (1985). Misconceptions in chemical equilibrium, *European Journal of Science Education*, 7, 205-214.

Gates, P., & Jorgensen, R. (2009). Foregrounding social justice in mathematics teacher education. *Journal of Mathematics Teacher Education, 12(3),* 161-170.

Gibert, J.K., Osborne, R.J., & Fensham, P.J. (1982). Children's Science and its Consequences for Teaching. Sci. Ed.,66: 623-633. doi:10.1002/sce.3730660412.

Giroux, H.A. (2004). Critical pedagogy and postmodern/ modern divide: Towards pedagogy of democratization. *Teacher education quarterly, 31(1),* 132-153.

Goussia, M. R., & Abeliotis, K. (2004). Environmental Education on Secondary Schools in Greece. The Viewpoints of the District Heads of Environmental Education. *The Journal of the Environmental Education*, 35 (3), 29-35.

Gredler, M.E. (1997). Learning and Instruction: Theory into Practice, (3rd edition). Upper Saddle River: Prentice Hall.

Gruender, C.D. (1996). Construction and learning: A philosophical appraisal. *Educational technology. 36(3),* 21-29.

Hadden, R.A., & Johnstone, A. H. (2007). *Secondary school pupil's attitudes: the year of decision*. University of Glasgow, 429-430.

Haladyna, T., Olsen, R., & Shaughnessy, J. (1982). Relations of student, teacher, and learning environment variables to attitudes to science. *Science Education, 66*, 671–687.

Harlen, W., & James M., (1997). Assessment and Learning: Differences and Relationships between formative and summative Assessment, Assessment in Education. *Principles, Policies & Practice, 4(3),* 365-379.

Harlen, W., & Deakin Crick, R (2003). Testing and Motivation for Learning. Assessment in Education: Principles, *Policy and Practice, 10 (2),* 169-207.

Hartley, M.S, & Treagust, D.F. (2003). *Investigating the effectiveness of an outreach programme in science and mathematics for disadvantaged Grade 12 students in South Africa.* Paper presented at the 3rd International Conference on Science, Mathematics and Technology Education, January 2003, East London.

Hartley M.S. (2010, July). *Investigating the science-related attitudes of learners at 5 secondary schools where science clubs have been established. In a paper published in the 41st conference of the Australasian Science Education Research Association (ASERA), Port Shepstons, Sydney, Australia, 13-29*.

Hartley M.S. (2014). Science Clubs as a vehicle to Enhance Science Teaching and Learning in Schools. *International Proceedings of Economics development and research, 81-167.*

Häussler, P., & Hoffmann, L. (2000). A curricular frame for physics education: Development, comparison with students' interests, and impact on students' achievement and self-concept. *Science education, 84(6),* 689-705.

Havard, N. (1996). Student attitudes to studying A-level sciences. Public *Understanding of Science 5(4),* 321–330.

Hendley, D. (1996). Pupils' subject preferences at Key Stage 3 in South Wales. *Educational Studies, 22*, 177–187.

Henige, K. A. (2005). Students' attitude-related responses to inquiry learning in undergraduate kinesiology laboratory instruction.

Henry, G.T. (1990). *Practical sampling.* Newbury Park, CA: Sage.

Hlatshwayo, S.A. (2000). *Education and Independence: Education in South Africa*. Westport CT: Greenwood Press, 1658-1998.

Hodson, D. (1991). Practical work in science: Time for reappraisal. *Studies in science Education, 19,* 175-184.

Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education, 29(11),* 1347-1362.

Horton, P., Wyatt, J., Allison, S., Donoghue, D., & Kearney, K. (2003). *Evaluation of CMF Funded UK Online Centres.* Hall Aitken Associates, London.

Hsu, S. J. (2004). The effects of an environmental education program on responsible environmental behavior and associated environmental literacy variables in Taiwanese college students. *The Journal of Environmental Education, 35(2),* 37-48.

Johnson, R.B., & Turner, L.A. (2003). Data collection strategies in mixed methods research. In Tashakkori A. & C. Teddie (Eds.), Handbook *of mixed methods in social behavioral research.* (pp.297-319). Thousand Oaks, CA: Sage.

Johnson, R.B., & Gray, R. (2010). A history of philosophical and theoretical issues for mixed methods research. In A. Tashakkori & C. Teddie (Eds), *SAGE handbook of mixed methods in social behavioral research (2nd ed., pp 69-94).* Thousand Oaks, CA: Sage.

Kahn, M. (2003). “For whom the school bell tolls: disparities in performance in Senior Certificate. Mathematics and Physical Science”, *Perspectives in Education* 30 (4), 149-156.

Kersaint, G. (2003). Technology beliefs and practices of mathematics education faculty. *Journal of Technology and Teacher Education, 11(4),* 549-577.

Keys, W. (1987). International studies in pupil performance: aspects of science education in English schools (Windsor: NFER-Nelson).

Kim, C., & Fortner, R. W. (2006). Issue-specific barriers to addressing environmental issues in the classroom: An exploratory study. *The Journal of Environmental Education, 37(3)*, 15-22.

Kim, M., & Song, J. (2009). The effects of dichotomous attitudes toward science on interest and conceptual understanding in physics. *International Journal of Science Education, 31(17)*, 2385-2406.

Kincheloe, J. L. (Ed.). (2005). Classroom teaching: An introduction. Peter Lang.

Klopfer, L. E. (1971). Evaluation of learning in science. In B. S. Bloom, J. T. Hastings & G. F. Madaus (Eds.), *Handbook of formative and summative evaluation of student learning* (London: McGraw-Hill).

Kluever, C., Lam, T. & Hoffman, R. (1994). The computer attitude scale: Assessing changes in teachers' attitudes toward computers. *Journal of Educational Computing Research, 11(3)*, 251-256.

Kovaleva, E. G., & Lipscomb, J. D. (2007). Crystal structures of Fe2+ dioxygenase superoxo, alkylperoxo, and bound product intermediates. *Science, 316(5823),* 453-457.

Koohang, A. A. (1989). A study of attitudes toward computers: Anxiety, confidence, liking, and perception of usefulness. *Journal of Research on Computing in education, 22(2),* 137-150.

Kramer, E. J., Kwong, K., Lee, E., & Chung, H. (2002). Cultural factors influencing the mental health of Asian Americans. *Western Journal of Medicine, 176(4),* 227.

Kuh, G. D. (1995). The Other Curriculum: Out-of-Class Experiences Associated with Student Learning and Personal Development. *Journal of Higher Education 66 (2)*:123–155.

Kukla, A. (2000). *Social Constructivism and Philosophy of Science*. London, England: Routledge.

Langley, G. J., Moen, R. D., Nolan, K. M., Nolan, T. W., Norman, C. L., & Provost, L. P. (2009). *The improvement guide: a practical approach to enhancing organizational performance*. John Wiley & Sons.

Leach, J., & Scott, P. (2003). Individual and sociocultural views of learning in science education. *Science & Education, 12(1)*, 91-113.

Lederman, N.G. & O'Malley, M. (1992), Students' and teachers' conceptions of the nature of science: a review of research. *Journal of Research in Science Teaching, 19*,743- 760.

Leech, N. L., & Onwuegbuzie, A. J. (2011). Beyond constant comparison qualitative data analysis: Using Nviv*o. School Psychology Quarterly, 26,* 70-84.:10.1037/a0022711.

Lijnse, P.L. (1995), "Developmental research" as a way to an empirically based "didactical structure" of science*. Science Education 79 (2),* 189-199.

Lucas, K. (2004). A study of the influence of the Smart Moves presentation on students. A report prepared for Questacon: The National Science and Technology Centre, King Edward Terrace, Parkes, Canberra, Australia.

Lunetta, V.N., Hofstein, A., & Clough, M.P. (2007). Teaching and l earning in the school Science Laboratory. An analysis of research, theory, and practice.*in handbook of research on Science Education (end S.K. Abell and N.G. Lederman), 393-431. Mahwah, N.J: Lawrence Erlbaum Associates.*

Lyons, T. (2006). Different countries, same science classes: Students' experiences of school science in their own words*. International journal of science education, 28(6),* 591-613.

Makgato, M., & Mji, A. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and Physical Science. *South African Journal of Education*, 26(2). 253-266.

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education, 32(5),* 669-685.

Marshall, M (1997), *Fro Cliché to archetyp*e. New York: Pocket Book (2): 65.

Marton, F., & Pong, W. Y. (2005). On the unit of description in phenomenography. Higher Education Research and Development, 24(4), 335-348.

Matthews, B. (2002). Why is emotional literacy important to science teachers? *School Science Review*, 84 (306), 77-86.

McCaw, S. C. (1980). Teacher attitudes toward environmental education. *The Journal of Environmental Education, 11(2),* 18-23.

McLaren, P. (2015). Life in schools: An introduction to critical pedagogy in the foundations of education. Routledge.

McMahon, M. (1997). Social Constructivism and the World Wide Web: A Paradigm for learning. *In What works and Why: reflections on learning with technology: proceedings of the 1997 ASCILITE annual conference*. Perth: Australia (vol 327).

MICOA (1996). *Programa Nacional de Gestão Ambiental. Políticas e Estratégias*. Maputo, Moçambique.

MICOA (2002). Estratégia Nacional de Educação Ambiental (ENEA). Moçambique: Maputo.

Miller, J. D., Pardo, R., & Niwa, F. (1997). Public perceptions of science and technology: a comparative study of the European Union, the United States, Japan, and Canada (Bilbao: BBV Foundation).

MINED (2003). *Programa do Ensino Básico 2º Ciclo. Plano de estudo*. Moçambique: Maputo.

Mkwandawire, M. (20009). *Physical Science activities and skills development in the school curriculum of Namibia*. Unpublished Master of Education thesis. UNISA: Pretoria, South Africa.

Morrison, F. J. (2009). Parenting and academic development. *Merrill-Palmer Quarterly, 55(3)*, 361-372.

Morrison, H., Craig, C. L., & Jiang, X. Pan, S. Y., Cameron, C., DesMeules, M. (2009). Individual, social, environmental, and physical environmental correlates with physical activity among Canadians: a cross-sectional study. *BMC public health, 9(1),* 21.

Moss, B., Leone, S., & Dipillo, M. L. (1997). Exploring the literature of fact: Linking reading and writing through information trade books. *Language Arts, 74(6),* 418-429.

Morrison, K. (2000) Research Methods in Education. 5th Edition, Routledge Falmer, London and New York. https://doi.org/10.4324/9780203224342

Moore-Hart, M. A., Liggit, P., & Daisey, P. (2004). Making the science literacy connection: After school science clubs. *Childhood Education, 80(4),* 180–186.

Murphy. (2017). *The apartheid's legacy to black children,* 73 (5),367-374.

Muya, S. M., & Oguge, N. O. (2000). Effects of browse availability and quality on black rhino (Diceros bicornis michaeli Groves 1967) diet in Nairobi National Park, Kenya. *African Journal of Ecology, 38(1),* 62-71.

Mwamwenda, T. S. (1995). *Educational Psychology. An African Perspective*. London: Heinemann Butterworth Publisher Ltd.

Myers, R. E., & Fouts, J. T. (1992). A cluster analysis of high school science classroom environments and attitude toward science. *Journal of Research in Science Teaching, 29*,929–937.

National Diagnostic Reports (2013-2016).

National senior certificate (NSC) chief marker's report (2014), page 368.

Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science education, 87(2),* 224-240.

Novak, J. D. (1988). Learning science and science of learning. *Studies in Science Education,* 15 (1), 77-101.

Novak, J. D. (1996). Concept mapping: A tool for improving science teaching and learning. In D. F. Treagust, R. Duit, & B. J. Fraser (Eds.), *Improving teaching and learning in science and mathematics* (pp.32-43), New York: Teachers College Press.

O'Loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of Research in Science Teaching, 29, (8*). 791 – 820.

Osborne, J. F. (1996). Beyond constructivism. *Science Education. 80(1),* 52 – 82.

Osborne, J. F., & Collins, S. (2000). *Pupils' and parents' views of the school science curriculum.* London: King's College London.

Osborne, J., & Dillon, J. (2007). Research on learning in informal contexts: Advancing the field?

Pappas, C. C. (1993). Is narrative "primary"? Some insights from kindergarteners' pretend readings of stories and information books. *Journal of Reading Behavior, 25(1)*, 97-129.

Parajes, F., & Miller, M.D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem-solving: A path analysis. *Journal of educational Psychology, 86 (2),193.*

Parajes, F. (2007). Elements of a proposal. *Emory University. Retrieved from.*

Piaget, J (1951). The Psychology of Intelligence. London: Routledge and Kegan Paul Ltd.

Piaget, J. (1976). Piaget's theory. In P. H. Mussen (Ed). *Carmichael's manual of child psychology*. New York: Wiley.

Pike, K.M., & Dunne, P.E. (2014). *Cultural trends and eating disorders. Current opinion in psychiatry,27(6),436-442. DOI: 10.1097/YCO.0000000000000100.*

Polly, D., & Hannafin, M. J. (2010). Reexamining technology's role in learner-centered professional development. Educational Technology Research and Development, 58(5), 557-571.

Popper, K. (1959). The Logic of science Discovery, reprinted (2004) by Routledge, Taylor and Francis.

Popper, K. (1981). The Logic of Scientific Discovery (1959), reprinted (2004) by Routledge.

Pratt, R.S., & Floden, R.E. (1994). Philosophical Perspective on constructivist views of learning. *Educational Psychology,*29 (1), 37-48. Doi:10.1207/s15326985cp290_4.

Randler, C., & Hulde, M. (2007). Hands-on versus teacher-centred experiments in soil ecology. *Research in Science & Technological Education, 25(3),* 329-338.

Redding, G., & Wallace, B. (1996). Adaptive spatial alignment and strategic perceptual-motor control. *Journal of experimental Psychology: Human Perception and Performance,22 (2),*379.

Reid, N., & Skryabina, E.A. (2002). Attitudes Towards Physics. *Research in Science & Technological Education. 20 (1)*. 67-81.

Rennie, L. J. (2007). Learning science outside of school. Handbook of research on science education, 1.

Roberts, G (2002). Set for success (final report of sir Gareth Roberts' Review).

Robinson, P. (2002). Long-Range Dependence. *Encyclopedia of environmentrics.*

Roth, W. M., & Lee, Y. J. (2007). "Vygotsky's neglected legacy": Cultural-historical activity theory. *Review of educational research, 77(2),* 186-232.

Roth, W. M., & Roychoudhury, A. (1994). Physics students' epistemologies and views about knowing and learning. *Journal of research in Science Teaching, 31(1),* 5-30.

Rubeck, M.L., & Enochs, L.G., (1991). A path analytical model of variables that influence science and chemistry teaching self-efficacy and outcome expectancy in middle school science teachers. Annual Meeting of the National Association for Research in Science Teaching, April. Fontana, WI. 31.

Rubeck, M. L. H. (1992). Path analytical models of variables that influence science and chemistry teaching self-efficacy and outcome expectancy in middle school science teachers.

Rudner, L. M., & Schafer, W.D. (2001) Reliability. ERIC Digest.

Sadler, T. D. (2004). Informal reasoning regarding socio-scientific issues: A critical review of research. *Journal of research in science teaching, 41(5),* 513-536.

Sánchez-DelBarrio, J. C., Messeguer, X., Rozas, J., & Rozas, R. (2003). DNA SP, DNA polymorphism analyses by the coalescent and other methods. *Bioinformatics, 19(18),* 2496-2497

Savery, J.R., & Duffy, T.M. (1995). Problem based learning: An instructional model and its constructivist framework*. Educational technology,*31-37.

Selwyn, N. (1997). Students' attitudes toward computers: Validation of a computer attitude scale for 16–19 education. *Computers & Education, 28(1),* 35-41.

Shadreck, M., & Isaac, M. (2012). Science teacher quality and effectiveness: Gweru urban junior secondary student' points of view. *Asian Social Science 8 (8).* 160-165.

Shaffer, D.R., & Kipp, K. (2007). *Developmental Psychology, child and adolescence. Eighth edition*. USA: Wadsworth Cengage learning, 83.

Shakespeare, D. (2003). Starting an argument in science lessons*. School of Science Review. 85 (11),* 103- 108.

Sheldon, S. B., & Epstein, J. L. (2005). Involvement counts: Family and community partnerships and mathematics achievement. *The Journal of Educational Research, 98(4),* 196-207.

Simpkins, S. D., Ripke, M., Huston, A. C., & Eccles, J. S. (2005). Predicting participation and outcomes in out-of-school activities: Similarities and differences across social ecologies. *New Directions for Student Leadership, 2005(105),* 51-69.

Simpson, R. D., Koballa Jr, T. R., Oliver, J. S., & Cranley, F. E. (1994). Research on the effective dimension of science learning. In D. Gabel (Ed.), *Handbook of research on science teaching and learning*. New York: Macmillan.

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of educational research, 75(3),* 417-453.

Smolkin, L. B., & Donovan, C. A. (2001). The contexts of comprehension: The information book read aloud, comprehension acquisition, and comprehension instruction in a first- grade classroom. *The Elementary School Journal, 102(2)*, 97-122.

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

Staver J.R. (1997). Constructivism: Sound theory for explicating the practice of science and science teaching. *Journal of Research in Science Teaching, 35 (5)*:501 – 520.

Stemler, S.E. (2004). A comparison of consensus, consistency and measurement approaches to estimating interrater reliability. *Practical Assessment, Research & Evaluation.9 (4).* 1-19.

Sternberg, R. J. (2003). *Wisdom, intelligence, and creativity synthesized*. Cambridge University Press.

Stocklmayer, S. M., Rennie, L. J., & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education, 46(1),* 1-44.

Stol, H. (2003). Supercollect. A Data Capture System Using an Electronic Network. ASC 2003, 207.

Tashakkori A., & Teddie, C. (2003), *Handbook of mixed methods in social behavioral research.* (pp.297-319). Thousand Oaks, CA: Sage.

The 'teacher' newspaper 2010, SADTU news, p12.

Thomas, G. E. (1986). Cultivating the interest of women and minorities in high school mathematics and science. *Science Education, 73*, 243–249.

Tiberghien, A., & Le Maréchal, J. F. (2004). Learning hypotheses and an associated tool to design and to analyze teaching–learning sequences. *International Journal of Science Education*, *26*(5), 579-604.

TIMSS (1999). Science Benchmarking Report. TIMSS 1999-Eighth Grade. Available at: http.//timss.bc.edu./timss1999b/sciencebench_report/t999b_sciencebenchreport.html. Accessed 1 November 2013.

Trivedi, R. (2013). Research Scholar, Mewar University. *Gangrar International Journal of Scientific and Research Publications,* 3, Issue 8, August 2013, 4 ISSN 2250-3153.

Trowbridge, l. W., Bybee, R.W., & Powell, J.C. (2004). *Teaching Secondary School Science.* Strategies for developing scientific literacy. Merrill, an imprint of prentice hall. Upper Saddle River. N.J. Columbus, Ohio. USA.

Trochim, W. M. K. (2006). Introduction to Validity. Social Research Methods, retrieved from www.socialresearchmethods.net/kb/introval.php, September 9, 2010.

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and teacher Education, 23(6),* 944-956.

Twillman. (2006). Science for fun? Try a high school science club. *The science teacher.*

Tytler, R., & Osborne, J. (2012). *Student attitudes and aspirations towards science*. In Second international handbook of science education (pp. 597-625). Springer Netherlands.

van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education, 96(1),* 158-182.

Van Loggerenberg-Hattingh, A. (2003). Examining learning achievement and experiences of science learners in a problem-based learning environment. South African Journal of Education, 23(1), 52-57

Viegas, A. (2004). The importance of Science Clubs: Methods used in school case. *Teaching science 50 (4): 22-25.*

Viennot, L., & Rainson, S. (1999). Design and evaluation of a research-based teaching sequence: the superposition of electric field. *International Journal of Science Education*, *21*(1), 1-16.

Vhurumuku, E. (2010). The Impact of Explicit Instruction on Undergraduate Students: Understandings of the Nature of Science. *African Journal of Research in MST Education,* 14(1): 99 – 111.

Von Glasersfeld, E. (1989). Knowing without Metaphysics: Aspects of the Radical Constructivist Position.

Von Glasersfeld, E. (1996). Footnotes to 'the many faces of constructivism'. *Educational researcher, 25(6),* 19.

Vosniadou, S., & Ioannides, C. (1998). From conceptual development to science education: A psychological point of view. *International journal of science education, 20(10),* 1213-1230.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. (1978). Thought and language. Cambridge: MIT Press.

Walczyk, J. J., & Ramsey, L. L. (2003). Use of learner-centered instruction in college science and mathematics classrooms. *Journal of research in science teaching, 40(6),* 566-584.

Wandersee, J.H., Mintzes, J.J., & Novak, J.D. (1994). Research on alternative conceptions in science. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177–210). New York: Macmillan.

Wellington, J. (1990). Formal and informal learning in science: The role of the interactive science centres. *Physics education, 25(5)*, 247.

Woolard, I. (2002). *Income inequality and poverty: methods of estimation and some policy applications for South Africa* (Unpublished PhD thesis). University of Cape Town.

Woolnough, B. (1994). *Effective science teaching*. Buckingham: Open University Press.

Yin, R. (1993). Applications of case study research. Newbury Park, CA: Sage Publishing.

Young, H. D., & Freedman, R. A. (2008). Sears and Zemansky's university physics (Vol. 1). Pearson education.

Zeidler, D.L. (1997). The central role of fallacious thinking in science education. Science Education, 81, 483–496

Zembylas, M. (2004). Emotion Metaphors and Emotional Labor in Science Teaching. *Science Education, 88 (3)*, 301-324.

Ziglar, Z. (2002). American motivational speaker and author.

APPENDIX F QUESTIONNAIRE FOR LEARNERS

QUESTIONNAIRE

The questionnaire consists of thirteen (15) items, each **item has five options (strongly agree, agree, neither agree nor disagree, disagree and strongly disagree) from which you choose** the one that best suits your opinion. Mark with a cross the best option item.

Pre-and Post ATQ

Items	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1 Interests in physical sciences. 1.1 I find Physical Sciences is interesting and fascinating.					
1.2. Science debates are fun					
1.3. I feel like studying Physical Science everyday					
1.4 Physical Science lessons are a base for my future career					
1.5 practical work make Physical Sciences concepts clear					
2. Perceptions about science 2.1 My family sees me furthering in sciences					
2.2. My parents think Physical Sciences is a difficult subject.					
2.3. My friends see Physical Science as an easy subject.					
2.4. I think it is important to do well in Physical Sciences at school					
2.5 I feel confident when doing physical Sciences class works &homeworks					
3. Use of scientific language and application 3.1. I understand better, when my teacher uses different teaching approaches.					
3.2**.** I am able to link knowledge learnt in Physical Sciences in other subjects.					
3.3 I understand the language used in Physical Sciences very well.					
3.4. I easily learn Physical Sciences topics through practical work.					
3.5 I can apply Physical Sciences laws and principles in everyday life					

APPENDIX F

OBSERVATION SCHEDULE

LEARNER Participation in science expo

Learner number………………. Gender………………….. Grade…………………

C. ORGANISATION OF THE PROJECT FOR SCIENCE EXPO

AREA	OBSERVATION	COMMENTS
1. Identification of a research problem		
2. Choice of a topic		
3. Identification of variables		
4. Formulation of research question		
5. Choice of research resources		
6. Hypothesis development		
7. Testing the hypothesis		
8. Procedure using scientific method and scientific concepts		
9. Data collection		
10. Data analysis		
11. Formulating conclusion		
12. Application to higher order questions		

APPENDIX G: INTERVIEW SCHEDULE FOR EDUCATORS

A. BIOGRAPHICAL INFORMATION:

School number……………………………………….. Date………………………………….

Teacher number……………………………….. Gender……………………………….

Teaching experience………………………… Subject teaching …………………………..

SECTION B:

INTERVIEW SCHEDULE

1. Do learners view physical sciences as a difficult or an easy subject?

Give reasons.

2. Are learners able to give details of a phenomenon that is explained by certain scientific concepts or terms? Give reasons why you think so.
3. How often do learners ask for assistance on physical sciences' activities from you as an educator?
4. How do learners link scientific knowledge learnt at school with real life situations?
5. Are there any learners who can be confident to be peer tutors in your class? What it their depth of understanding physical science?
6. Explain how learners handle higher order questions during exams?

University of the Western Cape

Faculty of Education, Private Bag X17, Bellville, South Africa

APPENDIX 1:

Background information sheet

Dear Sir/Madam,

My name is Juta, Zukiswa, a Masters student in science education in the SSME of the Faculty of Education at the University of the Western Cape. I am conducting research on the attitudes of learners towards physical sciences.

Research Title: Examining the influence of co-curricular activities on learner attitudes towards physical sciences. The study will be guided by the following research question:

What is the influence of co-curricular activities on learner attitudes towards physical sciences?

The research participants will comprise two Grade 10 &11 physical sciences educators and grade 10& 11 physical sciences learners. Data collection will be in the form of questionnaires, observations and interviews. Participation in this study is voluntary. Participants have the right to withdraw from the research at any stage of the research process without having to give any explanations. Participants are guaranteed utmost confidentiality regarding all information collected from them. Pseudonyms or a system of coding will be used to protect their identity.

Should you wish to find out more about the research, you are welcome to contact my supervisor, Professor Hartley, whose contact details are provided below or indeed me.

Yours sincerely

Researcher: Ms Zukiswa Juta
Contact number: 0787190306
Email: jutazukiswa@webmail.co.za

Supervisor: Prof. M.S.Hartley
shartley@uwc.ac.za Tel. 021-9592680

Signature of the researcher: ………………………….. Date:……………………………

University of the Western Cape

Faculty of Education, Private Bag X17, Bellville, South Africa

APPENDIX 2: PERMISSION LETTER

THE Eastern Cape EDUCATION DEPARTMENT (WCED)

X Secondary School
Stepping Stone Weg,
7550
Durbanville

The Research Director
Eastern Cape Education Department
P/B X91
Bisho

Dear ________________

Re: Permission to conduct research at X School

My name is **Zukiswa Juta,** a Masters student in the Science Education Department in the school for SSME in the Faculty of Education at the University of the Western Cape. I would like to request your permission to observe teachers' and learners' interaction in the Grade 10&11 physical sciences in one of the senior secondary schools in Butterworth district. I am conducting research on the impact of co-curricular activities on learner attitudes towards physical sciences to explore how learners make use of curricular activities to improve their performance towards physical sciences. The target group will be Grade 10& 11 physical sciences' learners.

The research will not interfere in any way with the functioning of the school or with learning in the classroom. In addition, participation will be voluntary and so participants will be free to withdraw at any time without giving reasons should they feel uncomfortable with my research. Their participation in the study will remain anonymous. Information received as part of the study will be used for research purposes only. It will not be used in any public platform for any purposes other than to understand how the use of co-curricular activities enhances learners' towards physical sciences.

Should you wish to find out more about the research, you are welcome to contact my supervisor, Professor Hartley, whose contact details are provided below or indeed me.

Yours sincerely,

Researcher: Ms Zukiswa Juta
Contact number: 0787190306
Email: jutaZukiswa@webmail.co.za

Supervisor: Prof. M.S.Hartley
Tel. 021-9592680
Email: shartley@uwc.ac.za

Signature of the researcher: ………………………….. Date:……………………………

University of the Western Cape

Faculty of Education, Private Bag X17, Bellville, South Africa

APPENDIX 3: PERMISSION LETTER

THE PRINCIPAL X PRIMARY SCHOOL

X Primary School,
Stepping Stone Weg,
7550
Durbanville

Dear ________________

Re: Permission to conduct research in your School

My name is **Zukiswa Juta,** a Masters student in science education in the SSME Department of the Faculty of Education at the University of the Western Cape. I am conducting research on the impact of co-curricular activities on learner attitudes towards physical sciences to explore how learners make use of curricular activities to improve their performance towards physical sciences. The target group will be Grade 10& 11 physical sciences' learners.

I would like to request your permission to observe Grade 10& 11 learners' interaction in the physical sciences. I request you as the Principal of the school and the physical Head of Department to participate in the interviews. I also request your permission to interview the Grade 10&11 teachers and observe learners engaging in co-curricular activities.

The research will not interfere in any way with the functioning of the school or with learning in the classroom. In addition, participation will be voluntary and so participants will be free to withdraw at any time without giving reasons should they feel uncomfortable with my research. Your participation and that of the learners in the study will remain anonymous. Information received as part of the study will be used for research purposes only. It will not be used in any public platform for any purposes other than to understand how the use of co-curricular activities Grade 10&11 physical sciences classroom.

Should you wish to find out more about the research, you are welcome to contact my supervisor, Professor Hartley, whose contact details are provided below or indeed me.

Yours sincerely,

Researcher: Ms Zukiswa Juta
Contact number: 0787190306
Email: jutaZukiswa@webmail.co.za

Supervisor: Prof. M.S. Hartley
Tel. 021-9592680
Email: shartley@uwc.ac.za

Signature of the researcher: ………………………….. Date:……………………………

University of the Western Cape

Faculty of Education, Private Bag X17, Bellville, South Africa

APPENDIX 4: PERMISSION LETTER

THE PHYSICAL SIENCES EDUCATOR

X Primary School,
Stepping Stone Weg,
7550
Durbanville

Dear _________________

Re: Permission to conduct research in Grade 10 & 11 physical sciences classes 6

Re: Permission to conduct research in your School

My name is **Zukiswa Juta,** a Masters student in science education in the SSME Department of the Faculty of Education at the University of the Western Cape. I am conducting research on the impact of co-curricular activities on learner attitudes towards physical sciences to explore how learners make use of curricular activities to improve their performance towards physical sciences. The target group will be Grade 10& 11 physical sciences' learners.

I would like to request your permission to observe Grade 10 & 11learners' interaction with co-curricular activities. I also request you as the physical science educator to participate in the interviews.

The research will not interfere in any way with the functioning of the school or with learning in the classroom. In addition, participation will be voluntary and so participants will be free to withdraw at any time without giving reasons should they feel uncomfortable with my research. Your participation and that of the learners in the study will remain anonymous. Information received as part of the study will be used for research purposes only. It will not be used in any public platform for any purposes other than to understand how the use of co-curricular activities improves learner attitudes towards physical sciences.

Should you wish to find out more about the research, you are welcome to contact my supervisor, Professor Hartley, whose contact details are provided below or indeed me.

Yours sincerely,

Signature of the researcher: ………………………….. Date:……………………………

Researcher: Ms Zukiswa Juta
Contact number: 0787190306
Email: jutaZukiswa@webmail.co.za

Supervisor: Prof. M.S. Hartley
Tel. 021-9592680
Email: shartley@uwc.ac.za

University of the Western Cape

Faculty of Education, Private Bag X17, Bellville, South Africa

APPENDIX 6: PERMISSION LETTER

THE PARENTS

X Primary School,
Stepping Stone Weg,
7550
Durbanville

Dear _________________

Re: Permission for your child's participation in a research in

My name is **Zukiswa Juta,** a Masters student in science education in the SSME Department of the Faculty of Education at the University of the Western Cape. I am conducting research on the impact of co-curricular activities on learner attitudes towards physical sciences to explore how learners make use of curricular activities to improve their performance towards physical sciences. The target group will be Grade 10& 11 physical sciences' learners.

I would like to request your permission to include your child in participation on co-curricular activities and observe how he/she interacts with his/her peers.

The research will not disrupt the class schedules or teaching and learning in the classroom. In addition, participation will be voluntary, so participants will be free to withdraw at any time without giving reasons should they feel uncomfortable with my research. The identity of the learners in the study will remain anonymous. Information received as part of the study will be used for research purposes only. It will not be used in any public platform for any purposes other than to understand how the use of co-curricular activities impacts his/her attitude towards physical sciences.

Should you wish to find out more about the research, you are welcome to contact my supervisor, Professor Hartley, whose contact details are provided below or indeed me.

Yours sincerely,

Signature of the researcher: ………………………….. Date:……………………………

Researcher: Ms Zukiswa Juta Supervisor: Prof. M.S. Hartley
Contact number: 0787190306 Tel. 021-9592680
Email: jutaZukiswa@webmail.co.za Email: shartley@uwc.ac.za

University of the Western Cape

Faculty of Education, Private Bag X17, Bellville, South Africa

Appendix 8:

Participants' Informed Consent form:

I agree to be part of the study and I am aware that my participation in this study is voluntary. If, for any reason, I wish to stop being part of the study, I may do so without having to give an explanation. I understand the intent and purpose of this study.

I am aware the data will be used for a Master's thesis and a research paper. I have the right to review, comment on, and/or withdraw information prior to the paper's submission. The data gathered in this study are confidential and anonymous with respect to my personal identity, unless I specify or indicate otherwise. In the case of classroom observations and interviews, I have been promised that my personal identity and that of the school will be protected, and that my duties will not be disrupted by the researcher.

I have read and understood the above information. I give my consent to participate in the study.

____________________ ____________________

Participant's signature Date

____________________ ____________________

Researcher's signature Date

University of the Western Cape
Faculty of Education, Private Bag X17, Bellville, South Africa

Appendix 7:

Parents' Informed Consent form:

I agree my son/ daughter (...(name) to be part of the study and I am aware that his/her participation in this study is voluntary. If, for any reason, I wish him/her to stop being part of the study, he/she may do so without having to give an explanation. I understand the intent and purpose of this study.

I am aware the data will be used for a Masters' thesis and a research paper. He/she has the right to review, comment on, and/or withdraw information prior to the paper's submission. The data gathered in this study are confidential and anonymous with respect to my personal identity, unless he/she specify or indicate otherwise. In the case of classroom observations and interviews, he/she has been promised that his/her personal identity and that of the school will be protected, and that his/her duties will not be disrupted by the researcher.

I have read and understood the above information. I give my consent to my son/daughter in the study.

____________________ ____________________

Participant's signature Date

____________________ ____________________

Researcher's signature Date