THE EFFECT OF AN ACTIVE LEARNING APPROACH ON GRADE 11 LEARNERS' ACHIEVEMENT IN NEWTON'S LAWS OF MOTION: A CASE STUDY OF A SCHOOL IN THE EASTERN CAP`E

by

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DECLARATION

I declare that the title "**THE EFFECT OF AN ACTIVE LEARNING APPROACH ON GRADE 11 LEARNERS' ACHIEVEMENT IN NEWTON'S LAWS OF MOTION: A CASE STUDY OF A SCHOOL IN THE EASTERN CAPE"** is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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SIGNATURE DATE

(Mr. I. B. Aboagye)

ABSTRACT

The aim of this study was to investigate the effect of an active learning approach (ALA) on the achievement of 11^{th} grade learners in Newton's laws of motion, The case study was done in one school by comparing the achievement of learners in Newton's laws of motion through an Active Learning Approach (ALA) with that of learners taught through Traditional Direct Instruction (TDI) and to determine whether learners taught with ALA retained the material better than those taught with TDI. Two grade 11 classes in one school in the Queenstown District of the Eastern Cape were selected on their performance in two different tests and used as case study. The Force Concept Inventory was used to determine the achievements and retention of knowledge of the two groups. The effect of the active learning approach on the treatment group was also measured by asking each learner in the group to complete a learner assessment of instruction form. The treatment group was also subjected to a classroom group interview. The following information emerged from the study:

i) Learners taught using the ALA achieved significantly better in FCI post-test than those taught with traditional direct instruction.

ii) In the retention of knowledge test, the mean score of the learners taught using the ALA was 4.8% higher than those taught with TDI although insignificant.

iii) Learners subjected to the ALA liked the instructional approach and as such put in extra time to learn.

The findings suggest that the active learning approach had positive effect on the achievement of the Grade 11 learners and thus, can be adapted to enhance learning in the classroom.

Key words: Active Learning Approach, Learners' Achievement, Traditional Direct Instruction, Retention of Knowledge, Newton's laws of motion, Scaffolding

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LIST OF ABBREVIATIONS

ALA Active Learning Approach

CAPS Curriculum and Assessment Policy Statement

CAT Common Assessment Task

DOE Department of Education

FAL First Additional Language

FCI Force Concept Inventory

FMCE Force and Motion Conceptual Evaluation

GPS Geographical Positioning System

ICU Interactive Conceptual Instruction

JITT Just in Time Teaching

LOLT Language of Learning and Teaching

PBL Problem Based Learning

MDT Mechanics Diagnostic Test

MKO More Knowledgeable Other

NCS National Curriculum Statement

OBE Outcome Based Education

PER Physics Education Researchers

SAI Student Assessment of Instruction

TDI Traditional Direct Instruction

TIMSS Third International Mathematics and Science Study

TSI Tshikululu Social Investment

ZPD Zone of Proximal Development

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CHAPTER ONE

Introduction

1.1 Background And Context of The Study

Internationally, science is recognized as the backbone of technological development which leads to the economic well-being of nations (Fraser & Walberg, 1995). All countries embrace science because of the many challenges facing us (Wambugu & Changeiywo, 2008). These challenges include the outbreak of many incurable diseases, dangers of global warming and emergence of drug resistant bacteria, amongst others (Alsop & Hicks, 2001; Minishi, Muni, Okumu, Mutai, Movangasha, Omolo & Munyeke, 2004). As such, research in science is crucial to bring about improvement in communication, agriculture and medicine (Wambugu & Changeiywo, 2008). Research in science, for example in medicine, depends on the knowledge obtained in physics, because instruments and techniques used to diagnose and treat a variety of illnesses emanate from discoveries in physics. Examples of these are microscopy, radiography, ultra-sound, the use of laser beams for eye operations, and fibre optics for gastrointestinal endoscopy.

In addition, the Computerized Axial Tomography Scanner (CATS) is a widely-used non-invasive medical diagnostic instrument. This fundamental tool of modern medicine was developed in the Physics Department of the University of Cape Town (South African Institute of Physics, 2004). In 2003, physics-trained people were not only awarded the Nobel Prize for Physics, but had shares in both the Nobel Prize for Medicine and for Economics (South African Institute of Physics, 2004). In fact the commonly used touring, hiking and sailing tool, the Geographic Positioning System (GPS) that provides accurate positioning, requires Einstein's General Theory of Relativity (South African Institute of Physics, 2004).

Further examples of the applications of the principles of physics include weather forecasting, designing of rockets for space exploration, proliferation of different types of television and use of electronics for communication (Vaidya, 2003). It has been affirmed that physics is and will remain the fundamental science (Wenham, Dorlin, Snell, & Taylor, 1984). It can therefore be inferred that other sciences rely on the knowledge obtained through the study of physics. Physics is thus the pillar of science and technology since it seeks to explain natural phenomena and propels the increasing technological changing society (Zhaoyao, 2002).

Newton's laws of motion are encountered in our daily activities. How a spaceship is launched into space is explained by the third law. The force of the exploding gases pushes the rocket through the air into space. Once the rocket is in space, the engines are switched off and it keeps on moving at a constant velocity. This is possible because the first law states that an object will move with constant velocity if no net force acts on it. The first law of Newton also makes us realise the importance of wearing seat belt in cars. The seat belt protects us when a car is involved in an accident. If a car is travelling at 120 $km \cdot h^{-1}$, the passengers in the car are also travelling at 120 $km \cdot h^{-1}$. When the car suddenly stops a force is exerted on the car (making it slow down), but not on the passengers. The passengers will carry on moving forward at 120 $km \cdot h^{-1}$according to Newton's first law. If they are wearing seat belts, the seat belts will stop them by exerting a force in the opposite direction on them and so prevent them from getting hurt.

Studying physics could instil the basic knowledge of life and reasoning abilities that helps one to make ethical decisions on the use of science and technology (Das, 1985). The challenges of our present society demand knowledge of problem-solving and decision-making skills (Kleeves & Aikenhead, 1995; Mohanty, 2003).

1.2 Physics in South African schools

In order to address critical thinking, analytical skills and problem-solving techniques, the Department of Education, DoE (2005) specifies three learning outcomes (LO) for physics in the National Curriculum Statements (NCS).

LO 1: Practical Scientific Inquiry and Problem-solving Skills

> Learners act confidently on their curiosity about natural phenomena; they investigate relationships and solve problems in science, technology and environment contexts

LO 2: **Constructing and Applying Scientific Knowledge**

> Learners know, interpret and apply scientific, technological and environmental knowledge

LO 3: **The Nature of Science and its Relationship to Technology, Society and the Environment**

> Learners are able to demonstrate an understanding of the interrelationships between science and technology, society and the environment

This implies that the teaching of physics should provide learners with understanding, skills and scientific knowledge needed to foster technological and economic growth in South Africa (Minishi, et al, 2004). South Africa needs to develop its human capacity in physics, science and technology to be able to achieve growth of knowledge-based economy (South

African Institute of Physics, 2004). A research report released by the Centre for Development and Enterprise, CDE, (2008) states that one of the most significant obstacles to economic advancement in South Africa is its inability to improve mathematics and science education.

Table 1.1 National pass rate in physical science~~s~~ in the past six years

Year	**% pass at 30% And above**	**% pass at 40% And above**
2006	43.0	
2007	39.5	
2008	54.9	28.6
2009	36.8	19.41
2010	47.8	23.5
2011	53.4	25.9

Although science is essential for industrialization, there has been a decline in academic achievement scores of secondary school learners. A number of international surveys have shown that South Africa learners are seriously underachieving in mathematics and science. For example, the Third International Mathematics and Science Study (TIMSS) showed that the average scores of South African learners in science in 1995, 1999, and 2003 were 263, 243, and 244 respectively, which were far below the international mean of about 489 (Kanjee, 2006). Also, the performance of Grade 12 learners in the National Senior Certificate Examination in physical science~~s~~ is a cause for concern. The failure rate is observable from table 1.1 which reveals that in six years only twice did more than half the candidates succeed (TSI, 2010). Further, the number of learners who achieved at 40% and above in 2008 and 2009 were 62 530 (28.66%) and 41 899 (19.41%) respectively

(Department of Basic Education, 2010). All these figures, in fact, reveal that the achievement of learners in physical sciences has not been impressive.

1.2.1 Physical Science in Eastern Cape schools

As in the national context, the Eastern Cape learners did not perform well in the physical sciences examinations too. An analysis of results for physical sciences from 2008 to 2011 in the selected district revealed a similar trend (See Table 1.2).

Table 1.2 The achievement of learners in schools in circuit A*

SCHOOL	YEAR	NUMBER WROTE	% PASS AT 30% AND ABOVE
A	2008	36	83.3
	2009	25	60.0
	2010	30	93.3
	2011	35	91.4
B	2008	43	41.9
	2009	25	24.0
	2010	42	38.1
	2011	32	37.5
C	2008	24	62.5
	2009	45	22.2
	2010	39	41.0
	2011	35	54.3
D	2008	30	43.3
	2009	17	11.8

	2010	13	15.4
	2011	23	13.0
E	2008	89	77.5
	2009	155	14.8
	2010	97	17.5
	2011	115	27.8
F	2008	27	74.1
	2009	43	14.1
	2010	29	34.5
	2011	40	15.0

* Names of Schools have been removed for ethical reasons

It was observed from the table that even in cases where the pass rate in percentage terms appeared to be acceptably high the real numbers of learners however were extremely small. One also needs to be mindful of the fact that the pass rate depicted in Table 1.2 is at 30% which cannot be used to seek for admission to any tertiary course that requires a pass in physical sciences. Also, in Table 1.1 the national percentage pass in physical sciences at 40% level were 19.41%, 23.5% and 25.9% for 2009, 2010 and 2011, respectively. These percentages were, by all standards, unacceptably very low.

1.2.2 The Status of Physics in South Africa

Learners avoid sciences, particularly physics, when given an option and this especially applies to girls (Aduda, 2003). That is, given a choice, learners would rather drop physics in favour of other science subjects. Data for the three years, 2000 – 2002, supplied by the South Africa Institute of Physics (SAIP) indicated that about 85 to 100 students graduated annually as physics major students. This constituted about 7% of the total number that graduated in the physical and life sciences (SAIP, 2004). According to the International Panel Report on the future of Physics in South Africa about half of the graduates proceeded to Honours level and ended in other professions aside teaching (SAIP, 2004).

Reports (SAIP, 2004; Muwanga-Zake, 2001) showed that few physics graduates joined the industry to propel the economic growth and even fewer got into the classroom to help produce prospective physics under-graduates. Physics is waning in South Africa because most researchers in the field are ageing and only few learners are enrolling in physics (SAIP, 2004). Among some of the problems cited by the SAIP, (2004) as contributed to the decreased number of young physics graduates was poor preparation of physics learners in high schools.

According to Spady (1994), OBE is a developmental process that focuses on what is important for learners to be able to do, then organising the curriculum, instruction and assessment to make sure this ultimately happens. Here, outcome is defined as a demonstration of what has been learned. Geyser (2000), quoting from the Department of Education (1997a: 12) described “outcomes” as the declared knowledge, skills, attitudes and values that learners must have at the end of a learning experience. She further explains the concept “based” used in outcomes based as “to define direct, derive, determine, focus and organise what we do according to the substance and nature of the learning result that we want to happen at the end of the learning process.”

The DoE (2002) affirms that the process of learning is as important as the content. In OBE, the process and content are emphasised by spelling out the outcomes to be achieved at the end of the process. Both concepts of lifelong learning and active learning lie at the heart of OBE. Gultig, Lubisi, Parker & Wedekind, (1998), highlight that outcomes-based to teaching and learning implies that learning should be directed towards acquiring abilities and skills rather than memorising information. This means that, among others, learners can effectively solve problems, communicate, and work in groups by practicing such activities and constantly refining their performance. This then suggests that learners should be

- actively involved in learning, with opportunity for learners to explore ideas and practice skills.
- engaged in cooperative as well as individual learning contexts so that learners can develop skills to work collaboratively in a group and individually, and be able to recognise which approach is appropriate in a given situation.

In 2009, a Ministerial Committee was tasked with the review of the implementation of the NCS (Motshekga, 2010). The committee made several recommendations that necessitated the NCS to undergo some changes. Some of the changes that were accepted for implementation are as follows:

- number of projects for learners should be reduced
- portfolios for learners assessments should be done away with
- common Tasks for Assessment (CAT) for grade 9 learners should be discontinued and replaced with externally-set assessments at grades 3, 6 and 9.
- learning areas and programmes should be called subjects
- number of learning areas in the Intermediate phase are to be reduced from eight to six
- language of learning and teaching is to be taught together with home language from grade 1.

The aims of the curriculum review were:

- to lessen the administrative load on teachers,
- and to give clear guidance to enable teachers to be consistent in their teaching.

The main foci that changed include:

- the terminology Learning Outcomes and Assessment Standards was replaced with “Content” and “Skills”.
- CAPS Foundation Phase (Grades R, 1, 2 & 3), Numeracy to be called Mathematics and Literacy is called Language.
- CAPS Senior Phase, school-based assessment counts for 40% and the end-of-year examination counts for 60%.
- CAPS for Grade 10, 11 and 12: content has been reorganized for several of the subjects and the examination structure has changed in some of the subjects.

However, the new curriculum that emerged, named Curriculum and Assessment Policy Statement (CAPS), maintained the teaching approaches and methodologies prescribed under OBE. Furthermore, one of the general aims of the new curriculum (i.e. CAPS) stipulates that Grade R – 12 should be based on the principle of “Active and Critical approach to learning, rather than rote and uncritical learning of given truths” (DoE, 2011: p. 3).

Despite the fact that active learning is a core methodology in the NCS (DoE, 2002), which was prescribed when this study was done, teacher-centeredness, pupil passivity, rote learning and the like remain common practice in many classrooms (Vinjevold and Taylor, 1999). Vinjevold and Taylor (1999) gave two reasons for teacher-centred practices in South African schools, namely fundamental pedagogy as well as language and knowledge. Fundamental pedagogy is based on the belief that an adult knows better and must lead the child to maturity (Enslin, 1990). This implies that the teacher, as a knowing adult, leads the child to maturity. The teacher provides information and decides what should be learned, how it should be learned and when it should be learned (Wood, 2008). In the 1990s, about 30000 school teachers registered with University of South Africa (UNISA) to improve their qualifications. These teachers were trained in fundamental pedagogy. This was equally true with the teachers who were trained in most of the black universities (Hayes, 2008). With respect to language and knowledge, according to Macdonald (1990), black children spend most of their time in class listening to their teachers. Also, questions asked by teachers are mostly on a lower cognitive level (questions are mainly data recall or checking whether learners are listening to the lesson). He goes further to say that learners are not encouraged to read, write, listen and speak in English language. This implies that most of the learners do not have the language skills needed to process abstract concepts.

Macdonald (1990) adds that the teachers encourage their learners to use rote learning which worsens the situation. The teachers justify the action by saying that drilling is an effective way of teaching since children cannot read. Macdonald is rather of the opinion that the teachers who encouraged learners to memorize information, most often, lacked conceptual knowledge and reading skills. The teachers used teacher-centred method to enable them to control the learners' access to knowledge (Macdonald, 1990). Koulaidis (1987) confirms that science educators in South Africa prefer invariably to use traditional pedagogy (direct instruction or "the telling method"), which involves placing much emphasis on presentation of knowledge and the ability of learners to think in abstract terms. Research done by Ochrub (2001) and Tabuluwa (1997) reveal that the problem is not only common in South Africa. They state that policies put in place in Namibia and Botswana intended to change teaching approaches of educators from teacher-centred to learner-centred approach were not successful. Spillane and Zeuli (1999), Cohen (1990) add that educators in developed countries also struggle to implement learner-centred approach to teaching.

In view of what exists in classrooms in Namibia, Botswana, and developed countries, it can be argued that the reasons presented by Vinjevold and Taylor (1999) may not be the only hindrance for learner-centred approach to be implemented in classrooms. Prince and Felder (2007) recount works done by Ramsden, 2003; Norman and Schmidt, 1992; Coles, 1995; Felder and Brent, 2004 and state that active learning promotes mastery of content and develops learners' skills in thinking and writing. Bransford, Brown and Cocking (1999) add that significant number of learners is more receptive to active learning strategies. Active learning approach (ALA) is an instructional method where learners are involved in doing things and thinking about what they are doing (Chickering & Gamson, 1987). ALA is therefore a learner-centred approach to teaching.

1.3 Context

The school in this study is located at Mlungisi, a suburb of Queenstown. It was founded as a result of excess numbers of learners in the high schools in the disadvantaged Mlungisi community. There are five high schools in the community. One of the high schools is, historically, a coloured school that uses both English and Afrikaans as language of learning and teaching (LOLT), and it comprises of both black and coloured learners. The learner body in the other four secondary schools (grade 8 – 12) is 100% black and serve high percentage of learners from low socio-economic status. One of the four schools was granted a no-fee-paying school status in 2009 and the school in which this study was done was granted no-fee-paying school status with effect from 1st April 2011.

The school chosen for this study was founded in 1994 and has served high percentage of learners from low socio-economic status. Approximately 40% of the learners in the school struggle to pay an annual school fee of two hundred and fifty rand (R250). The school's learner capacity is 950, but the 2010 enrolment was 780 learners and the current 2011 enrolment is 803. The learners in the school are 100% Black Xhosa speaking South Africans.

There are 30 educators that are composed of 4 Indians, 1 white, 1 Ghanaian, 2 coloureds and 22 black Xhosa speaking South Africans. The 30 educators is composed of 1 principal, 1 deputy principal, 3 heads of department, 1 master educator, 5 senior educators and 19 post level 1 educators. There are other personnel including two office-based staff who are black females, one black male caretaker and three black female cleaners.

The school enrols learners from grade 8 to 12. It is a mixed gender institution that caters for learners who fall between the ages of 14 to 22 years. The goal for this research was to determine whether an active learning approach generates higher learning for 11^{th} grade physics learners who are second language speakers of the LOLT. Every November, learners in 11^{th} grade are tested with common examination papers set by the provincial examiners. The examination scores are used for promotion from Grade 11 to 12.

The teaching staff of school A where the study took place is striving to overcome low examination scores/grades and pass rate. Various programs have been implemented to enhance learner achievement. One of such programs is the after-school lessons. The overall purpose of the after-school lessons is to provide learners extra opportunities for academic achievement. In the after-school lessons program, learners are tutored in the areas of Mathematics, Physical Sciences, Accounting, History, Geography and Business Studies. Learners are also engaged in public speaking instruction to improve their English language communication skills. Since the above program is not compulsory, learner participation has not been encouraging. The school recognises that learner achievement in grade 11 is vital for the academic success of each learner. Research indicates that learners who receive poor grades, who repeat, or who are over-aged for their class are more likely to drop out of school (United States Department of Education, 2002).

1.4 Statement of the problem

According to Prince and Felder (2007), several active learning instructional strategies have been designed and are available to be used but educators rarely use any. Prince and Felder (2007) explain that active learning instructional methods usually need great effort and time of the educator to plan. This study assumed that learner-centred teaching is not implemented by even highly knowledgeable educators because they do not have the time and the effort it takes to plan. The researcher also observed teachers in his circuit and none of them used any active learning instructional method. This study is aimed at examining the effect of a relatively simpler (i.e. requires less preparation time) active learning instruction strategy on learners achievement in Newton's Laws of motion, which is part of Grade 11 Physical Sciences curriculum. This method of teaching has not been tried out in physics teaching and learning in Queenstown District in Eastern Cape Province where performance in physical sciences in previously disadvantaged schools has continued to decline. This study aimed at determining the effects of the ALA on the academic achievement in physics in one disadvantaged school in the Isibane circuit in the Queenstown District.

Despite the fact that physical sciences is an important learning area for economic, scientific and technological development, it is optional in Grades 10, 11 and 12 in most secondary schools due to learners' poor performance in the subject. Often the educator is blamed for the poor performance among other factors such as availability of teaching facilities and the attitude of the learners towards the subject. Teaching methods, therefore, are crucial factors that affect the academic achievement of learners (Mills, 1991). The use of Lasher's ALA in teaching physics in secondary school has not been reported in South Africa. This study was therefore intended to add to the body of knowledge. The study provides empirical evidence on the effects of the ALA on English second language learners' achievement in grade 11 physics.

In 1994 when the DoE was ushered in, it was deemed necessary to restructure the education system of South Africa. In order to accomplish this objective, the ruling political party rolled out a curriculum transformation that could rid the education system of dogmatism, racism, and promote contemporary learning and teaching approach (African National Congress, 1994).

Curriculum 2005 was consequently introduced in 1997 and was later revised, streamlined and strengthened between 2000 and 2002 and eventually dubbed National Curriculum Statement (NCS) (Eastern Cape Department of Education, 2004: 10). One of the principles underpinning the NCS is OBE. “The OBE lay emphasises on participatory, learner-centred and activity-based education” (ibid, 13). Thus, with the inception of OBE it was anticipated that educators will make learners play an active role in teaching and learning. Vinjevold and Taylor (1999) report that direct instruction which is void of activities that promote high thinking skills continues to be classroom practice.

The heart of learner-centred teaching is to ensure that information and concepts are meaningfully understood and relevant to learners' future learning and activities (McCombs, 2001). Thus, the need to improve learners' achievement in physics makes it imperative to find acceptable and efficient learner-centred teaching approach. Therefore, the problem statement is to assess the effect of Lasher's ALA on learners' achievement and retention of knowledge in Newton's laws of motion.

Also, during an informal discussion with the facilitator in the District it was stated that only a few educators in the district use any learner-centred teaching approaches. Secondly, the researcher has taught physics in grade eleven for several years and has realised that most learners know what Newton's laws say, but many do not know what they mean (or simply do not believe what they mean). In addition, learners have many misconceptions about Newton’s laws (see section 2.8).

1.5 Rationale of the study

The researcher’s awareness of problems such as:

- educators unwillingness to use active learning teaching approaches
- learners’ distrust of what Newton’s laws say
- learners’ misconceptions of Newton’s laws

and the fact that there are available materials to confront the misconceptions prompted him to select Newton’s laws of motion as a study topic.

Newton’s laws of motion were selected as a topic for the study for the following reasons:

1. Newton’s laws of motion can be used to explain many observable phenomena (http://ierg.net/lessonplans/unit_plan.php?id=38).
2. They are conceptually difficult for students to learn (Kelly, 2011; Finegold & Gorsky (1991) and
3. Well-developed instruments (such as FCI, Force and Motion Conceptual Evaluation (FMCE) and MDT) exist to measure conceptual understanding of Newton’s laws (Hestenes & Wells, (1992); Hestenes et al, 1992; Thornton, & Sokoloff, 1998)

1.6 Objectives of the study

The objectives of this study were to investigate the effect of an active learning approach on the achievement of 11th grade learners in Newton's laws of motion. The study was done by comparing the achievement of learners taught Newton's laws of motion with an Active Learning Approach (ALA) to that of learners taught through Traditional Direct Instruction (TDI).

In addition, the study also determined whether learners taught with ALA retained the material better than those taught with TDI after 10 months.

1.7 Research questions

Therefore, the dissertation focuses on the following three questions:

1. How will Lasher's ALA affect Grade 11 learners' achievement and retention of knowledge in Newton's laws of motion?
2. Will the ALA make learners participate actively in teaching and learning?
3. Will the learners approve of the ALA?

Question 1 will be answered by the two FCI post-tests, question 2 will be answered by the informal observation and question 3 will be answered by SAI questionnaire and the classroom group interview.

1.8 Hypotheses of the study

The two hypotheses below were used for the study. Each hypothesis was tested at a significance level of $p < 0.05$.

I) There is no statistically significant difference in achievement in Newton's laws of motion tasks between learners who are taught using the active learning approach (ALA) and those taught using traditional direct instruction (TDI).

II) There is no statistically significant difference in the retention level of knowledge on Newton's laws of motion by learners taught using ALA and those taught with TDI.

1.9 Significance of the study

This research is of significance to the domain of teaching and learning practises as it extends the knowledge base that currently exists in that field. The concept of active learning has not been embraced by majority of educators. A handful of educators who have chosen to embrace the approach and have implemented varieties of ALA have welcomed the benefits it offers to teaching and learning. Therefore, research which explores the advantages of an ALA will help to raise awareness among those who are unacquainted with its potential applications and benefits within their educational setting. To illustrate the potential of the ALA, the research investigated the achievement and retention of knowledge in Newton's laws of motion of two Grade 11 classes in an underachieving school. The findings which will result from the case study may impact upon the method by which teaching is executed in physics classrooms.

Studies in active learning approaches have been of significance to Physics Education Researchers and interested educators who wanted to learn more about its impact on learners' learning, achievement and retention of knowledge (Prince & Felder, 2006; Slunt & Giancarlo. 2004; Prince, 2004; Bonwell & Eison, 1991).

The ALA might assist learners to understand how to read and interpret text, which are useful life-skills. It might also provide physics' educators an active learning approach that could be easier to execute in secondary school physics classrooms. In addition, it was presumed that the active learning-approach might lead to a livelier classroom. This is possible, because the learners might have opportunity to contribute to the lesson.

1.10 Definition of terms

Active learning approach (ALA) is an approach to instruction in which learners engage the material they study through reading, writing, talking, listening, and reflecting.

Traditional direct instruction (TDI) is instructional approach in which students sit passively in a classroom and absorb the knowledge transmitted by an expert. According to Slavin (2006), direct instruction describes "lessons in which the teacher transmits information directly to students structuring class time to reach a clearly defined set of objectives as efficiently as possible" (pp. 209-210).

Learners' achievement is the scores or marks attained by learners in an administered test.

Learner: In this study, learner refers to a high school pupil. Note that, in this study, this term is used interchangeably with the word student (*see student below*).

Student: Is a learner, or someone who attends an educational institution. In some nations, the English term (or its cognate in another language) is reserved for those who attend university, while a schoolchild under the age of eighteen is called a pupil or learner.

Approaches, methods and strategies: these terms were used interchangeably in the study.

1.11 Outline of chapters

The study consists of five chapters.

Chapter one

This chapter reviews the background to the study. It proceeds to identify the statement of the problem, the objective of the study, the research hypothesis, limitations of the study, and a brief definition of terms.

Chapter two

This chapter examines the major concepts and theories regarded as relevant and present the theoretical framework that underpins the study. The topics described are traditional direct instruction, active learning approaches, Lasher's active learning approach, and Newton's laws of motion.

Chapter three

The chapter describes the research design, including the sample, the instruments, and the methodology employed in the research. The chapter further explains and provides an analysis and justification of the data collection method employed and the research location.

Chapter four

The findings from the two different teaching approaches are presented by offering the results obtained from the questionnaire and the interview administered.

Chapter five

The findings of the study are summarised and their implications to teaching and learning physics were used to make recommendations.

1.12 Summary

In this chapter the background of the study was presented and was put into context. The problem was stated, the objectives of the study introduced and the hypotheses declared. Also, the significance and limitations of the study were discussed. Finally, the definitions of terms used in the study were presented.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

Given the significance of the need to improve teaching approaches, it is not surprising that many different teaching methods have been developed within the past 30 years. In physics education, variations of active learning include experiential learning (Kolb, 1984), problem-based learning (Miller, 2004), participative learning (Mills-Jones, 1999), and cooperative learning (Johnson, Johnson, & Smith, 1991). In this study, active learning and some other related teaching approaches that are commonly categorized as active learning will be discussed briefly (see section 2.8), and then these methods will be compared with the traditional or passive approach (see below). Lastly, the problems when teaching Newton's laws of motion and the theoretical framework that underpins this study will be discussed respectively.

Physics is considered by students to be a difficult subject and that has resulted in students' interest in physics decreasing all over the world (Fischer & Horstendahl, 1997). For example, in Australia, the proportion of Year 12 students enrolling in science public examination subjects has decreased continuously from 1980 to 1998, and the percentage of the Year 12 cohort enrolled in physics has reduced from 29% in 1980 to 18% in 1998 (Goodrum, Hackling & Rennie, 2001).

Research in science education during the last two decades has attributed this problem to methods of teaching and the effect different teaching and learning factors have on learners (Barlia & Beeth, 1999; Elton, 1997; Metz, 1991). This problem poses a challenge for science education researchers and physics teachers all around the world.

2.2 Traditional direct instruction

Traditional direct instruction (TDI) has been the most popular method to teaching for many years (Killen, 2000). It is all about teaching the child everything in explicit detail just because the teacher knows everything and the learner is still naive (Kuszewski, 2011). The teacher seeks information that is supposedly the only truth and transmits it to learners (Kuszewski, 2011). Thus, the teacher tells the learners all the facts about the topic and occasionally validates what has been said with a demonstration. Robson (2002) states that, teachers who decide to use TDI to teach a topic usually believe that to learn is equivalent to remembering (i.e. to acquire knowledge which is an approved 'truth' or 'fact').

2.2.1 Preparing the lesson for traditional direct instruction

According to the Aviation Instructor's Handbook (AIH, 2003), the key to successful presentation as a classroom direct instructor is careful preparation. According to AIH (2003), the preparation usually involves the following four steps:

- Establishing the objective and desired outcomes;
- Researching the subject;
- Organizing the material; and
- Planning productive classroom activities.

These were the steps followed by the researcher to deliver the lesson to the comparison group.

2.2.2 Types of delivery of traditional direct instruction

Basically, there are two common ways that teachers use to deliver lessons. These are explained in the following paragraphs 2.2.2.1 and 2.2.2.2.

2.2.2.1 Extemporaneous delivery

When TDI is delivered in an extemporaneous manner the teacher speaks from a mental or written outline, but does not read or memorize the material to be presented (AIH, 2003). Since the teacher talks directly to the learners, their reactions can be readily observed, and adjustments can be made based on their responses (ibid). The teacher that has better control of the situation, can change the approach to meet any contingency, and can tailor each idea to suit the responses of the students (Killen, 2000). For example, if the teacher realizes from baffled expressions that a number of learners fail to grasp an idea, it can be elaborated on until the reactions of the learners indicate they understand. The extemporaneous presentation reflects the instructor's personal enthusiasm and is more flexible than other TDI (AIH, 2003). For these reasons, it is likely to hold the interest of the learners.

2.2.2.2 Use of notes

Here the teacher either reads, writes on the board from well prepared notes or show power point slides and occasionally pause to explain. A teacher who is thoroughly prepared or who has made a presentation before can usually speak effectively without notes (AIH, 2003).

2.2.2.3 Formal versus informal lectures

The primary consideration in the TDI, as in all other teaching methods, is the achievement of desired learning outcomes. The teacher normally achieves active student participation in the informal lecture through the use of questions. In this way, the learners are encouraged to make contributions that supplement the lecture. The teacher can use questions to determine the experience and background of the learners in order to tailor the lecture to their needs, and/or to add variety, stimulate interest, and check learner understanding. However, it is the instructor's responsibility to plan, organize, develop, and present the major portion of the lesson (see appendix C).

2.2.3 Advantages of Traditional Direct Instruction

Killen (2000) lists a number of advantages to the lecture method. For example, a lecture is a convenient way to instruct large groups. If necessary, a public address system can be used to amplify the speaker's voice. Direct instruction can be used to present information that would be difficult for the learner to understand other ways, particularly if the students do not have the time required for research, or if they do not have access to reference material.

Direct instruction also can usefully and successfully supplement other teaching devices and methods for example a brief introductory lecture can give direction and purpose to a demonstration or prepare learners for a discussion by telling them something about the subject matter to be covered.

In a lecture, the teacher can present many ideas in a relatively short time. Facts and ideas that have been logically organized can be concisely presented in rapid sequence. Lecturing is unquestionably the most economical of all teaching methods in terms of the time required to present a given amount of material (Cangelosi, 2003).

The lecture is particularly suitable for introducing a new subject and for explaining the necessary background information. By using a lecture in this way, the teacher can offer learners with varied back-grounds a common understanding of essential principles and facts.

Ross and Kyle (1987) and Berliner (1982) in Killen (2000) suggest that direct instruction is particularly suited to teaching low achieving learners. It is argued that low achieving learners often lack the skill to locate, organize and interpret information (Killen, 2000). Direct instruction creates non-threatening and reasonably stress-free environment for low achieving learners because they are not forced to participate and become embarrassed (Killen, 2000).

2.2.4 Challenges of Traditional Direct Instruction

Although the lecture method can help the teacher meet special challenges, it does have several disadvantages. Too often the lecture inhibits learner participation and, as a consequence, many learners willingly let the instructor do all the work (Killen, 2000). Learning is an active process, and the lecture method tends to foster passiveness and teacher-dependence on the part of the learners. As a teaching method, the lecture does not bring about maximum attainment of certain types of learning outcomes. Motor skills, for example, can seldom be learned by listening to a lecture (ibid). The only effective way students can perfect such skills is through hands-on practice.

According to cognitive scientists (Gopnik, 2011; Bonawitz et al, 2011; Buchsbaum, 2011) showing a learner what to do, instead of letting her figure out the solution herself severely affects the learner’s ability to independently and creatively solve problems, or to find different possible hidden solutions in Kuszewski (2011). According to Killen (2000) a lecture does not easily allow the teacher to estimate the learners' understanding as the material is covered. This emanates from the fact that within a single period, the teacher may unconsciously present more information than learners can absorb. Also, the lecture method provides no accurate means of checking learner progress (ibid).

Many teachers find it difficult to hold the attention of all learners in a lecture throughout the class period (Killen, 2000). To achieve desired learning outcomes through the lecture method, a teacher needs considerable skill in speaking. As indicated by research, a learner's rate of retention drops off significantly after the first 10-15 minutes of a lecture period (Killen, 2000; Cangelosi, 2003). In addition, the amount of material retained after a lecture is about five per cent after 24 hours (ibid).

Another shortcoming of TDI, which can also be considered as rote memorization method of teaching, is that it requires learners to stay in their seats, pay attention, watch the teacher, and imitate what the teacher does (Kuszewski, 2011)

2.3 Teaching Practices in South Africa

To address the poor teaching practices in South Africa, the Department of Education (DoE) through the curriculum innovations, which began in 1999, has continually advocated for learner-centred teaching practices (DoE, 2003; DoE, 2011). The curriculum innovations and reviews since1999 have specifically recommended active learning instruction strategies to ensure that teaching practices are learner-centred, collaborative and or promote critical thinking (DoE, 2011).

Many schools have traditionally held a TDI in which a teacher or lecturer ‘transmits’ information to students. In contrast, Vygotsky’s theory promotes learning contexts in which students play an active role in learning. Roles of the teacher and learners are therefore shifted, as a teacher should collaborate with his or her learners in order to help facilitate meaning construction in learners. Learning therefore becomes a shared experience for the learners and teacher.

2.4 Vygotsky’s Social Development Theory

According to Vygotsky (1978), a learner’s cognitive development is promoted by his/her social interaction. He added that the level of a learner’s cognitive development can be enhanced by a more knowledgeable other (MKO). Vygotsky recognised that there is a gap between what a learner can do without being assisted and what the learner can do if assisted by a more knowledgeable person. He called the gap the zone of proximal development (ZPD). According to him, learning occurs in this zone.

Crawford (1996) inferred that social interaction between people with different levels of skills and knowledge should promote learning. Its educational implication is that it would be easier for learners to create meaning to phenomena if they worked together with their educator.

William and Burden (1997) affirmed that a learner’s learning would be enhanced if assisted by a more knowledgeable person. The assistance offered by a more knowledgeable person to a learner is referred to as scaffolding. Scaffolding can be in the form of an educator initiated discussion between learners in a class or an educator referring a learner to a resource that can help the learner to learn more about a skill. Thus, scaffolding impels a learner to participate actively in a learning process. Also, one needs the assistance of a more knowledgeable person if one wants to learn at a level beyond one's normal capability.

2.5 Scaffolding

According to, Teo, Cheong, Chang, Gay, and Leng (2006), scaffolding is any type of mediation that learners need to be able to function at higher levels of their ZPD.

Scaffolding is, therefore, the role an adult or more knowledgeable peer plays to guide a child's learning and development (Stone, 1998; Wells, 1999; Hammond, 2002; Daniels, 2001). Donato (1994) added that if learners are given the opportunity to work together, the same scaffolding help as in expert-novice relationship is created.

The social constructivist requires an educator to be a facilitator and not a teacher (Bauersfeld, 1995). Rhodes and Bellamy (1999) distinguish between a teacher and a facilitator. According to them, a teacher transmits/conveys knowledge that covers a topic whereas a facilitator helps learners to form deeper understanding of the content of a topic. This implies that, a facilitator must make learners to think carefully about a concept or a phenomenon and consequently create deeper understanding that might not be possible alone (Greeno, Collins, & Resnick, 1996). This further implies that learners should be made to engage in activities that will lead them to discover principles, concepts and facts for themselves. Therefore, this study is set in a constructivist theory which has its roots in Vygotsky's (1978) work.

In the next paragraph the Active Learning Approach will follow and then the two approaches will be compared in terms of effectiveness to improve learners' achievement in Newton's laws.

2.6 Active Learning Approach

From the adage of Confucius, "I hear and I forget. I see and I remember. I do and I understand," The root of active learning approach to teaching might have emanated from the latest part of the above statement. ALA teaches learners to be actively involved in their learning. This can only be realised if learners are taught to ask questions and think about problems before receiving the solution (Kuszewski, 2011). Kuszewski adds that teaching learners to ask questions encourages more non-linear, divergent and creative thinking, to produce better innovators, problem-solvers, and problem-finders.

According to Meyers and Jones (1993: 6), "Active learning involves providing opportunities for students to meaningfully talk and listen, write, read, and reflect on the content, ideas, issues, and concerns of an academic subject". It can be deduced from the definition that active learning requires learners to have the impetus to generate and ask themselves meaningful questions and then search for answers, and interact with the text by summarizing what they read rather than highlighting lots of statements in the textbook. However, most learners have to be provided with active learning opportunities to be able to draw near this ideal.

The senses Confucius claims to be effective track for understanding is not used in most classrooms. According to Bonwell (2000), when learners learn actively they retain more content for a longer time and are able to apply the material in a broader range of contexts.

New research (Ferrance, 2000; Lasher, 2004; Prince & Felder, 2007) shows that educators who use an active learning approach in their classrooms succeed in preparing learners for lifelong learning and make them more capable to work in fields that require new skills and knowledge regularly.

In comparison to traditional direct instruction, the rate of retention for active learning is more intense. An instructor who can introduce some form of active student participation in the middle of a lecture will greatly increase retention (AIH, 2003).

The Edgar Dale's cone of learning (see figure 2) distinguishes clearly between active learning and passive learning. As indicated in the cone, a mere reading of textbook, listening, looking at pictures and occasionally watching videos is passive learning which invariably leads to limited retention. On the other hand, participating in a discussion, giving a talk on a topic, dramatizing, simulating the real experience and doing the real thing is active learning (Berk, 2003)

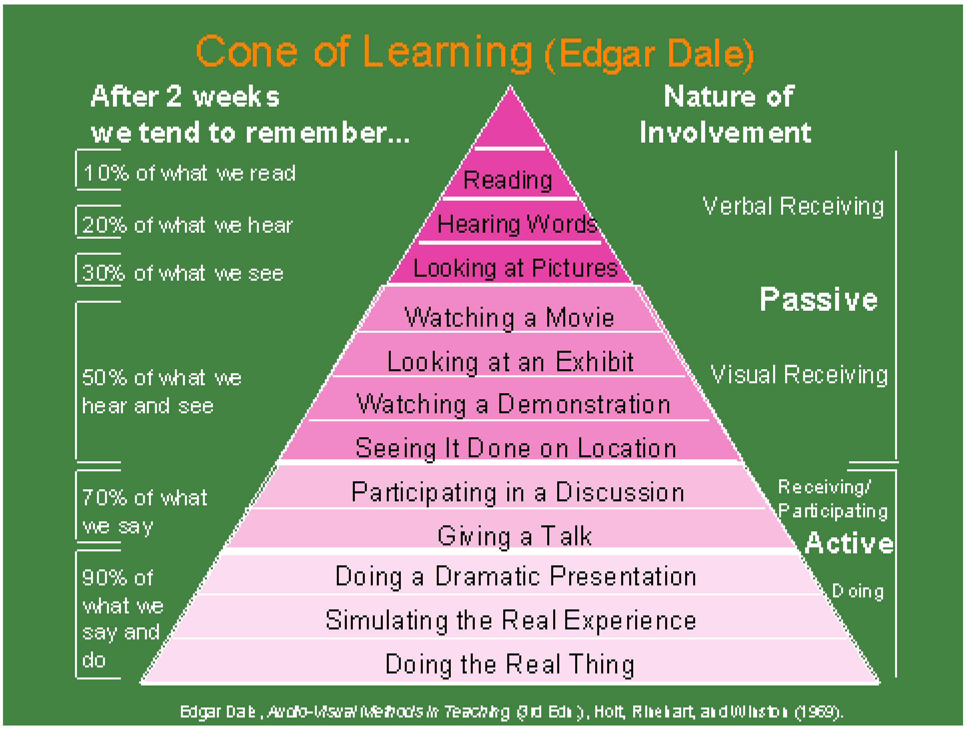


Figure 2.1: Edgar Dale's Cone of Learning*

* Obtained from http://www.cals.ncsu.edu/agexed/sae/ppt1/img012.GIF

The cone of learning also depicts the retention of knowledge that occurs when one combines and engages learning procedures, such as reading, hearing, seeing, doing. The more learning procedures one uses, the more one engages the senses, and the more one understands what is learned and as a result leads to retention of the acquired knowledge. If one listens to a lecture without engaging the other senses, one will only retain 10% of what one hears. According to the cone, if instruction is re-organised or strategies are adapted to lure learners' cooperation to read, generate questions; participate in discussions and do some peer teaching in the classroom environment, knowledge retention should increase significantly.

2.7 Benefits of Active Learning Approach

Researchers (Felder and Brent, 1997; Lasher, 2004; Mckeachie, 2002; Prince, 2004;) view the active learning approach as very efficacious in bringing about increased retention and improved thinking skills among learners. Some of the benefits of Active Learning Approach cited by the researchers (Felder and Brent, 1997; Lasher, 2004; Mckeachie, 2002; Prince, 2004) are:

1. Learners are more likely to access their own prior knowledge, which is important to learning.
2. Learners are more likely to find personally meaningful problem solutions and interpretations.
3. Learners receive more frequent and more immediate feedback.
4. The need to contribute to discussion forces learners to retrieve information from memory rather than simply recognising a correct statement.

5. Learners increase their self-confidence and self-reliance.
6. For most learners, it is more motivating to be active than passive.
7. A task that you have done yourself or as part of a group are more highly valued.
8. Learners who work together on active learning tasks could learn to work with other people of different backgrounds and attitudes.
9. Learners could learn schemes for learning by observing others.

This study presents an active learning approach that may help lessen the limitations, such as coping with learners with differing learning styles, boredom, frustration and socialisation of learners, in most classroom situations.

2.8 Different Types of Active Learning Methods

Prince (2004) also sees active learning as introducing activities into the TDI of teaching to promote learner engagement. Prince (2004) then infers that the type of activities introduced has made a wide range of teaching methods to be classified as active method.

Many active learning approaches have been proposed by many researchers. Some of these approaches are: Pause procedure, inquiry-based learning, problem-based learning, case-based learning, just-in-time teaching and cooperative learning. An attempt has been made to expound on these approaches in the paragraphs that follow. Prince and Felder (2007) say that all these approaches are similar in the sense that learners are offered with a challenge and then learn what they need to know to deal with the challenge. However, Prince and Felder (2007) state that there are differences between the methods. They explain that, owing to the uniqueness and nature of a challenge and the type of help a learner may require, a particular challenge can effectively be addressed by only one of these active learning approaches.

2.8.1 The pause procedure method

The procedure requires the teacher to pause periodically and allow learners to clarify their notes with a partner (Prince, 2004). Prince (2004) explains that during the pause period learners get the opportunity to study from each other which can improve the effectiveness of lectures. This differs from the lecture method, because when a teacher pauses during a lecture the learners think individually and not interact with one another.

Research published by Ruhl, Hughes and Schloss (1987) and Di Vesta and Smith (1979) in Parker (2004) show that the pause procedure show significant results. Ruhl et al. (1987) studied 72 students over two courses in each of two semesters. They divided the students into two groups and taught one group using straight lecture and the other group using the pause procedure. The researchers interrupted each 45-minute lecture three times with two-minute breaks during which students worked in pairs to clarify their notes. The researchers tested short and long-term retention of the material taught. During the short-term retention test, students were asked to write down everything they could remember in three minutes after each lecture. The average score for those taught with the pause procedure averaged 108 correct facts compared to 80 correct facts recalled by classes with straight lecture. Long-term retention was assessed with 65-item multiple choice exam given one and half weeks after the last of five lectures used in the study. Test scores were 89.4% with the pause procedure compared to 80.9% without pause for one class, and 80.4% with pause procedure compared to 72.6% with no pause in the other class.

Hartley and Davis (1978) and Wankat (2002) stated that students could not hold their attention for more than fifteen minutes during a lecture. They also included in their report that after a lecture lesson, students remember 70 per cent of what was taught during the first ten minutes but remember only 20 per cent of the information presented in the last ten minutes.

They therefore concluded that the pause procedure might work because as learners' minds start to wander they get a break and the activities they engage in with their partners provide the opportunity to start afresh again.

The above discussion on pause procedure suggests that the type of activity learners engage in will determine how much material is retained (Di Vesta, 1979). Activities that encourage learners to think about what they are learning are what define active learning (Prince, 2004).

Whereas the activity used by Ruhl et al (1987) appears to be simple and was reported to be highly efficacious, the researcher for this study was apprehensive about the capability of the two-minute break to yield fruitful clarification of notes in a grade 11 classroom. Perhaps the single greatest barrier of all is the risk that students may neither participate nor use higher-order thinking skills.

2.8.2 The inquiry-based learning

According to Exline (2004), "inquiry" is defined as "a seeking for truth, information, or knowledge -- seeking information by questioning". Thus, inquiry-based learning implies involving learners in making observations, posing questions, examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of the student's experimental evidence; using tools to gather, analyse and interpret data; proposing answers, explanation, and predictions; and communicating the results (Exline, 2004).

The process of inquiring begins with gathering information and data through applying the human senses -- seeing, hearing, touching, tasting, and smelling. The next step is to convert the information and data into knowledge that can be applied (Warner & Myer, 2011). This implies that acquired knowledge must be a means to an end not end itself. Thus, the purpose of inquiry-based learning is to inculcate in the learner the ability to retrieve acquired knowledge to learn new information in his/her field with little effort. And more importantly, is the ability to generate new knowledge from information and data gathered through applying the senses (ibid).

Inquiry-based learning accepts that it is necessary to transmit "what we know" but more emphasis is placed on teaching "how we come to know" (Warner & Myer, 2011). This becomes important when one realizes that while knowledge is constantly increasing, so is the boundary of the unknown. Consequently, learners must be equipped with skills for processing information. These are: observing, inferring, measuring, and recording, analysing, evaluating and synthesizing (Warner & Myer, 2011). In a nutshell, inquiry-based learning is about questioning and searching for answers. It must be emphasized that conceptual context for learning help greatly to generate knowledge from the questioning and searching for answers.

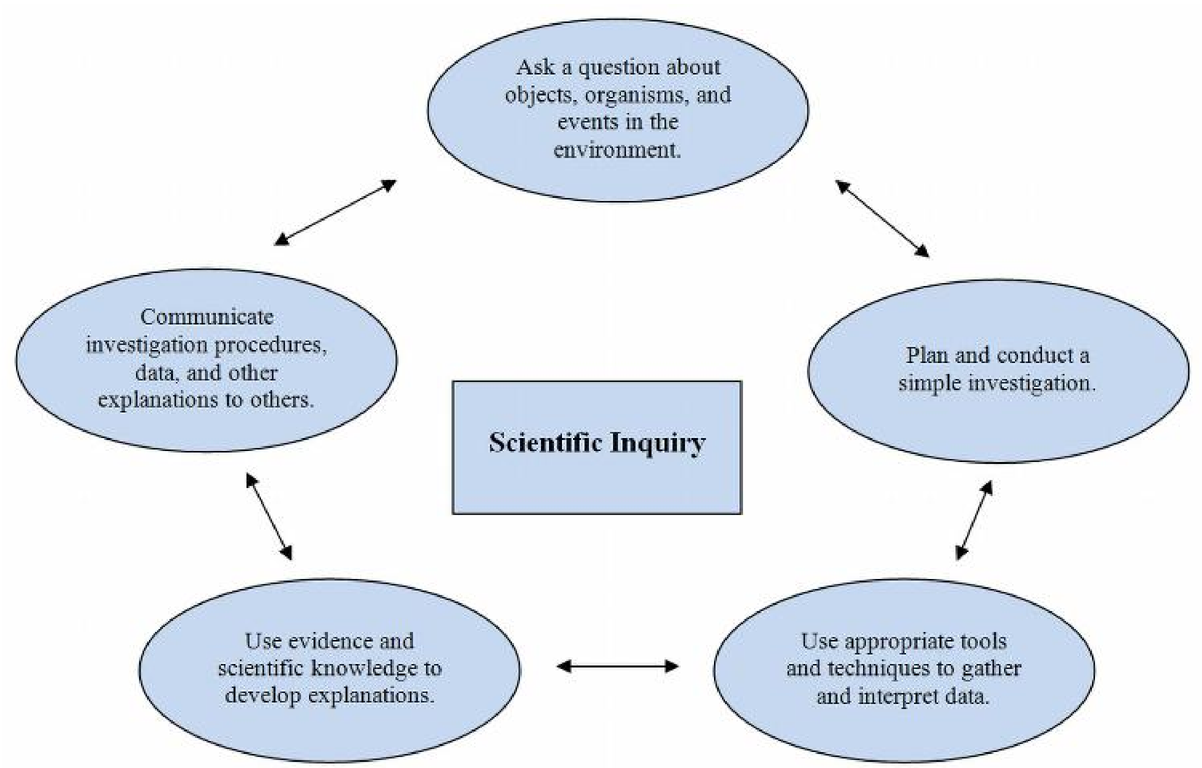


Figure 2.2: Tasks of Inquiry

Adapted from: Carin, Bass, & Contant, (2005, p. 21)

The inquiry process focuses on helping learners to construct their own learning, instead of the teacher transmitting information to the learner (Warner & Myer, 2011; Exline, 2004). It enhances learning by:

- Increasing learner involvement (i.e. learners derive knowledge from investigation)
- Using multiple ways of knowing (i.e. multiple intelligence of learners are engaged)
- Sequencing the phases of cognition (i.e. Bloom's learning phases are mirrored) (Warner & Myer, 2011).

The task cycle above depicts the steps inquiry based learning usually adheres to.

- The teacher first asks a question about an object(s), event(s) or a demonstration.
- Learners' responses are gathered and subsequent questions are solicited from them without providing them with answers.
- Learners collaborate to plan methods of inquiry, such as designing experiments and or tests.
- Learners use appropriate tools to conduct experiment and gather information or data.
- Learners use the gathered information and their scientific knowledge to describe, explain and predict the cause.
- Learners connect evidence to knowledge and draw conclusion.
- Finally, learners present their solution to the problem through oral presentation, a poster, a graph or evaluative write-up.

It thus needs to be mentioned that inquiry based learning is central to all active learning approaches. The active learning approach used in this study employs some of the tasks enumerated above.

2.8.3 Problem-based learning

Problem-based learning (PBL) requires that learners are given ill-structured open-ended real world problems to solve (Prince & Felder, 2007). Learners, working in teams, define the precise problem, figure out what they are to determine and knowledge and skills needed to solve the problem (Miller, 2004). According to Prince and Felder, PBL is time-consuming in the sense that it is difficult to construct authentic open-ended problem that will require the full range of skills specified in the learning objectives of an instructor.

2.8.4 Case-based teaching

Lunderberg, Levin, and Harrington (1999) explain case-based teaching as presenting learners with historical or hypothetical cases which involve scenarios that are likely to be encountered in professional practice. Prince and Felder (2007) reiterate that constructing clear and realistic cases can be extremely time consuming.

2.8.5 Just-in-time teaching

"In just-in-time teaching (JITT), learners respond electronically to conceptual questions before each class, and the instructor adjusts the lesson to react to misconceptions revealed by learners' responses" (Prince & Felder, 2007). The Just-in-Time Teaching Web site: <*http://webphysics.iupui.edu/jitt/jitt.html*>) provides information and resources for JITT. JITT requires that the educator prepares conceptual questions prior to every lesson and adjusts his/her lesson plans for each lecture to address learners' responses and this may force the educator to have different work schedule for different classes (Prince & Felder 2007).

Studies done by Novak, Patterson, Gavrin, and Christian (1999) to determine the effectiveness of JITT in the teaching of physics, produced a normalized gain of 35-40% on the Force Concept Inventory. Other researchers, such as Marrs and Novak's (2004) study on large enrollment biology course and Slunt and Giancarlo's (2004) study of general chemistry and organic chemistry courses revealed that JITT improves the achievement and engagement of learners.

At this juncture, it can be realised that the active learning approaches that have been discussed are endowed with one difficulty or the other. Lasher's active learning method, unlike the others, is less cumbersome, in terms of time needed for preparation. It also does not require one to acquire complex skills, for example, needed to construct authentic cases. The researcher opted for this method, so that if it is found to be effective teachers could be lured to adopt it.

2.8.6 Lasher's active learning method

In this method, students are made to read a technical text in preparation for in-class discussion (Lasher, 2004). The instructor writes critical thinking questions for the text to be assigned to the students. The students are then given the reading assignment and the questions, and are asked to be prepared to discuss the questions in the next class. Students are held accountable for the reading by the instructor's evaluation of their in-class performance.

According to Lasher (2004), this technique has been successfully employed in several upper-level engineering courses, and has resulted in better learning.

Lasher (2004) reports that sixteen students (eight in each course) in first year engineering courses were taught for one semester using traditional lecture and given examination to write. According to Lasher, the scores on the examination were very close – “the average differed by less than 4%, and the median was identical” (Lasher, 2004: 6). During the second semester, one group was taught using the active learning technique and the other the traditional lecture. “On the second exam, the average was 11 points higher and the median 12 points higher for the course taught using the” (Lasher, 2004: 6) technique. It is also reported that the entire grade distribution for those taught using the active learning technique shifted up. Lasher adds that students’ comments about the technique were mostly positive.

Lasher’s active-learning approach suggested in this study is intended to teach learners how to think critically about issues, and to read with understanding. Rather than the educator lecturing or dictating, learners are made to read and interpret technical information and share the selected piece of information relevant to the topic with their peers (Lasher, 2004). The classroom discussions that ensue the learners’ reading and answering of questions given to them, may obliterate learners’ misconceptions about the topic, encourage learners to work together and to develop clarity in communication and observation. It also promotes active auditory skills which can be easily transferred into different learning areas. When learners read an assignment before listening to a lecture, their brains recognize that they need that information and store it (Northern Ireland Curriculum, 2007). When a learner listens actively she uses such higher thinking skills as analysing, synthesizing, predicting, and identifying causes and effects (Bonwell & Eison, 1991). Also answering questions stretches the mind because one may need plenty of time to think of an answer (Bonwell & Eison, 1991).

2.9 Traditional Direct Instruction versus Active Learning Approach

The TDI differs from active learning approach to teaching in several ways. In the first instance, a lecture, primarily, gives learners passive learning experience, in that, learners become recipients of information and are not given the opportunity to process it. Research in cognitive science suggests (e.g., Bolles, 1988; Craik & Lockhart, 1972) in Pulfrey (2002) that the deep active processing of information increases the chance of recalling it later. This then suggests that, learners need to reflect on, relate to, and examine concepts as they are presented. This is unlikely to occur in traditional lecture classes where the constant flow of information leaves learners struggling to take accurate notes.

Second, listening attentively over the course of a lecture may be a problem for many students. Studies (Cox, & Rogers, 2005; Matheson, 2008) suggest that learners' attention is greatest during the first 10 to 15 minutes of a lecture, after which the attention drops continuously and may only pick up at the final minutes of class. With this type of listening pattern, learners may not be able to capture adequate information. Thus, if learners use only their notes when preparing for class exams, information gathered from those notes may be incomplete. This type of listening pattern may produce a typical situation where learners (Keeley, 1997; LaBerge, 1995; Sylwester, 1996) may only be able to accurately recall information that was presented at the very beginning and very end of a lecture.

Third, Peek, Winking and Peek (1995) argue that the traditional lecture method is more effective than other teaching methods in transmitting information (especially large amounts). Research has shown that this is not necessarily the case (see Bligh, 2000; Costin, 1972; Lasher, 2004). In fact, the lecture approach has been found to be no more effective in transmitting information than other teaching methods (Bonwell & Eison, 1991) and is actually less effective than discussion methods when one considers "...measures of retention of information after the end of a course, measures of transfer of knowledge to new situations, ... measures of problem-solving, thinking, ... attitude change, or motivation for further learning ..." (McKeachie, 1986, p. 26).

Finally, the traditional lecture method cannot appropriately deal with many of today's broader educational objectives. Presently, greater emphasis is placed on teaching learners how to learn, using critical and creative thinking skills, stimulating writing across the curriculum, and cultivating independent, yet cooperative learning, it is questionable whether the use of the traditional lecture method can accomplish any of these goals (Pascarella & Terenzini, 1991; 2005). It is for this reason, and the others listed, that the traditional lecture method is being challenged and the increased use of active learning strategies in the classroom is promoted.

The growing importance of technological literacy in the workplace makes it imperative for teachers to provide value to more of their learners. Evidence suggests that with the right kind of learning environment teachers can provide valuable learning experience for the majority of learners. According to Redish and Steinberg (1999), how learners hear and interpret material presented to them depends on the experiences they bring to class. These experiences can only be known if learners are listened to and ways are found to learn what they are thinking. In order to find learners' difficulty, Redish and Steinberg suggest that learners must be encouraged to think aloud and to explain their reasoning. This can only be accomplished if active learning approach is utilised to teach the learners. In principle, active learning approaches provide learners an opportunity to share their own ideas, attitudes, and beliefs about the subject matter (p. 2). In totality, active learning "involves students in doing things and thinking about the things they are doing" (p. 2).

When one considers the nature of learning itself and the benefits of retaining what one has learned, then the increased use of active learning approaches becomes clear. As Chickering and Gamson (1987) in Bangert (2004) note:

> “Learning is not a spectator sport. Students do not learn much just by sitting in the class listening to teachers, memorizing pre-packaged assignments, and spitting out answers. They must talk about what they are learning, write about it, relate it to past experience, and apply it to their daily lives. They must make what `they learn part of themselves” (p. 3).

2.10 Newton’s Laws of Motion

According to literature, students learning Newton’s laws for the first time usually struggle to form meaningful understanding (Nussbaum, 1985; Perkins, 1992). Students’ difficulties have invariably been pinned on lack of understanding of inertia and force which are the fundamentals of the theory. Researchers (Gambie, 1989; Gunstone & Watts, 1985; Hellingman, 1989; Heywood & Parker, 2001) cited in Hart (2002) attribute this to the teaching approaches used. Khiari (2011) has also suggested that learners’ misconceptions are the sole cause of their inability to form meaningful understanding of the concepts.

The most common misconception is the idea that sustaining motion requires a continued force. Learners find it difficult to believe that forces are not needed to sustain motion but forces are needed to accelerate objects. It must be understood that a block of wood pushed briefly across a table would experience a force that is associated with friction. The frictional force acts in the opposite direction to the motion. If the frictional force is decreased (for example, by placing oil on the table) the block of wood would move further and further before stopping. From this, it can be inferred that if the frictional force could be reduced to exactly zero (not possible in a realistic experiment, but it can be approximated to high precision) an object pushed at constant speed across a frictionless surface of infinite extent will continue at that speed in the same direction forever when the pushing is stopped, unless a new force acts on it at a later time. Thus, forces make objects speed up, slow down, and or change direction. Forces do not sustain motion; forces cause changes in motion.

Also, Newton’s third law of motion pose some difficulty for learners and even some physics teachers. The statement of the third law is often interpreted as interacting forces and little as a law of motion. This approach to the law leads learners to think that

1. When a heavy object interacts with a light object, the heavy object exerts a greater force on the light object whereas the light object exerts a smaller force on the heavy object.
2. The interacting forces act on the same object. For example, if the earth pulls down a book lying on a table then the table pushes up on the book with equal but opposite force.

Some learners’ misconceptions about Newton’s laws of motion are as follows: Learners’ think that

1. Inertia is a force (The Physics Classroom, n.d.)
   Available online: http://www.physicsclassroom.com/class/newtlaws/u2l1b.cfm)
2. Force is needed for an object to continue moving (Chandler, 1991)

3. Objects (and astronauts) in orbit are weightless (or float) because there is no gravity in space (Chandler, 1991). According to Chandler (1991: 312c), "weightlessness arises from orbital motion, not from diminished gravity and not from being above the Earth's atmosphere". If there is no gravity in space then the planets will drift apart!

Saglam-Arslan & Devecioglu (2010) studied student teachers' levels of understanding of Newton's Laws of Motion and reported that the student teachers had difficulty learning basic concepts such as force, acceleration, movement and gravitational acceleration. This result is consistent with previous research done by Atasoy and Akdeniz (2007) that focused on student misconceptions about Newton's Laws of Motion. Saglam-Arslan & Devecioglu (2010) also found that the inability of the student teachers to learn the basic concepts made it difficult for them to understand most of the material taught in Newtonian mechanics. The student teachers could not provide accurate scientific explanations to Newton's laws of motion and were unable to relate Newton's laws of motion to real life phenomena and experiences. Saglam-Arslan & Devecioglu (2010) attributed the deficiencies of the student teachers to weaknesses in teaching processes. Therefore, recommended that materials for teaching that use cognitive activities that promote student thinking, discussing, interpreting and provide concrete real life examples must be used to teach Newton's laws of motion and fundamental physics concepts.

Their study also showed that students developed alternative models of understanding about Newton's Laws of Motion, with only a small number using scientifically acceptable models of understanding. This finding was said to have been perpetuated by the poor teaching processes inherited by student teachers (Saglam-Arslan & Devecioglu, 2010). Newton's Laws of Motion have been included in secondary (FET) curricula and play a fundamental role in explaining real life physical phenomena. If the alternative models employed to explain Newton's Law of Motion is not halted, the weaknesses will be perpetuated in preparing and implementing future teaching activities, and will adversely affect the learning of future generations of students.

Consequently, instructional materials that employ cognitive activities that promote student thinking, discussing and interpreting and providing concrete real life examples (Driver & Bell, 1986; Legendre, 1997; Posner et al., 1982; Tobin & Gallagher, 1987; White & Gunstone, 1992; Yiğit et al., 2002) are recommended when teaching fundamental physics concepts and topics related to Newton's Laws of Motion (in Saglam-Arslan & Devecioglu, 2010).

Kara (2007) also reported that three reasons account for the common misconceptions in Physics. These are listed as education, language use in everyday life and life experiences. Research done in Nigeria and South Africa to reveal misconceptions in physics among learners in secondary school showed that textbooks and teachers are the main reason for misconceptions (Kara, 2007). It is most pertinent that learners learn the concepts in Newton's Laws correctly since they form the basis for understanding future physics topics.

Many research studies (Bayraktar, 2006; Brown, 1989; Jimoyiannis & Komis, 2003; Maloney, 1984; Montanero et al., 1995) in Saglam-Arslan & Devecioglu (2010) have been done to determine learners' misconceptions on Newton's laws of motion, but not much studies have been done about how to change learners' misconceptions on Newton's laws of motion (Saglam-Arslan & Devecioglu 2010). All the same, Joan Lucariello (2010) reported about instructional strategies that have been found to be effective in achieving conceptual change and helping students leave their alternative conceptions behind and learn correct concepts or theories. Listed below are her instructional strategies:

1. New concepts or theories that you are teaching must be presented in a plausible, high-quality, intelligible and generative way.
2. Use learners' correct conceptions to create examples that will lead to the new concept or theory that students are having trouble learning due to misconceptions they hold.
3. Use reasoning, which helps students construct new representations that vary from their intuitive theories.
4. Use diverse instruction, wherein you present a few examples that challenge multiple assumptions, rather than a larger number of examples that challenge just one assumption.
5. Help students become aware of (raise student metacognition about) their own alternative conceptions (misconceptions).
6. Present students with experiences that cause cognitive conflict in students' minds.
7. Experiences (as in strategy 3 above) that can cause cognitive conflict are ones that get students to consider their erroneous (misconception) knowledge side-by-side with, or at the same time as, the correct concept or theory.
8. Engage in Interactive Conceptual Instruction (ICI).
9. Develop student's epistemological thinking which incorporates beliefs and theories about the nature of knowledge and the nature of learning, in ways that will facilitate conceptual change.
10. The more naïve students' beliefs are about knowledge and learning, the less likely they are to revise their misconceptions.
11. Help students "self-repair" their misconceptions.
12. Once students have overcome their alternative conceptions (misconceptions), engage them in argument to strengthen their newly acquired correct knowledge (representations).

This study seeks to address the issue of poor achievement of learners on Newton’s laws and examine the effect of an active learning approach on these learners’ achievement in Newton’s laws. It is hoped that learners’ achievement will improve because they will be actively involved in teaching and learning. This will be achieved by encouraging learners to read, answer questions, prepare questions for in-class discussion, talk about what they are learning and apply it to their daily life. The theoretical framework that underpins this study is discussed in the next paragraph.

2.11 Misconceptions on Newton’s Laws

Lots of physics’ learners have misconceptions that impede further learning (Hestenes, Wells, & Swackhamer, 1996). Misconceptions can be overcome if learners are made aware of them and are given an alternative conceptions or explanations that are more plausible than the previously held-misconception (Lucariello, 2010).

The most common misconception is the idea that a force is needed to keep an object in motion. Newton's first law of motion declares that a force is not needed to keep an object in motion. If a book is pushed across a table it glides to a rest position. The moving book comes to a stop because of force of friction. If friction is reduced by polishing the surface of the table to make it smooth the book moves further than before. It can be inferred that, in the absence of force of friction, the book would continue in motion with the same speed along a straight line forever. A force is not required to keep a moving book in motion.

Another misconception held by learners is that friction is an inherent part of an object. Friction occurs when an object interacts with its environment. Friction is not a characteristic an object so it is not an inherent part of an object.

Thirdly, a satellite orbiting the earth at a steady speed in a circle means the satellite is not undergoing acceleration. Velocity, like force and other properties, has two measurements: magnitude and direction. A satellite moving with a constant ‘speed’ in orbit changes direction when it goes around the earth. When an object changes direction its velocity changes and thus accelerates.

Fourthly, the mass of an object is the same as its weight. The mass of an object is the quantity of matter it has whereas the weight of the object is the gravitational force that acts on it.

Another misconception is that when an object is in equilibrium no forces act on it. There is no circumstance in which an object has no forces acting on it. When the sum of the forces acting on an object is zero in value that the object does not undergo acceleration. That is when an object is said to be in equilibrium.

There are host of other misconceptions on Newton’s Laws, such as air pressure contributes to force of gravity. This is false because force of gravity always acts vertically downwards but air pressure acts in all directions. Hestenes, Wells, and Swackhamer (1996) FCI deals with 28 distinct misconceptions on Newton’s laws of motion that is why it was used for the study.

The vital points to know about forces are that:

- they cause change in motion. It speeds up, slows down, changes direction but does not keep an object going.
- changes in motion are accelerations.
- the resulting accelerations are inversely proportional to mass of the object being affected.

- net force is the sum of all the forces acting on an object, A net force of zero magnitude is a state called equilibrium.
- When the net force on an object is zero, an object's inertia is in control. Inertia is the object's tendency for continuing its state of motion (moving straight or not moving at all).
- forces in the same direction add up to increase or decrease speed, and forces perpendicular to a motion change the motion's direction. The total velocity may increase as well.
- the force of gravity is called weight and equals the mass of an object multiplied by g, the acceleration due to gravity.
- friction forces are always resistive forces, opposite to motion.

See http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html

2.12 Studies on FCI

The Force Concept Inventory (FCI) consists of 30 multiple choice questions based on Newton's laws of motion. It was designed to probe learners' misconceptions about Newton's laws and how they compare with experts understanding of the laws (Hestenes, Wells & Swackhamer, 1992). The FCI is regarded as one of the most carefully researched tools to probe student conceptual understanding of Newtonian mechanics (Steinberg & Sabella, 1997). It compels students to make a choice between common sense beliefs and the Newtonian counterpart (Hestenes, Wells, & Swackhamer, 1992).

Since the inception of the FCI, several studies have been done on it to ascertain its validity, reliability, to determine what it measures and to find out if its results are affected by external factors like socioeconomic level learners or the community in which a school is built. Halloun and Hestenes (1995) studies on FCI show that FCI is reliable, has face validity and context validity. Heller and Huffmann (1995) agree that the FCI is reliable, has face validity and context validity but all four do not agree that the FCI has construct validity.

Factor analysis was used by Heller and Huffman (1995) to check if the FCI test items correlated to one another. The study revealed that all the items are loosely related to one another. In other words, learners' responses to the individual questions were not consistent with the defined structures of Newtonian force. However, results of studies from Physics Education Research (PER) reveal that students' responses in physics knowledge do not correlate. Hestenes, Halloun, Minstrell and diSessa confirm that learners' physics knowledge structures are illogical, ill-defined and fragmented. They added that learners' physics knowledge and reasoning depend on the context.

According to Steinberg and Sabella (1997), learners' performance on examination problems and FCI test questions with corresponding concepts to solve the problems showed correlation. However, responses of great minority of learners to the FCI and the examination problems varied greatly. Steinberg and Sabella (1997) inferred that FCI may not be a good measure of learners' ability to use concepts or may not be able to test the functionality of learners' conceptual knowledge. Also, since FCI is a multiple choice test it was construed that the responses to a question did assist to direct some learners' thinking.

PER has shown that FCI appear to measure students' understanding of basic concepts compared with their common-sense beliefs. The FCI has proved its validity and reliability through extensive testing and comparisons with interviews and open-ended versions of the questions. In addition the results have been shown to be very robust in classes at many institutions. The results of pre- and post-course testing indicate that classes taught with traditional lecture instruction show small gains on these tests, while classes using research based active-engagement activities resulted in significantly better gains. Validation studies have shown that the results are consistent with students' understanding of basic Newtonian concepts; although factor analysis suggests that student knowledge is fragmented.

2.13 Theoretical framework

The theoretical framework to guide the study was based on the Systems Approach (Joyce & Weil, 1980) in Wambugu and Changeiywo (2008). The approach holds that teaching and learning process has inputs and outputs. The input to teaching and learning process consists of people, resources and information, and the output consists of people whose knowledge, skills and attitudes have to be improved in some desired way. To get good results (output) the input must have suitable materials. It was, therefore assumed that learners' failure can be blamed on quality of teaching and not lack of learners' ability to learn (Bloom, 1981; Levin, 1985). A schematic representation of the framework is shown below in figure 2.3.

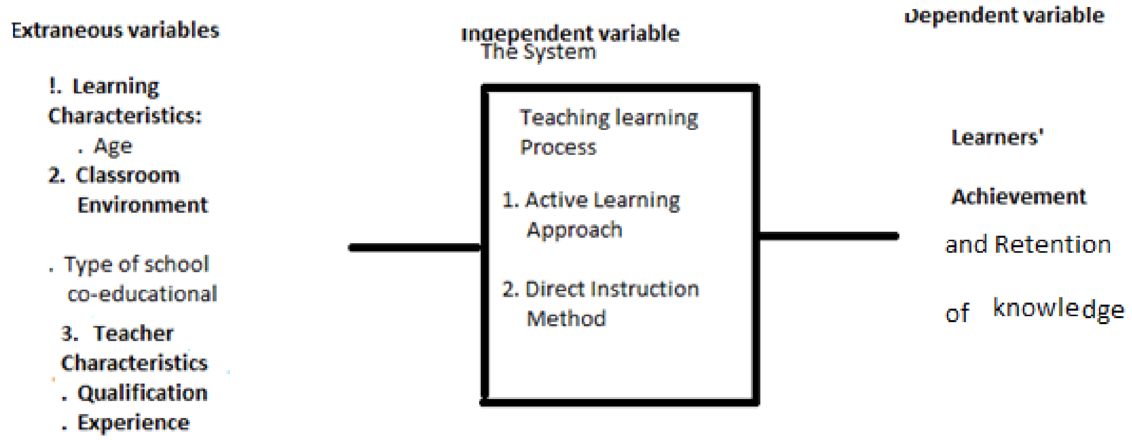


Figure 2.3: The 'systems' model of the educational process

Such a systems approach attempts to mould the input to a course in such a way as to enable the optimal assimilation of knowledge and skills to take place during the learning process, and hence maximize the quality of the output. The scheme represents the relationship of variables for determining the effects of using Active Learning Approach on grade 11 learners' achievement in physics. Learners' achievement is influenced by various factors. These factors include: learner characteristics, classroom environment and teacher characteristics as shown in figure 2.1. These were the extraneous variables that needed to be controlled. The teacher characteristics determine the content knowledge and how effective the teacher will use each approach. The study used the researcher who is qualified and has over 30 years' experience teaching physics in high school to control the teaching variable. The learners' age and their class determine what they are taught. Grade 11 learners of approximately the same age participated in the study. The type of school as a teaching environment affects learners' achievement. The two classes of grade 11 used were in the same school and had almost the same number of girls and boys and that controlled the effect of classroom environment to a large extent.

The independent variables were Lasher's ALA and the TDI. The ALA and TDI generated the dependent variables, learners' achievement and retention of knowledge, which were measured. The TDI used an instructional model in which the educator transferred information to learners. In contrast, the ALA used Vygotsky's theory to promote learning, in contexts in which learners play an active role in learning. Roles of the educator and learner were shifted, as the educator collaborated with his or her learners in order to help facilitate meaning construction in the learners. Learning therefore became a reciprocal experience for the learners and educator.

2.14 Summary

From the examination of the literature and concepts relevant to this research the following have emerged:

(1) The role of a teacher is to help learners to learn instead of to teach

(2) A teacher can help learners to learn by affording them the opportunity to engage actively with the material to be taught.

(3) Using active learning approach in the classroom does not delay the pace of instruction.

(4) Generally, active learning approach help learners to interpret course material into something they can integrate into their long-term memory and knowledge bank.

In the study, the aim was to investigate the effect of an active learning approach on students' achievement in one disadvantaged high school in Eastern Cape and to establish whether the findings in the literature are applicable to the high school physics learners in Queenstown in South Africa.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research design, the research population and sample, data collection instruments, data collection procedure as well as the data analyses methods. It also includes a discussion of ethical issues considered in the study. The research methods were based on the objectives of the research outlined in chapter 1 as well as the theoretical framework and literature review in chapter 2. The purpose of the study was to determine the effectiveness of an active learning approach to teaching and learning of Newton's laws to Grade 11 learners as a case study in a selected school in the Eastern Cape Province.

3.2 Research Design

This study was quasi-experimental in nature. Random selection of learners to the treatment and comparison groups was not possible because secondary school classes exist as intact groups and school authorities do not usually allow the classes to be reshuffled for research purposes (Borg & Gall, 1989; Frankel & Wallen, 2000). Initially there were three physical sciences Grade 11 classes and all of them were taught by the researcher. The researcher used the physical sciences controlled test scores of the learners in March 2010 and mid-year examinations to select two of the classes for the study. The two classes were selected because their mean scores were similar; that is, their mean scores were almost the same in both the March and mid-year examinations. The first two tests were only used to select the groups. The items for the two tests were different in content and thus avoided test effect (Bless & Higson-Smith, 2000). Thereafter, one class was declared to be the comparison group, while the other the treatment group. Here, the treatment group was subjected to an intervention involving an active learning approach (ALA). On the other hand, the comparison group was subjected to a traditional direct instruction (TDI).

The ALA was employed after the mid-year break. Before the mid-year break, teaching was done using the TDI. The FCI post-test was administered immediately after using the ALA. Thus, the data was collected at the same school and at the same time.

The research design for this study was a post-test with comparison group.

N	**X**	**O**	**Where N = NON-EQUIVALENT GROUP**
N		**O**	**O = OBSERVATION**
			X = TREATMENT

Figure 3.1: Post-test with Comparison Group Design

This design was identical to the Post-test Comparison Group design, with the exception of randomization of individual participants. However, the choice of group that received the experimental treatment was made randomly.

Furthermore, the conditions under which the instruments (see section 3.5) were administered were kept as similar as possible in both classes in order to control instrumentation and selection.

The treatment group was taught using the active learning approach (ALA) and the comparison group was taught using traditional direct instruction (TDI). Both groups received the same FCI post-test after the treatment and then 10 months later knowledge retention was measured by administering the FCI post-test items to the learners in 2011, when they were in Grade 12.

3.3 Population

The target population for this study was grade 11 students studying Physical Sciences. The accessible population was students attending a disadvantaged secondary school in a township in Queenstown District. All the students enrolled in the school were Xhosa speaking and were mixed in terms of gender. The school is categorized as no-fee paying. The school is a no-fee paying because most learners come from poor families. This also means that learners receive free meals every school day.

The school was selected because (1) the researcher teaches physical sciences in the school (2) the learners' performance has not been generally good and (3) the school had three separate classes that offer physical sciences in grade 11. One of the three classes was not included in the study because the mean score of the class on the pre-test was found to be very different from the other two.

3.4 Sample

In order to select the groups for the study, two pre-tests were conducted on the three classes that offered physical sciences in the school. In both pre-tests, it was discovered that there was no significant difference between the mean scores of two of the three classes. The two classes with similar means were then selected for the study. The two classes were randomly assigned to the treatment group and the comparison group.

The sample size in the research study was 67 Grade 11 physical sciences learners. This number was taken to be adequate for this particular study because it is viewed, based on the recommendation that in a comparative quantitative analysis there should be at least 30 subjects per group (Fraenkel & Wallen, 2000). The sample in each of the two selected classes is shown below:

Table 3.1: Participants in Treatment and Comparison Groups

	Number of learners	Male	Female	Age
Group 1: Treatment / Experimental group	32	15	17	17 – 22
Group 2: Comparison / Controlled group	35	16	19	17 – 22

3.5 Research Instruments

Five measurement instruments were used to collect data to address the purpose and research objectives of this study (see section 3.5.1 to 3.5.5). Physical Sciences March Controlled Test (see Appendix A) and June Examination (see Appendix B) were used as pre-test. Both papers were set by selected Physical Sciences teachers in the district and were moderated by the district Subject Advisor for Physical Sciences. The purposes of the moderations were to ensure that:

(1) "Questions in tests and examinations assess performance at different cognitive levels across all the Learning Outcomes" (DoE, 2008).

(2) Questions test all the content stipulated in the National Curriculum Statement for the term.

(3) The knowledge, skills, values and/or attitudes described in the assessment standards for the grade concerned are assessed.

Learners' achievement and knowledge retention were determined by scores on the Force Concept Inventory (FCI) paper- pencil test. The FCI used is the version revised by Ibrahim Halloun, Richard Hake and Eugene Mosca (1995). It is used to determine learners' conceptual understanding of Newton's laws of motion.

Learners' rating of instruction was determined using Student Assessment of Instruction (SAI) questionnaire Form D (see Appendix E). Form D (Available from: http://oira.utk.edu/sais) was used because it is designed for those classes whose purpose is the teaching of problem-solving or heuristic methods. Clear explanations, dealing with student difficulties and quality of problems are emphasized. Student Assessment of Instruction questionnaires were originally developed by the University of Washington but have been adopted by other academic institutions, including the University of Tennessee. The forms provide students opportunity to evaluate teaching.

Student interest in the teaching approach was measured using the SAI questionnaire. According to Davis (1993), students' interest in a teaching approach is a predictor of their academic achievement.

In addition, the treatment group was given a classroom group interview to verify some of the findings of the SAI questionnaire.

3.5.1. March Controlled Test and June Examination

Both March controlled test and June examination papers were based on the topics that had been taught from the beginning of the academic year to the time of examination. The topics taught were those stipulated in the provincial Physical Sciences work schedule. The questions for both tests were compiled by the Physical Sciences subject advisor for the District from past National Examination papers. The scores of the learners in both tests were used to determine whether the treatment group and the comparison group were of the same academic ability.

3.5.2 The Force Concept Inventory (FCI) test

A Force Concept Inventory (FCI), revised by Halloun, Hake and Mosca (1995), was used as a post-test to evaluate the effectiveness of the instruction and learners' retention of knowledge. It contains 30 multiple choice items and has been used successfully for several years and by several institutions to determine learners' conceptual understanding of Newton's laws of motion. Unfortunately, the multiple choice items for the FCI are not allowed to be published in a dissertation. The FCI test can be downloaded from the Arizona State University site:

> Available online at: http://modeling.la.asu.edu/R&E/Research.html with a password obtainable from Dr David Koch FCIMBT@verizon.net.

Quantitative methods were used to analyse the FCI post-test administered after the instruction.

3.5.3 Student Assessment of Instruction Questionnaire

A modified Form D of Student Assessment of Instruction from the University of Tennessee was used to rate the effectiveness of the teaching. According to the developers, the

Student Assessment of Instruction (SAI) provides for student evaluation of teaching. The Form D was used because it is designed for classes that use problem-solving or heuristic methods to teach. It lays emphasis on explanations that deal with student difficulties and quality of problems (http://oira.tennessee.edu/sais/forms).

In addition, the SAI is a closed-question questionnaire. The learners in the treatment group gave paper and pencil responses to the questionnaire. Cohen, Manion and Morrison (2000) suggest that if general group responses are required closed format questions are more suitable, because statistical treatment and analysis can be performed more easily on them than on open-ended format of questions.

The comparison group was not asked to answer the questionnaire because the group was not exposed to any new instructional approach apart from the TDI. The treatment group was exposed to both TDI and ALA so was in a position to compare the two teaching approaches.

3.5.4 Interview

The classroom group interview (i.e. a form of focus group interview) was used to determine the effectiveness of the instruction and also as a follow up on the student assessment of instruction questionnaire. A focus group interview is an interview with a small group of four to eight people who are interviewed together on a specific topic (Bless & Higson-Smith, 2000).

The treatment group was reconstituted into six groups and subjected to an interview. The treatment group was used because the members could give the information needed about the ALA and TDI. They were randomly reconstituted into six groups. Each member pulled a group number from numbered folded papers. The same five questions were asked to the newly formed groups. According to Kvale (1996), this approach makes interviews faster and easier to analyse and compare. Questions asked are listed in section 3.8.2.4. The questions were designed to solicit information to determine the learners' responses to the teaching approach used. The interview was conducted by someone other than the researcher. In this case a colleague whose home language is Xhosa and also teaches English Language.

3.6 VALIDITY AND RELIABILITY OF THE INSTRUMENTS

It is argued in literature (Cramines & Seller, 1979 cited in Mayer, 1999; Bless & Higson-Smith, 2000) that validity and reliability are the essential tools used in judging the quality of instruments. Reliability is the extent to which a questionnaire, test, observation or any measurement procedure produces the same results on repeated trials. In short, it is the stability or consistency of scores over time or across scorers.

According to Golafshani (2003), there are three aspects of reliability, namely: equivalence, stability and internal consistency (homogeneity):

Validity is defined as the extent to which an instrument measures what it claims to measure (Bless & Higson-Smith, 2000). Validity may be measured in different forms. These forms include: content validity, face validity, criterion-related validity (or predictive validity), and construct validity, factorial validity, concurrent validity, convergent validity and divergent (or discriminant validity) (Golafshani, 2003). The first four are most commonly referred to in reference to the validity of an instrument.

3.6.1 Validity of the Pre-tests (March and June Examination question papers)

"Content validity establishes that items or questions are relevant to the various components of what is being studied and that the learners interpret the questions and answers in the same way the researcher intended" (Saul, 1998; p.109).

Content validity was established for the question papers by experts' judgment of the subject officers, specialists of National, Provincial and District Department of Education. The questions were selected from past grade 11 examination question papers set by provincial and national examiners. The experts established that the questions were in line with the National Senior Certificate curriculum for grade 11 Physical Sciences and were appropriate for the time allocations before the question papers were distributed to schools for the purpose of the examination (see appendix A and B for copies of the question papers).

3.6.2. Reliability and Validity of the Force Concept Inventory (FCI) test

The content validity of the FCI was not formally established by the developers, but 14 of the original 29 questions of the FCI were extracted from the Mechanics Diagnostic Test (MDT) (Heller & Huffman, 1995). Four different ways were used to establish the validity of the MDT. Firstly, professors and physics graduate students were asked to assess the test items (ibid.). Secondly, graduate students wrote the MDT to authenticate the correct answers. Thirdly, introductory physics students were interviewed to find out if their understanding and responses to the questions were the same as the developers. Lastly, the responses of thirty-one students who received A's in the introductory physics class were checked for common misunderstandings of the test items (Heller & Huffman, 1995).

Notwithstanding, the developers of FCI have confirmed that "the results of the FCI and MDT on comparable classes were very similar" (Saul, 1998; p.109). Also, an interview conducted by Hestenes et al. (1992) on 20 high school students and 16 first-year graduate students about their responses to the FCI revealed that the responses of the high school students were almost the same as the responses that actuated the publication of the MDT. The foregoing thus verifies the criterion validity of the FCI. According to White (2002), a criterion valid test should closely produce the same result as other measures of the same theoretical construct. That is, "a valid test of intelligence should correlate highly with other intelligence tests" (White, 2002: p23).

Furthermore, Hestenes et al. (1992) showed that the results of the FCI is reproducible, which in itself signified that the FCI is a good experimental measurement. Hestenes et al. (1992) also reported that seven groups comprising of over a thousand physics introductory classes who were taught Newton's laws using the traditional style at Arizona State University wrote the FCI and the groups obtained similar average scores of 60 to 64% (cited in Saul, 1998; p. 121).

The FCI has been used globally among high school, college and university students and has been reported to be "useful instrument for evaluating instruction" (Saul, 1998; p. 121). The FCI's validity and reliability have been established by several researchers (Hestenes et al, 1992; Hake, 1998; Heller & Huffman, 1995; Huffman & Heller, 1995; Spurlin et al, 2008) and was therefore used as is.

3.6.3. Reliability and Validity of the Questionnaire

This SAIS questionnaire was first introduced by the University of Washington (UW) in 1974. It has since been used at UW and by 1991 twenty other institutions were using it for students' rating of instruction. In the 1989/1990 academic year, 7000 classes comprising of more than 150000 students rated instruction at UW. The rating was used to determine the mean and the reliability estimates of the SAIS. Item reliability by class size of 20 to 50 varied between 0.68 and 0.97.

Ratings suggested by Landis and Koch (1977) are: (< 0.00, 'poor'; 0.00-0.20, 'slight'; 0.21-0.40, 'fair'; 0.41-0.60, 'moderate'; 0.61-0.80, 'substantial', and 0.81-1.00 'almost perfect').

This means that the reliability estimates of the SAIS is substantial for class size of 20 and increases to almost perfect as the class size reaches 50. The item “Student confidence in instructor’s knowledge” having the lowest reliability of 0.68. In 2000, Gilmore analysed data from over 2 800 instructors teaching over 23 000 classes and the results showed adequate instructor-level reliability of ratings. McGhee (2002) presented a report based on the assessment of approximately 4000 instructors and concluded that average ratings of instructors were meaningful. McGhee (2002) constructed confidence interval for the mean of class median ratings that provides a reliable way for users of student evaluation data to determine whether there are true differences between instructors.

According to Shaw and Racine (2004) questionnaires from community groups have already been tested and used but warns that even in good model questionnaires, some questions may not be suitable as they are worded. They suggest that:

- Unnecessary or unsuitable questions should be omitted.
- Existing questions should be modified (in terms of language, reading level and specialized vocabulary, knowledge, and cultural experience, attitudes and community context) to suit respondents.

As indicated in section 3.5.3, the questionnaire for this study comprised of questions drawn from Form D of the Student Assessment of Instruction of the University of Tennessee. Some of the questions were modified in terms of specialized vocabulary and also to suit the context. For instance, the word “course” was replaced with the word “topic” in questionnaire items in which it appeared. For example, “THE INSTRUCTOR’S CONTRIBUTION TO THE COURSE WAS” was changed to read as “THE INSTRUCTOR’S CONTRIBUTION TO

THE TOPIC WAS”. Also, the questionnaire was conducted to the third grade 11 physics class that was excluded from the study to determine if each question could be answered easily without much thinking.

According to Germain-Rutherford (2003, 11) “assessment of instruction questionnaires that are well designed, properly managed and its results carefully interpreted are valid and reliable tools, and can provide valuable information to the instructor for teaching enhancement purposes and information to the administration for personnel decision. He adds that elements that determine the reliability of a questionnaire are the correlations among responses to different items designed to measure the same component of effective teaching, and the agreement among ratings by different students in the same class”

3.6.4. Reliability and validity of the Interview

Interviews are usually associated with qualitative research. The positivists label qualitative research as subjective and therefore unscientific, because it does not try to eliminate all influences of the researcher (Kvale, 1996). Kvale rejects this tag and states that objectivity in itself is a subjective concept (ibid.). Instead, Kvale (1996) argues that interviews can be freed of bias and provide objectivity and reliability if many subjects as necessary are interviewed to find out what is wanted and the subject(s) is/are allowed to speak without coercing or fear. McNamara (1999) adds that interviews are useful for getting the story behind a participant’s experiences. In fact it is pointed out that interviews can help pursue in-depth information around a topic and are generally easier for respondents (ibid.). In this study, these were achieved by interviewing the 32 learners in the treatment group using classroom-grouped interviews.

The purpose of the interview was to find out if the learners preferred the ALA to TDI. The comparison group was excluded from the interview because the group did not experience the ALA.

The interview involved the entire class of the treatment group, but was conducted by a colleague of the researcher. This process was carried out in this manner also in consideration of ethical issues. A colleague, for example, interviewed the students so the researcher did not know who said what. In conducting the interviews this way this meant that the interviewees were also protected. That is, the process allowed them to speak freely because the researcher who they knew was not present. The process therefore also eliminated subjectivity on the part of the researcher. An important issue here is the fact that the group interviews allowed students the freedom to express themselves without fear. In fact the learners were not subjected to any stress, because they expressed their opinions among peers and in the comfort of their classroom.

3.7 Method of Triangulation

Triangulation is the attempt to increase reliability by reducing systematic error through the use of multiple methods of measurement (e.g. questionnaire, observation, tests). In this study, evidence was collected from three different sources: learners’ achievement (i.e. learning outcome measure) (see FCI section 3.5.2), student interviews (see section 3.5.4) and learner ratings (see section 3.5.3) to test the effectiveness of the teaching method. According to Berk (2005), each source of evidence supplies unique information but has some weakness. If the alternative methods do not share the same source of systemic error, examination of data from the alternative methods may make one aware of how the data form the different sources may be adjusted to come closer to reflecting true measurements, thereby increasing reliability. According to Patton (2002), triangulation may provide deeper insight into the relationship between the method of measurement and the phenomena being studied.

In this study, triangulation was used here in order to determine learners' engagement and changes in competence in knowledge acquisition from different perspectives. Also, the first post-test was used to determine if the ALA had an effect on the achievement of the grade 11 learners in Newton's Laws of Motion. Finally, the second post-test provided insight into retention of knowledge when students are exposed to the active learning approach.

3.8 Treatment and Procedure

The unit of instruction used for this study, consisting of sixteen lessons spread over four weeks, was Newton's laws of motion. Each lesson lasted for a period of one hour. The material used in the study comprised lesson plans. A sample of a lesson plan is presented for the traditional direct instruction (see Appendix- C) and the active learning approach (see Appendix-D). The researcher developed lesson plans for all the topics which are stipulated in the National Curriculum Statement for Newton's laws of motion.

3.8.1 The Comparison Group

The traditionally-designed physics instruction was based upon lessons employing lecture method to teach Newton's laws of Motion. Teaching strategies depended upon teacher explanations, discussions and textbooks. The teacher treated the entire class as a unit, wrote notes on the chalkboard about the definition of different terminology, stated laws, drew diagrams and performed demonstrations related to Newton's laws of motion. After the teacher explanation, the concepts were discussed, recapitulated by the teacher's questions.

The direction of communication in the classroom was from teacher to student and therefore teacher-centred. Here the teacher was the focal point of discussion and dispenser of the knowledge.

3.8.2. The Treatment Group

The treatment group was taught Newton's laws of motion with an active learning approach employed by Lasher (2004) to teach first year engineering students at Behrend College in United States of America. He reported that the "technique has been successfully employed in several upper-level engineering courses, and has resulted in better learning" (Lasher, 2004:1).

3.8.2.1. The Active Learning Approach

According to Lasher (2004) teachers have to adhere to an instructional procedure and a summary of this procedure is presented in table 3.1.

Table 3.1 Summary of Instructional Procedure Adapted from Lasher (2004)

1. Read the text, make notes and highlight important issues.
2. Identify 5 – 10 key issues or questions.
3. Write questions for the learners.
4. Give questions to the learners at least one class in advance.
5. Call on individual learners to answer specific questions, and make sure the response is a paraphrase, not an exact quote.

In preparation for a lesson on Newton's laws of motion, a section of one of the learner' textbooks was selected (usually 1- 3 pages) to read and approximately five questions drafted by the researcher. The students were given the page numbers that they had to read in their textbooks at home and the questions to answer before coming to class at least a day before the class period. A sample of the questions given to the learners prior to lessons on Newton's laws of motion can be found in Appendix E. In addition, learners were asked to develop questions with regards to the pages they had to read. The teacher's questions (Appendix E) and the questions developed by the learners (see below) formed the basis for the class discussion. Examples of questions developed by learners are given below:

1. Can an object have zero velocity and still accelerate?
2. If a moving object has no acceleration, does it mean that no force is acting on it?
3. Why is the unit of acceleration $m.s^{-2}$?
4. If we have a car with a mass of 800 kg and a constant velocity 60 $km.h^{-1}$ and it hits some wall, what force will be applied to the wall? As the velocity is constant the acceleration would be zero and substituting in the 2nd law $F = 800 \times 0 = 0$. Which is impossible - please explain.
5. Does the force an object exerts on an object supporting it always constant? Why or why not?
6. If you push a book lying on a table and the book pushes you back with the same force, why does the book move away from you?

During each classroom session, the researcher/teacher asked learners to answer specific questions. As an example of questions asked by the researcher when discussing Newton's first law, "Why is it that we do not experience perpetual motion in everyday life?" This question is fundamental to understanding the role played by friction during motion. It brings to fore the fact that force slows down, speeds up or changes the direction of an object but does not cause motion. This was to ensure that learners read the assigned text. The number of learners in the classroom made it impossible to ask each learner a question in a given session. To make sure that each learner participated in the lesson, the researcher mentally kept track of learners who answered questions during each lesson. After each class lesson, the researcher ticked off the names of the learners who answered questions. According to Lasher (2004), the process of tracking learners on a form tends to distract the class from the discussion. As much as possible, the researcher made certain that each learner answered a question during the period the study was conducted. It was, however, not obvious that if a learner answered a question in a previous class session s/he was not going to be asked a question in the next class.

While searching for a solution to a problem, learners were usually paired to enable them to share their knowledge, express their ideas and experiences with each other. Pair groups were formed by the teacher and were not permanent. Each learner was asked to work with as many learners as possible during the period the study was conducted. Each of them had to be sensitive to the needs and feelings of the others.

During the Active learning sessions, the teacher ensured that students contributed to the discussion. When guidance was needed, the teacher asked questions and gave ample opportunity to students to focus on the question. The treatment lasted for four weeks (i.e. a total of 960 minutes of 60 minutes per period) after which a post-test (FCI) was administered to both the treatment and the comparison groups.

3.8.2.2. Informal observation

These were the teacher's/researcher's impressions of what happened in the classrooms during teaching and learning (Johnson, Johnson, & Holubec, 1998). What happened in the classrooms were not written down or recorded with an electronic device. The researcher mentally recorded only the important and specific events involving students (ibid). The researcher used this method because recording events in class tends to disrupt the discussion (Lasher, 2004). According to Johnson, Johnson, & Holubec (1998), the teacher should take into account only qualitative incidents and be specific and brief when recording them.

3.8.2.3. The Questionnaire

The questionnaire was initially administered to eighteen learners from the third Grade 11 physical sciences class that was excluded from the study. The purpose of this technique was to test understanding of the items in the questionnaire. Changes were effected to the wording of some of the questions without changing the essence. After the changes were made, the questionnaire was tried again on another group and only one learner could not understand all the questions. The modified questionnaire was accepted for the research.
The questionnaire was administered by the researcher and his co-worker to the treatment (experimental) group, which comprised of thirty two learners. Learners were asked to complete the questionnaire anonymously to encourage truthfulness in the completion of the questionnaire. Although, learners were told that the completion of the questionnaire was voluntary and they were free to leave some or all items unanswered, all the learners answered all the items in the questionnaire.

3.8.2.4. The Interview

The interview was conducted by a Xhosa-speaking colleague of the researcher. The colleague went to the researcher’s class during the researcher’s normal physical sciences period. The interviewer grouped the learners into groups of six and assisted each group to select a spokesperson to write the group’s comments. Four open-ended and one closed-ended question (see below) were posed to the learners and each group discussed and responded to the questions in writing. Learners were told to give their honest opinion about the instructional method, because it was the researcher's intention to use the method to teach them often if it was satisfactory. The colleague guided the learners with the following questions:

1. What did you like most about the instruction method?
2. Compared to the teaching that the educator tells you everything, is this teaching method more enjoyable? Yes or No?
3. If you found the teaching method more enjoyable, what made it more enjoyable?
4. If you did not find the teaching method enjoyable, what did you dislike about the instruction?
5. Provide any other information you prefer to add with regards to the teaching method.

After the learners had finished writing down their responses, the interviewer discussed their responses with them to ensure that how he understood their responses was the same as what they intended in writing. The interviewer then wrote a summary of their answers to the questions and submitted them to the researcher.

3.9 Data Collection

The pre-tests were administered to both groups prior to the commencement of the lessons on Newton's laws of motion. The post-test (FCI) was administered after the instruction. The pre and post-tests were scored by the instructor.

After the intervention, the students from the ALA group were asked to reflect on their experience by providing written responses to the SAI. In addition, the ALA group was subjected to classroom group interview. Finally, the second post-test (knowledge retention unit test - FCI) was administered ten months after the intervention was conducted.

3.10 Data Analysis Methods

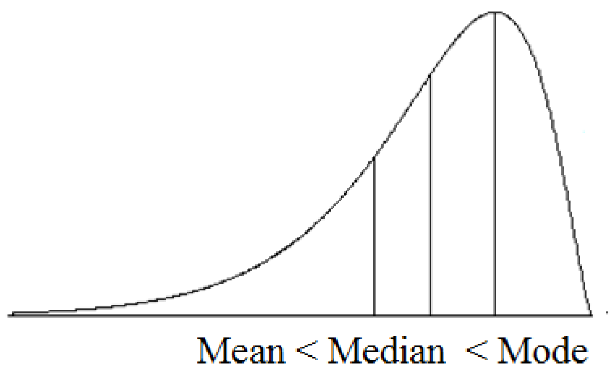
After obtaining the scores on the pre-tests, post-test and retention test, descriptive statistics and inferential statistics was used to analyse the data. The SAI was quantified and subjected to mathematical analyses. The responses to the classroom interview were grouped according to questions and analysed.

3.10.1 Descriptive statistics.

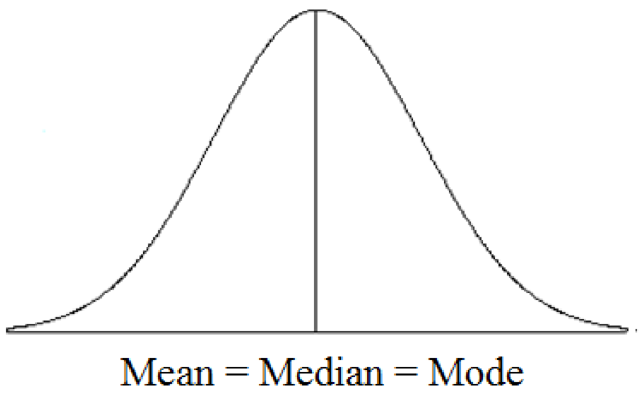
According to Trochim (2006), descriptive statistics provides a summary about a sample. Thus, the descriptive statistics was used to report what was found in different ways. In this study, the mean, standard deviation, range and skewness of the tests were calculated. For each test, the statistic for the treatment group was compared with and differentiated from that of the comparison group.

Skewness statistics compares the mean to the median in a precise way that students can understand (Doane & Seward, 2011).

Skewed Left: Long tail points left



Symmetric Normal: Tails are balanced



Skewed Right: Long tail points right

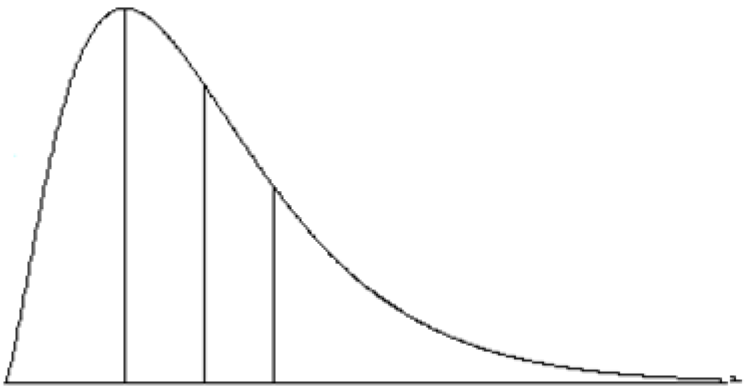


Figure 3.2: Sketches showing general position of mean, median, and mode in a population.

Source: Doane & Seward, (2011).

$$\text{Skewness} = \frac{\Sigma(yi - \bar{y})^3}{(n-1)s^3}$$

$\bar{y}$ is the mean and n is the sample size. y_i is the raw scores and s is the standard deviation.

The rules used to interpret skewness number are suggested as follows:

- A positive skew number means that the right tail of the distribution is longer than the left.
- A negative skew number means that the left tail is longer.
- If skewness = 0, the data are **perfectly symmetrical.**
- If skewness is less than −1 or greater than +1, the distribution is **highly skewed**.
- If skewness is between −1 and −½ or between +½ and +1, the distribution is **moderately skewed**.
- If skewness is between −½ and +½, the distribution is **approximately symmetric**.

3.10.2 Inferential statistics.

Inferential statistics was employed so that the results could be generalized to a population of individuals because of the limited number of research participants (Gay & Airasian, 2000). In this study, the inferential statistics, namely the paired t-test, was used to make a decision about the effectiveness of the intervention.

3.10.3 Paired t-test statistics

According to Gay and Airasian (2000, p. 491), "the appropriate analysis for two pre-test-post-test groups depends on the performance of the two groups on the pre-test … if both groups are essentially the same on the pre-test, neither group has been previously exposed to its treatment, then post-test scores are best compared using a t-test". In this study, the treatment group and the comparison group were essentially the same on the pre-tests and neither group had previously been exposed to its treatment. T-tests calculated on the treatment group pre-test mean and the comparison group pre-test mean for both March 2010 and June 2010 revealed no significant difference at $p < 0.05$ level of confidence. This made it expedient to use the t-test to determine whether the posttest means for the treatment group and the comparison group were significantly different at $p < 0.05$ level of confidence.

3.10.4 Student Assessment of Instruction Questionnaire

The SAI questionnaire was rated on a six point scale. Responses to the questionnaire, were made on a scale anchored by 5 = Excellent and 0 = Very poor. The ratings were used to compute the individual mean of the response to each item.

3.10.5 Classroom Group Interview

Finally, the learners' responses to the interviews were also analysed. This was helpful in determining learners' commitment and approval for the active learning approach in knowledge acquisition.

3.11 Ethical issues

The district education department was informed about the purpose of the investigation and the main features of the design. A copy of the letter addressed to the District Director can be found in appendix F. Similarly a letter was also sent to the Principal of the school, but the policy of the Eastern Cape Department of Education is that only the official appointed by the Superintendent General (to authorize research conducted in the provincial schools) can issue letter of approval. As at now, I have not succeeded to get a reply from the official, but a letter of acknowledgement of receipt from the District Director's Office has been given to me. The letter is attached to this dissertation (See appendix G).

3.12 Summary

The case study was conducted in one school the Queenstown District in Eastern Cape Province of South Africa. Two pre-tests (March Controlled test in Physical Sciences and Mid-year examination in Physics) were used to select two classes of 32 and 35 learners from three grade 11 classes. A FCI post-test was used to assess learners' achievement and retention of knowledge. A questionnaire – SAI was used to collect data from the learners in the treatment group. The learners in the treatment group were subjected to a focus group interview to verify the effectiveness of the instruction. Participants in this study were 67 grade 11 Physical Sciences learners. They comprised 32 - and 35 learners forming the treatment - and the comparison group respectively.

3.13 Projection for the next chapter

The next chapter will present the results and findings of data analyses. It presents both quantitative and descriptive statistics of data collected from grade eleven learners. This is followed by a t-test to compare the mean score of the active learning approach to that of the traditional direct instruction. Finally, the research hypotheses were tested and learners' assessment of the instruction verified.

CHAPTER FOUR

RESULTS AND FINDINGS

4.1 Introduction

This chapter presents the results of the data analysis. The study investigated Lasher's ALA and TDI and their effects on learners' achievement and retention of knowledge of Newton's laws of motion. Specifically, Lasher's ALA and TDI were used to teach Newton's laws of motion to the treatment group and the comparison group respectively. A questionnaire which was followed by classroom group interview was given to the treatment group to assess their perception of ALA.

Allegedly, if the instructor's delivery of lessons followed what was prescribed by Lasher, then the post-test is a fair measure of the efficacy of the ALA (Hestenes et al, 1992). Also, students' rating of instruction indicates their satisfaction or dissatisfaction to the teaching approach (Doyle, 2004). According to Theal and Franklin (2001) in Doyle (2004), learners who are satisfied with an instructional approach learn more. Gaubatz (2000) and Marsh (1982), in Doyle (2004), repeat that students who give an instruction a high overall rating learn more and thus obtain high academic success.

In addition, the questionnaire had to confirm if learners relatively spent more time studying. The questionnaire was followed by an interview to find out if the learners liked the active learning approach. Aside the forgoing, a post-test was administered again to assess the knowledge of Newton's laws of motion retained by both the treatment and the comparison group ten months later.

4.1.1 Pre-test: March 2010

In Table 4.1 a comparison is drawn between the March examination results of the treatment group and the comparison group in the subject Physical Sciences.

Table 4.1. A comparison of pre-test scores of treatment and comparison groups

	N	M	SD	Range	Skew	df	T	p (2-tailed)
Treatment group	32	29.4	8.62	33	0.73	65	1.102	1.997*
Comparison group	35	31.6	7.64	31	0.69			

- $P < 0.05$ [1.997 is the critical t value for $\alpha = 0.05$ (2 tail)]

Where

N = group size

M = mean

SD = standard deviation

df = degrees of freedom

t = calculated t value

p (2 tailed) = critical t value for $\alpha = 0.05$ (2 tail)

Table 4.1 shows an independent-sample t-test that was conducted to compare grade eleven learners' achievement in Physics. There was no significant difference in the scores for the treatment group (M = 29.42, SD = 8.62) and the comparison group (M = 31.60, SD = 7.64). The t-test statistics conducted showed that there was no significant difference between the scores of the treatment group and the comparison group, $t(65) = 1.10$, $p < 0.05$. These results suggest that the treatment group and the comparison group are similar in cognitive ability.

Depending on data given in table 4.1, it is seen that the skewness of the scores for the treatment group D (65) = 0.73, $p < 0.05$ is not different from the skewness of the scores for the comparison group D (65) = 0.69, $p < 0.05$. Both scores are moderately skewed to the right meaning that the right tail of the distribution is longer than the left (or median < mean).

Also, the range of marks for the treatment group (20-53) and the comparison group (17-48) are almost the same.

4.1.2 Pre-test: June 2010

Table 4.2 shows the comparison of the June 2010 examination results of the treatment group and the comparison group in the subject Physical Sciences. Here too no statistically significant difference between the treatment group and the comparison group, t (65) = 1.063, $p < 0.05$, was found. Based on this finding, it was also found that there was no significant difference between the scores of the treatment group (M = 31.31, SD = 11.30) and the scores of the comparison group (M = 28.13, SD = 12.76). These results confirmed that the two groups w ere similar in cognitive ability at the time of the pre-test.

Table 4.2 A comparison of pre-test scores of treatment and comparison groups

	N	M	SD	Range	Skew	df	T	p (2-tailed)
Treatment group	32	31.3	11.3	29	0.98	65	1.063	1.997*
Comparison group	35	28.1	12.76	32	1.04			

* $p< 0.05$ [1.997 is the critical t value for $\alpha = 0.05$ (2 tail)]

Based on the data given in table 4.2, it is seen that the skewness of the scores for the treatment group D (65) = 0.98, $p < 0.05$ is not different from the skewness of the scores for the comparison group D (65) = 1.04, $p < 0.05$. Both scores are moderately skewed to the right meaning that the right tail of the distribution is longer than the left (or median < mean). Also, the range of marks for the treatment group (20-49) and the comparison group (18-50) are almost the same.

4.1.3 Post-test: FCI test results

Table 4.3 shows the comparison of the FCI test results of the treatment group and the comparison group in Newton's laws of motion. The data showed that there was statistically significant difference between the treatment group and the comparison group, t (65) = 2.099, p = 1.997. Based on this finding, the hypothesis that there was no significant difference between the means of the scores was rejected. This means that the two means were significantly different on the post-test scores.

Table 4.3 A comparison of post-test scores of treatment and comparison groups

	N	M	SD	Range	Skew	df	T	p (2-tailed)
Treatment group	32	38.4	11.0	23	0.47	65	2.099	1.997*
Comparison group	35	31.6	15.0	30	0.72			

* $p < 0.05$ [1.997 is the critical t value for $\alpha = 0.05$ (2 tail)]

Depending on data given in Table 4.3, it is seen that the scores of the comparison group is more skewed to the right than the scores of the treatment group. This may be interpreted to mean that the median score of learners in the comparative group was far less than the mean mark of 31.6%, whereas the median mark for the treatment group was less but closer to the mean mark of 38.4%.

Also, the range of marks for the treatment group (27-50) is less than that of the comparison group (23-53).

The outcome of post-test scores indicated that the group that was taught using the active learning approach performed better than the group that was taught using the traditional direct instruction. Thus, the ALA used to teach Newton's Laws of motion resulted to an improved learning which led to a better understanding of Newton's laws concepts. This implication can be due to the fact that in the active learning approach, misconceptions were discussed and overcoming them was prioritized for clearer and better understanding.

4.1.4. Informal observation

It was observed by researcher that during TDI lessons, learners were usually engaged in writing notes and listening attentively without talking to each other. But, under the active learning approach, the classes were "lively", with learners asking and answering questions (see section 4.1.9).

4.1.5. Student Assessment of Instruction

Below are the responses of learners in the treatment group to the questionnaire designed to evaluate the ALA. Generally, questions 1 to 25 sought to assess how the learners perceived the instruction. On the other hand, question items 26 to 31 sought to measure the influence the ALA had on the learners learning (i.e. whether the ALA made the learners to relatively put in more effort to study or not).

Responses of learners to items 1 – 25 of the questionnaire were made on a scale anchored by 5 = Excellent and 0 = Very poor. The ratings were used to compute the mean response to each item.

Table 4.4(a) Distribution of learners' perception of instruction (N = 32)

	Number of Students N = 32	Respondents (Percentages)						Individual Mean
		E	VG	G	F	P	VP	
1	the topic as a whole was:	8(25%)	14(44%)	10(31%)	0	0	0	3.94
2	the topic content was:	15(47%)	8(25%)	7(22%)	2(6%)	0	0	4.13
3	the instructor's contribution to the topic was:	11(34%)	12(38%)	8(25%)	1(3%)	0	0	4.03
4	the instructor's effectiveness in teaching the subject matter was:	7(22%)	11(34%)	10(31%)	4(13%)	0	0	3.66
5	instructor's preparation for class was:	10(31%)	17(53%)	5(16%)	0	0	0	4.16
6	as a discussion leader, the instructor was:	4(13%)	10(31%)	12(38%)	6(19%)	0	0	3.38

7	instructor's contribution to discussion was:	6(19%)	15(47%)	11(34%)	0	0	0	3.84
8	conduciveness of class atmosphere to student learning was:	5(16%)	7(22%)	15(47%)	5(16%)	0	0	3.38
9	quality of questions or problems raised was:	4(13%)	14(44%)	12(38%)	2(6%)	0	0	3.63
10	students' confidence in instructor's knowledge was:	12(38%)	16(50%)	4(13%)	0	0	0	3.94
11	instructor's enthusiasm was:	7((22%)	19(59%)	3(9%)	3(9%)	0	0	3.94
12	encouragement given to students to express themselves was:	10(31%)	15(47%)	4(13%)	3(9%)	0	0	4.00
13	instructor's openness to students' views was:	9(28%)	14(44%)	11(34%)	0	0	0	4.19

14	interest level of class sessions was:	6(19%)	10(31%)	11(34%)	5(16%)	0	0	3.53
15	use of class time was:	8(25%)	13(41%)	8(25%)	3(9%)	0	0	3.81
16	instructor's interest in whether students learned was:	14(44%)	9(28%)	9(28%)	0	0	0	4.16
17	amount you learned in the topic was:	9(28%)	12(38%)	11(34%)	0	0	0	3.94
18	relevance and usefulness of topic content were:	15(47%)	11(34%)	6(19%)	0	0	0	4.28
19	reasonableness of assigned work was:	11(34%)	14(44%)	7(22%)	0	0	0	4.13
20	clarity of student responsibilities or requirements was:	17(53%)	11(34%)	4(13%)	0	0	0	4.41
21	explanations by instructor were	5(16%)	19(59%)	7(22%)	1(3%)	0	0	3.88
22	instructors ability to present alternate	5(16%)	20(63%)	7(22%)	0	0	0	3.94

	explanations when needed was							
23	instructor’s use of examples and illustrations were	4(13%)	22(69%)	6(19%)	0	0	0	3.94
24	answers to students’ questions were	4(13%)	21(66%)	7(22%)	0	0	0	3.91
25	instructor’s ability to deal with students’ difficulties was	5(16%)	21(66%)	6(19%)	0	0	0	3.97

* E = Excellent, VG = Very Good, G = Good, F = Fair, P = Poor, VP = Very Poor

Table 4.4(b) The effect of ALA on learners’ learning

	Relative to other topics you have studied	**Much Higher**		**AVERAGE**				**Much Lower**
26	do you expect your grade in this topic to be:	7(22%)	15(47%)	10(31%)	0	0	0	0
27	the intellectual challenge presented was:	9(28%)	10(31%)	6(19%)	7(22%)	0	0	0
28	the amount of effort you put into this topic was:	6(19%)	9(28%)	8(25%)	8(25%)	1(3%)	0	0

29	the amount of effort to succeed in this topic was:	6(19%)	8(25%)	9(28%)	8(25%)	1(3%)	0	0
30	your involvement in this topic (doing assignments, attending classes, etc.) was:	8(25%)	12(38%)	3(9%)	9(28%)	0	0	0

31 Number of Hours	Less than 2	2-4	5-7	8-9	10-12	13 or more
On average, how many hours per week did you spend on doing readings, writing questions, and any other work related to studying Newton's laws of motion?	0	16	10	6	0	0

Responses to items 1 and 2 indicated that learners considered Newton's Laws of motion as a very good topic ($3.9 \approx 4$) with very good content (4.13). Also, in item 3 learners indicated that the educators' contribution to the topic was very good (4.03). Learners' responses to item 5 show that the preparation of the educator for class was very good (4.16). On item 6, the learners ranked the educator as a good discussion leader (3.38). However, as many as 6 learners rated the educator as fair on item 6. This indicates that the 6 learners probably did not like the discussion or thought that the educator could not teach the content effectively. The latter assertion emanates from the responses of the learners to item 4. In item 4, it was indicated by 4 learners that the educator was not effective in teaching the topic. Considering the responses to item 6, it was surprising that the responses of learners to item 7 were good (11), very good (15), excellent (6) and no fair or poor. On the average, learners rated the contribution of the educator to discussion as very good (3.84).

Item 8 attempts to explore the conduciveness of the classroom to learning. This item received relatively low rating of 3.38. The lower rating might have been due to the fact that the class became noisy at times, especially when there was great disparity in learners' understanding of a concept. Notwithstanding, the mean rating was good (3.38). This indicates that the class atmosphere was within acceptable limits.

Item 10 dispels the notion that the educator could not teach the content effectively as inferred from the responses to item 4. Responses to item 10 indicated that students' confidence in the instructor's knowledge was very good (3.94). No learner indicated that the educator's knowledge was fair, poor or very poor.

Each item, from item 11 to 25 on the questionnaire received a rating of approximately 4 (very good). However, it needs to be pointed out that 5 learners indicated that interest level of class sessions was fair (item 14). This clearly indicates that the 5 learners were not happy with class sessions. It is also worth mentioning that 3 learners indicated that use of class time was fair. These learners were probably not happy with how class time was utilised. They were probably thinking that class time was being wasted.

In its entirety, the ALA was accepted by majority of the learners. This is because the average response for 23 of the 25 questions was approximately 4 (very good).

Table 4.5 (b) sought to find out whether the ALA made the learners to relatively put in more effort to study or not.

Responses to item 26 indicates that 7 learners expected their grades to be much higher than what they got in other topics they have studied and 15 learners expected their grades to be above average. Thus, a total of 22 out of 32 learners expected to improve their achievement after being exposed to the ALA.

In item 27, 9 learners felt that the intellectual challenge presented by Newton's laws of motion was much higher than other topics they had studied and 10 learners felt the challenge was above average. This means that 19 (59%) learners felt that the intellectual challenge posed by Newton's laws were higher than that of other topics they had studied.

In item 28, 6 and 9 learners indicated that they put in much effort and above average effort to study. In total, that represented 15 learners that put in higher effort to study.

Somehow item 29 appeared to affirm the response to item 28. Responses from the learners show that 14 of them put in higher effort to succeed.

Contrary to the responses to items 28 and 29, a total of 20 learners indicated that their involvement in the topic was high (i.e. much higher and above average).

Item 31 reveals that, on the average, 16 learners spent approximately 2 – 4 hours each (48 hours total time using a mean time of 3 hours per learner) per week, 10 learners spent 5 – 7 hours (60 hours total time) per week and 6 learners spent 8 – 9 hours (51 hours total time) per week learning Physical Sciences. From the latter analysis, it can be deduced that the average time spent by a learner to study Newton's laws of motion was 4 hours 58 minutes per week. Since a learner unofficially said that she did not have the urge to learn until the approach was introduced (see section 4.1.7) and if their responses to item 31 are something to go by, then the average time spent to study Newton's laws per week is commendable. This is indicated in their responses to items 28 and 29.

4.1.6. Classroom Group Interview

The analysis was focused on how all groups responded to each question. Thus, data was organised according to question to enable the researcher look across groups and their answers in order to identify consistencies and differences. For example, response to question one by group one was labelled 1.1 and response to question one by group two was labelled 1.2 and so on. All the responses to question 1 were then grouped together. These were done in accordance with Taylor-Powell & Renner (2003) suggested approach for analysing and interpreting data from group interview.

Themes or patterns in the responses were identified. The responses were then organised into coherent categories and summarized. This enabled the researcher to identify the ideas expressed within each category. Care was taken to determine opposing responses, similarities and differences including subtle variations. Relative importance of responses was determined by counting the number of groups that referred to a particular theme. Related themes were also noted. All these were done to enable the researcher to attach meaning and significance to the data. In reporting the result of the interview, more credence was given to interviewees' responses with regards to lessons to be learnt and suggestions for improving teaching and learning.

Learners' comments about the active learning approach were mostly positive. However, there were few negative comments expressed by learners. Examples of the negative comments made by two learners were as follows:

- We are at school to be taught not to be forced to learn on our own.
- I do not understand the text assigned to us to read before the lesson.

This was anticipated since researchers in the field have indicated that students exposed to active learning for the first time usually offer some resistance (Woods, 1994; Felder & Brent, 1996; Felder, 2007; Mohamed, 2008).

Question 1

When the learners were informally asked: What did you like most about the instruction approach? A typical response by Vuyo was "the idea of giving us questions to answer prior to class discussion compelled me to study with other learners". On the other hand Linda said that "other learners' contributions during in-class discussion helped to understand the material better".

Learners' responses to this question, in the group interview, may be summarised in the following way:

i) Three of the groups responded that "It gave us the opportunity to explain materials on our own".

ii) The response of one group was "It made us to realize that there can be other correct ways for solving a problem"

iii) "It provided an opportunity to reveal our thoughts about a concept" was the response from the remaining two groups.

Question 2

- Compared to the teaching that the educator tells you everything, is this teaching method more enjoyable?

  Unofficially, a learner revealed to the researcher that she did not have the urge to learn until the method was introduced; so to her the method has made her to realise the necessity to learn after normal classes.

  There were six groups that were formed out of the treatment group. Five of the groups answered yes and one group answered no to this question.

Question 3

- If you found the teaching method more enjoyable, what made it more enjoyable?
  - i) The idea of giving us questions prior to class discussions compelled us to read. Hitherto, we only read our notes or textbooks only when examinations were approaching. (3- groups)
  - ii) The open discussions created a livelier class and better understanding (2– groups).
  - iii) The group that answered no to question 2 did not answer this question.

Question 4

- If you did not find the teaching method enjoyable, what did you dislike about the instruction?
  - i) Assigned readings were usually difficult to understand (1 – group).
  - ii) Instead of the teacher telling us everything we needed to know, he always forced us to figure out things for ourselves (1 – group).
  - iii) The other four groups indicated that they liked the method.

Question 5

- Provide any other information you prefer to add with regards to the teaching method.

Some groups gave more than one answer to this question, but the responses are summarised below.

i) Homework assigned to us by other teachers made it difficult for us to have enough time to read the assigned pages thoroughly (3 - groups).

ii) We do not have enough space and time at home to learn (2 – groups).

iv) Homework assigned to us did not give us opportunity to learn other subjects (2 – groups).

v) The pace of instruction was a bit slow (1 – group).

vi) Privately, a learner wrote that “Physics seems easy and understandable when our teacher is in class, and then it gets confusing and twisting when you try reading it on your own. And it is even more difficult in the exam room.”

4.1.7. Retention Test: FCI Test Result

Almost ten months after the learners wrote the FCI test, those who were promoted to the next grade (i.e. Grade 12) wrote the test again. The number of learners enrolled in Grade 12 physical sciences class was 45. Of the original 32 learners in the experimental group, 21 were promoted to Grade 12 whereas 19 of the original 35 in the control group were promoted to Grade 12. The remaining 5 learners were from the third Grade 11 class that had 18 learners. The purpose of the test was to compare the knowledge of Newton’s laws retained by the treatment group to that of the comparison group.

Table 4.5: A comparison of retention test scores of treatment and comparison groups

	N	*M*	SD	Range	Skew	Df	T	p (2-tailed)
Treatment group	21	29.43	9.20	40	-0.29	38	1.713	2.021*
Comparison group	19	24.60	8.63	37	1. 33			

* $p< 0.05$ [2.021 is the critical t value for $\alpha = 0.05$ (2 tail)]

The knowledge of Newton's laws of motion retained by learners taught with traditional direct instruction (TDI) compared to the knowledge of Newton's laws of motion retained by learners taught with the active learning approach (ALA) showed that the difference at $p < 0.05$ (see Table 4.4) is not significant. However, the mean score for the treatment group (ALA) was higher than the one for the comparison group (TDI).

The marks for the treatment group (10 – 50) and the comparison group (17 – 54) have almost the same range.

The skewness of the treatment group was -0.29 which suggested that the marks were approximately symmetric about the mean, but the mean mark for the comparison group was highly skewed to the right. This meant that the median mark for the treatment group was approximately equal to the mean mark of 29.4% and the median mark of the comparison group was less than the mean mark of 24.6%. This meant that the treatment group performed better than the comparison group.

Surprisingly, the highest score was obtained by one of the learners in the comparison group (i.e. those exposed to the traditional direct instruction). The researcher could not point to anything that could explain the seemingly unexpected result.

4.1.8 Classroom discourse

During the researcher's classroom interaction with the treatment group there were lively learner-learner and learner-educator discourses that ensued. An example of such dialogues is set below:

In one of the periods that inertia was discussed, the following discourse ensued:

Learner A: stated that "inertia is defined as the property of an object which makes it to resist any attempt to change its state of motion".

Educator: Provide an example of a situation/scenario to illustrate inertia.

Student B: if a box is resting on a floor, the resistance it offers to a push or a pull is its inertia.

Student C: "I don't think what student B said is correct".

When student C was asked why she thinks B is wrong. She replied that "I know that the inertia of an object is always the same, but B's example will make inertia to vary. This is because if an object is on different surfaces it will require different amount of push or pull to move it."

At this stage, C was asked to provide an example of a situation in which inertia is experienced.

C replied, "I can't think of anything now".

Educator: So, what physical quantity is described by B's illustration?

Student X: I think B’s example describes the force between the two surfaces in contact, and that is friction.

Student P nodded her head to show that she agrees with X and said “yes”.

Educator: So, what is the answer to our initial question?

Student Q: When a box is at the back of a moving “Bakkie” and it is free to move, if the driver brakes suddenly to stop the car the box will continue to move forward. That shows the tendency of the box to continue with its state of motion when no net force acted on it. The brake the driver applied acted on the car not on the box, so the box continuing to move shows inertia.

4.2 Summary

In this chapter, data was collected from 67 Grade 11 students who were assigned into two groups of 32 in the treatment and 35 in the comparison. The comparison group was taught using traditional lecture instruction and the treatment group was taught using an active learning approach. The achievements of the two groups in FCI test indicated that the treatment group performed significantly better than the comparison group.

Again, average normalised gains were calculated for the TDI and the ALA. The normalised gains were used to compare the effectiveness of both the TDI and the ALA. The study revealed that both teaching approaches may not be effective in bringing about conceptual change because of the low normalised FCI gains ($g < 0.3$).

The FCI test was administered again to the two groups ten months after the first post-test to determine how much knowledge had been retained by the two groups. The test was written by only the students who had been promoted to grade 12. It was not possible to get all the 67 learners to write because some had stopped offering Physical Sciences as a subject and others had left the school. In all, 40 learners wrote the test to determine the knowledge retained by both treatment group (21) and the comparison group (19). The mean score of the treatment group was 4.83% higher than that of the comparison group but the difference between the mean scores was not significant at $p < 0.05$. Since the experimental mortality was high, it could be said that the retention of knowledge test was not reliable.

Except for two or three students, the responses of the learners to the questionnaire revealed that the students liked the active learning approach. Also, the ALA stimulated them to relatively learn harder which made them to achieve significantly better than those who were taught with TDI. Responses to items 4 and 6 indicate that 4 and 6 learners respectively, felt that the instructor's effectiveness in teaching the topic or as a discussion leader was just fair. These learners may fall into the group of learners who prefer traditional lecture instruction to active learning approach. This might be the case because an individual will change only if one can offer a new thing that brings more benefit than the one she/he is accustomed to.

The interview conducted on the treatment group revealed that two out of the six groups of learners felt that the researcher placed too much responsibility on them for their learning. The question can rightly be asked to what extent the notion of active learning is implemented by colleagues handling the other learning areas.

4.3 Projection for the next chapter

The next chapter discusses the findings and the implications of the analyses of the results. It also uses the relevant literature to support or criticise the findings of the study. Finally, the researcher's recommendations and suggestions for further study are also presented.

CHAPTER FIVE:

DISCUSSION, IMPLICATIONS OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses the findings and the implications of the analyses of the results. It also reviews the relevant literature to support or criticise the findings of the study. Finally, the researcher's recommendations and suggestions for further study are also presented.

5.2 Discussions of the Findings:

The study determined if the scores of learners taught with the ALA and those taught with TDI were significantly different.

The study was also aimed at determining if there was a significant difference between the knowledge retained by those taught with the ALA and those taught with the TDI. Two hypotheses were stated. The first hypothesis is: there is no statistically significant difference in achievement in Newton's laws of motion between learners who are taught using the active learning approach (ALA) and those taught using traditional direct instruction (TDI). The second hypothesis is: there is no statistically significant difference in the retention of material on Newton's laws of motion by learners taught using ALA and those taught with TDI.

The results of the FCI test administered to the learners just after the treatment showed that the difference in the mean scores of learners taught with the ALA and TDI was statistically significant, and that learners taught with ALA achieved significantly better scores than those taught with TDI.

Another time, FCI test was given to both the treatment and the comparison group to determine whether learners taught with ALA did significantly retain knowledge on Newton's laws better than those taught with TDI. The difference in their mean scores was found to be statistically insignificant. The responses to the SAI questionnaire and the classroom grouped interview showed that the learners embraced the ALA. The findings are further discussed here in a hypothesis–by-hypothesis and question-by-question order.

5.2.1 Hypothesis one

The first hypothesis tested in this study stated that there is no statistically significant difference between the achievement of learners taught with the active learning approach (ALA) and those taught using traditional direct instruction (TDI). The findings of the study as shown by the results of t-test in Table 4.3 showed that there is a statistically significant difference between the achievement of learners taught with ALA and those taught with TDI, $t_{65} = 2.099$, $p = 2.000$. The null hypothesis, $H_{0,}$ was rejected and the alternative hypothesis, $H_{1,}$ thus stood. In other words, students taught with the ALA would likely perform better in Newton's laws of motion than students who were taught with TDI. This finding confirmed the findings of many researchers in active learning (Lasher, 2004; Prince, 2004; McKeachie, 2002; Felder & Brent, 1997).

Lasher (2004) in his study, “using active learning to improve technical text comprehension and increase student participation”, found that ALA assists students learning Engineering better than TDI. This agrees with Laws, Sokoloff and Thornton (1999) finding reported in Prince (2004). Laws et al. (1999) found that active learning resulted in higher student conceptual understanding in basic Physics than the traditional direct instruction.

Misconceptions on Newton’s laws were identified and discussed in section 4.1.8. However, detailed data was not captured in order to determine if and how the misconceptions were addressed because this study is submitted as a dissertation of limited scope and would have gone beyond the scope of the dissertation.

5.2.2 Hypothesis two

The second hypothesis stated that there is no statistically significant difference between the retention of knowledge of learners taught Newton’s laws of motions with the ALA and those taught with TDI. The result of the t-test in Tables 4.5 showed that the difference between the mean scores of the two groups at $p < 0.05$ was not significant, $t_{38} = 1.713$, $p = 2.02$. Thus, the null hypothesis, $H_{0,}$ was accepted and the alternative hypothesis, $H_{1,}$ rejected. This finding was unexpected and suggests that learners taught Newton’s laws of motion with TDI retain knowledge equally well as learners taught with the ALA. This result contradicts results published by the proponents of active learning (Lasher, 2004; Prince, 2004; McKeachie, 2002; Felder & Brent, 1997). Bonwell (2000), also add that when learners learn actively they retain more content for a longer time and are able to apply the material in a broader range of contexts. This opposing result might be due to the fact that, during the teaching of the comparison group with TDI, previous skills and knowledge were reviewed before the new ones were taught. According to Kozloff and LaNunziata (1999), retention of knowledge is promoted when educators using TDI, integrate previous skills and knowledge with new ones being taught.

In addition, the mean score of the second post-test for the treatment group (i.e. those taught with ALA) was 4.83 higher than those taught with TDI. It must be pointed out that it was not possible to get all the 67 learners to write the retention test because some had cancelled Physical Sciences as a subject and others had left the school. In all, 40 learners wrote the test to determine the extent of knowledge retained by both the treatment group (21) and the comparison group (19). The 40 learners constituted learners from the treatment group and the comparison group who were promoted from grade 11 to grade 12. This number of learners represents 59.7% of the learners who took part in the initial study. Because the experimental mortality was high, it could be said that the retention of knowledge test was not fair. The 19 learners who were taught Newton's laws of motion with TDI and managed to pass to grade 12 may fall into the category of learners who have, in the past, enjoyed academic achievement with TDI. Regardless of the experimental mortality, it may be inferred that there is no statistically significant difference between the retention of knowledge of learners who have successfully learned Newton's laws of motion with the ALA and TDI. In other words, learners who have previously enjoyed academic achievement with TDI are equally able to retain knowledge as learners taught with ALA (Lasher, 2004; Kozloff & LaNunziata, 1999).

5.2.3 Summary of the findings

The systems approach was used as theoretical framework. The theoretical framework is rooted in a theory which says that learners' failure can be blamed on quality of teaching and not lack of learners' ability to learn (Bloom, 1981; Levine, 1985). In this study, the teaching learning process was the input (i.e. the independent variable) and learners' achievement and knowledge retention in Newton's laws were the output (i.e. the dependent variables). The result of the achievement post-test indicated that the ALA yielded a significantly greater output (better achievement in Newton's laws) than the TDI. This happened with learners with almost the same age and the classroom environment, type of school and the characteristics of the teacher (qualification, experience and personality) were kept constant. It can therefore be inferred, from the theory that, ALA is a better quality teaching approach than TDI when one has to deal with learners' conceptual understanding of Newton's laws of motion. This is in agreement with the findings of the proponents of active learning (Prince, 2004; Lasher, 2004; Mckeachie, 2002; Felder & Brent, 1996).

Secondly, the result of the post-test for finding out which group retained the knowledge of Newton's laws better indicated that there was no significant difference between the group subjected to ALA (treatment group) and the group subjected to TDI (comparison group). This finding contradicts those published by the advocates of active learning. Further studies must be done to find out whether Lasher's active learning approach helps South African high school physics learners to retain knowledge longer is recommended.

In addition, Hestenes and Halloun (1995) categorised learners who scored below 60% on the FCI as lacking logical usage of Newtonian concepts. They described such learners as learners who (1) did not know the difference between velocity and acceleration; (2) thought that motion is influenced by other things in addition to force; (3) had scrappy and illogical concepts about force and motion. Since the g factor for both groups were far less than 0.3 and their average scores were far below 60% (i.e. 38% for the treatment group and 32% for the comparison group), it was inferred that the two teaching approaches did not improve the learners' conceptual understanding of Newton's laws of motion. This might have been due to the fact that the treatment group was exposed to the ALA for the first time and the time the group was exposed to the ALA was very short to get them properly adjusted to the approach.

It was deduced from the responses to the SAI questionnaire in table 4.5 that the ALA got the learners involved in their own learning. The ALA also impelled the learners to put in more effort to succeed. This might have also contributed to the better achievement of the treatment group. In fact, a learner declared informally that the questions given prior to class discussion urged her to study after normal school hours. Another learner said that questions given to them before class discussion urged him to learn with other learners.

Furthermore, learners indicated in the interview that ALA gave them the opportunity to explain materials in their own words, urged them to read even when there were no scheduled tests, made them realize that discussion was valuable for understanding, and also motivated them to learn harder. As stated in section 4.1.7, Linda said that "contributions during in-class discussion helped her to understand the material better".

The foregoing observations imply that the active learning approach impacted positively on the learning styles of the learners. The findings of the current study are consistent with those of Lasher, 2004; Prince, 2004; McKeachie, 2002; Felder & Brent, 1996.

In addition, the classroom grouped interview indicated that the learners liked the ALA more than the TDI (see section 4.1.7). Probably, this explains why the treatment group achieved better than the comparison group.

5.3 Implications of Findings

Analyses of the impacts of the active learning approach (ALA) relative to the traditional direct instruction (TDI) on student achievement showed that students taught with the ALA did significantly better on the FCI test. This may suggest that students perform better when content is taught using the active learning approach. However, the fact that 2 or 3 learners did not like the ALA suggests that some learners may need more time to adapt to the approach.

When asked to comment on the usage of active learning approach to teach Newton's laws of motion, students' comments were positive, perhaps explaining why students taught with ALA did better. This finding lends credence to previous studies that reported that students who find a learning format enjoyable are more likely to improve than those who have negative impressions (Armstrong et al., 2007; Marks, 2000; Robbins, et al., 2006). This point is further supported by a strategy in which students were asked which teaching approach they preferred after exposure to the active learning approach. Two-thirds of the treatment group chose ALA (see section 4.1.7).

The ALA was used for only four weeks. It is incredible that majority of the learners preferred ALA to TDI after being exposed to ALA for such a short period. During the interview, three of the groups stated that ALA compelled them to read and that the reading helped them to understand Newton's laws of motion. Other two groups also wrote that the open discussions created a livelier classroom and better understanding.

One possibility of why learners alleged they learned better under ALA might be due to the fact that most of the learners, for the first time, entered class prepared. This is in agreement with classroom observations: student engagement with material was optimum under this format.

Here, it is important to note again that this study confirms earlier findings that active learning approaches are more effective than traditional direct instruction in terms of examination outcomes (Lasher, 2004; Bradley et al., 2002; Farrell et al., 1999). While the ALA and other active learning methods might not result in improved test scores for some learners, especially those who perform very well when taught with traditional direct instruction, the benefits are manifested in other ways. Lasher (2004), Felder (2006), Sessa (2005) and others reported that more learners received better grades, retained more knowledge and showed higher-order thinking skills when compared to their counterparts taught with traditional direct instruction.

This study has implications for the introduction of new and innovative instructional modes in the classrooms. It suggests that student resistance to active learning can be overcome if students perceive that the new format could help them learn in ways that traditional direct instructions fails to do. However, educators need to be explicit in this regard and guide students through the benefits of the new methods. Most importantly, the study showed that students are willing to change roles from passive listeners to active learners by taking responsibility for their own learning when the right environment and classroom dynamics are created for them.

5.4. Informal Classroom Observations

The researcher taught both the treatment group and the comparison group. During teaching and learning in the classroom, the educator made the following observations:

Under the traditional direct instruction, students had no opportunity to crosscheck their understanding of the material with their peers but rather listened to the direct transmission of material by the researcher (see appendix C). Under the active learning approach, the classes were "lively", with learners asking and answering questions (see section

4.1.9).This collaborative effort among the learners coupled with a sense of owning the learning process could have contributed to the better achievement under the active learning approach.

As expected, some learners in the present study complained and voiced their frustrations with the technique (see section 4.1.7). Since this was the first time the learners were exposed to the ALA, the initial resistance was expected. First, students are accustomed to traditional direct instruction for the eleven years in their education and thus expect the teacher to transfer knowledge to them. Also, the learners are used to playing passive role in the classrooms, they could resist new and innovative modes of instruction that require self-directed learning and the shift of responsibility for learning from the teacher to themselves (Keeney-Kennicutt, Gunersel & Simpson, 2008). A learner was usually asked to explain a concept or an idea first and after that other learners were asked to add or subtract from the explanation given. The teacher/researcher then moulded or summarised the learners' explanations making sure to point out and exclude misconceptions. When learners had no reasonable explanation(s), the teacher/researcher did the explanation.

In fact, some of the learners resisted the active learning approach on the basis that it forced them to study on their own and commented that they "were at school to be taught by teachers not to be forced to learn on their own". However, majority of the learners strongly accepted the ALA and connected with its positive values. This contributed to their learning and thus made the learners to achieve relatively better.

5.5 Recommendations

The ALA improved Grade 11 learners' achievement in Newton's laws of motion. It is recommended that it is used in teaching other topics in physics to confirm its efficacy.

The negative perception of 5 learners, however, is a hurdle one must overcome under the ALA (see section 4.1.6, item 14). The researcher therefore suggests that, for the learners who felt that the ALA in the present study did not give them enough time to study other subjects, the ALA should be used occasionally. Other active learning techniques should be sought and mixed with the ALA. Maybe this can be done in the form of computer simulated models that engage students visually or by guided-inquiry questioning. Future work will examine the effectiveness of this proposed method.

In this context, it is also suggested that traditional direct instruction should be mixed with active learning exercises and group work during a lesson. This might result in active class discussions and could increase students' achievement which may in turn lead them to accept the new approach.

It was observed that the active learning approach

1. forced learners to think about the questions that were assigned to them
2. allowed the teacher to assess the level of understanding of the learners
3. provided peer-to-peer and learner-educator dialogue,
4. allowed learners to spend more time thinking critically about issues,
5. provided positive feelings about the learning process more than the traditional format, and
6. provided general feelings of "effective learning environment" to both the teacher and learners.

For these reasons, an educator using traditional direct instruction can break for 5 – 10 minutes after every fifteen minutes of instruction to ask learners

- to clarify notes with their peers,
- to seek clarification with him/her (the educator)
- to answer some pertinent questions on what has been delivered or
- to use information delivered to solve a problem in paired groups

Any of these can bring about better achievement and retention of knowledge under the TDI. These recommendations are based on the studies done by Ruhl et al. (1987) and Di Vesta & Smith (1979) recounted in Parker (2003). It is said that learners rate of retention vanishes after 10 -15 minutes of direct instruction. This assertion is supported by Killen (2000), Cangelosi (2003), Wankat (2000) and Hartley & Davis (1978). Thus the break after 10 – 15 minutes of direct instruction may help the learners to review what has been taught. Di Vesta (1987) also suggests that learners' environment be designed to support and challenge their thinking. Prince (2004) adds that activities should be introduced into TDI to make learners participate in the lesson and also comp el them to think about their learning.

Another problem mentioned by the learners was lack of time and space at home to study. It is recommended that, since the majority of the learners live in the township, the school opens its doors after school to the learners who want to study to do so.

The present study was restricted to one school. It is recommended that future study on this topic should incorporate other high schools.

The study was also confined to a school with children from a township school. Therefore, the results cannot be generalised to rural and urban schools. It is recommended that similar studies should be replicated in rural schools as well as in urban schools.

Effectiveness of ALA may be verified for different population groups, such as slow learners, special students, children from high socioeconomic environment and students with learning disabilities.

5.6 Limitations

A limitation of the present study is that the approaches of teaching (ALA and TDI) were performed without requesting a competent person to supervise and judge whether the teaching methods were done aptly. An observer's report of the classroom practices would have been more accurate than teacher's self-report.

Secondly, the initial 67 participants should have participated in the post-test for retention of knowledge. The analysis of the results of all the 67 participants would have given a better assessment of the efficacy of the TDI or ALA to retain knowledge.

The study was limited to one school located in a township with children from low socioeconomic environment, therefore the results of the study cannot be generalised.

5.7 Conclusions

The present study that investigated the effect of Lasher's active learning instruction on Grade 11 learners' achievement in Newton's laws of motion has not been carried out before in South Africa. Thus the findings add to the available body of knowledge. Some findings are consistent with findings reported in literature. The present study also established positive effects on Grade 11 students' achievement in Newton's laws of motion. Learners exposed to the ALA were found to have performed significantly better than learners taught with TDI.

Secondly, the learners who were taught with the ALA retained knowledge of Newton laws of motion better than those taught with TDI but the difference in the mean scores of the retention of knowledge test was found to be insignificant.

Furthermore, the study found that the Lasher's active learning approach improved the learning style of the learners who were subjected to it. Generally, the study indicated that the ALA had positive effect on the achievement of Grade 11 learners in Newton's laws of motion.

5.8 Final thought: The key to the technological development and economic empowerment of South Africa lies in the hands of the physics teachers in the nation. With dedicated physics teachers willing to employ active learning methods in the classroom the country will be put on the economic growth and technological growth map of the world.

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APPENDICES

A: MARCH PRE-TEST

CONTROLLED TEST MARCH 2009

TIME: 2 HRS MARKS: 100

Answer ALL questions

SECTION A

Question 1

Write one-word or an expression to replace what each statement is describing.

1.1 The lens used to correct short sight.

1.2 The ability an atom in a molecule has to attract the shared pair of electrons.

1.3 A regular succession of pulses.

1.4 A measure of the average kinetic energy of the particles in a substance.

1.5 The type of semiconductor that forms when silicon is doped with phosphorus.

[5]

Question 2

State whether any of the statements below is TRUE or FALSE. If a statement is false correct it. Do not use the word **NOT** in your statement.

2.1 An increase in temperature increases the conductivity of conductors because more electrons are able to jump the energy gap.

2.2 The product of the pressure and volume of an ideal gas is inversely proportional toits absolute temperature.

2.3 At a given temperature, the particles making up a gas have the same kinetic energy.

2.4 The oxidation number of S in H_2SO_4 is +6.

2.5 Any molecule containing polar bonds will be a polar molecule.

[10]

Question 3: Multiple-choice questions

Choose the answer and write the letter for correct response next to the question number (3.1 – 3.5) on your ANSWER SHEET.

3.1 The energy band in a substance that contains orbital of highest energy.

A. Valence band B. Conduction band

C. forbidden band D. Visible band

3.2 The time interval for an ultrasound pulse to be transmitted and then received again after it was reflected from a foetus that is 50 mm under the skin is _________ (Assume that the speed of sound in the body is 1500 $m.s^{-1}$).

A. $7,5 \times 10^4$ s B. $6,7 \times 10^{-5}$ s C. 6,7 s D. $3,3 \times 10^{-2}$ s

3.3 Which of these substances is compressible?

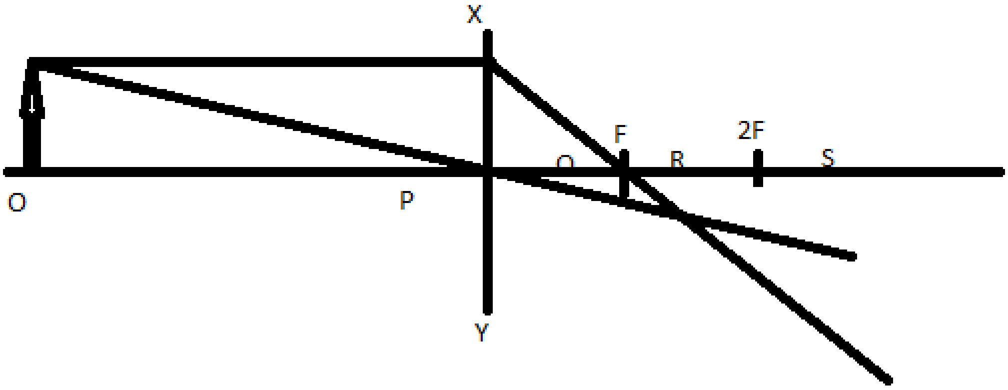
A. Ebonite rod B. Silicon C. Copper D. Chlorine gas

3.4 A liquid that is a good conductor of electricity is called

A. An electrolyte B. A solution

C. A solvent D. Pure hydrochloric acid.

3.5 In the diagram, XY represents a convex lens. Points labelled F are one focal length from the lens and points labelled 2F are two focal lengths from the lens. The object is placed at O.



Refer to the diagram above:

An optical instrument which uses this arrangement is a …

A. Camera B. Magnifying glass C. Photographic enlarger

D. Projector

[10]

Question 4

4.1 Use the energy band to explain the difference between a semiconductor and an insulator. (4)

4.2 Draw diagrams to show how a forward biased diode and a reverse biased diode operate. (4)

4.3 What is an LED? (2)

4.4 Give two advantages of LED over ordinary filament lamps. (4)

4.5 Consider only the elements of **PERIOD 3** of the Periodic Table. Write down only the symbol of the element in question. The same symbol may feature more than once in your answers.

4.5.1 It is a monatomic gas

4.5.2 It reacts vigorously with water

4.5.3 Its valence electron structure is $s^2 p^3$

4.5.4 Its gas is a yellow-green colour

4.5.5 It can oxidise I- ions but not F- ions

4.5.6 It forms a divalent cation (6)

4.6 Write the oxidation number of Mn in each of the following compounds.

4.6.1 $KMnO_4$

4.6.2 MnO_2 (2x2=4)

[24]

Question 5

5.1 Thando sets up an experiment to determine the properties of concave lens. He places an object that is 20 mm high at a distance of 60 mm from the concave lens. The focal length of the lens is 40 mm.

Draw an accurate ray diagram and determine:

5.1.1 The size of the image (7)

5.1.2 The magnification of the image (2)

5.2 Draw Lewis diagram for the following molecules:

5.2.1 Hydrogen chloride

5.2.2 Hydrogen sulphide

5.2.3 Ammonia (6)

5.3 Use the VSEPR theory to predict the shape of each molecule in question 5.2. (3)

5.4 State whether each of the molecules is polar or non-polar. Give a reason for each of your answer. (9)

[27]

Question 6

6.1 What do we mean by bond strength? (2)

6.2 Consider the factors given below and explain with examples how each factor influences bond strength:

6.2.1 Type of bond

6.2.2 Polarity of bond

6.2.3 Bond length (9)

6.3 What effect does the polarity of water have on our lives? (2)

6.4 Determine the oxidation number of S in:

6.4.1 SO_2 6.4.2 H_2S (4)

6.5

Pressure (kPa)	Volume (cm^3)	Pressure x Volume (pV) $Pa.m^3$
100	30	
130	23	
150	20	
200	15	
300	10	

6.5.1 Complete the table above. (3)

6.5.2 What can you conclude about how the volume of a given mass of gas changes as its pressure increases? (2)

6.5.3 Write an equation to show the relationship between p and V. (2)

[24]

B: GRADE 11 JUNE EXAMINATION 2009

PHYSICAL SCIENCES P 1 (PHYSICS)

TIME: 2 HOURS **MARKS: 100**

Section A

Question 1: One-word items

Give ONE word/term for each of the following descriptions. Write only the word/term next to the question number (1.1–1.5) on the attached ANSWER SHEET.

1.1 Change in momentum (1)

1.2 The unit of measure of sound intensity (1)

1.3 Region of space in which an electric charge experiences a force (1)

1.4 The work done in moving a charge between two points in a circuit (1)

1.5 Rate of change of magnetic flux (1)

[5]

Question 2: False items

Each statement below is FALSE. Write down the correct statement next to the question number (2.1–2.5). Do not correct the statements with a negative statement, i.e. '… IS NOT …,"will not be accepted as the correct answer.

2.1 A stationary object has no forces acting on it. (2)

2.2 In an inelastic collision, only kinetic energy is conserved. (2)

2.3 Whole number multiples of the fundamental frequency are called octaves. (2)

2.4 A converging lens only forms real images. (2)

2.5 When resistors are connected in parallel, they are referred to as potential dividers. (2)

[10]

Question 3: Multiple choice

Four options are given as possible answers to the following questions. Each question has ONE correct answer. Choose the correct answer and next to the question number (3.1–3.5) write down the letter of the correct answer.

3.1 A person suffers from short-sightedness (myopia). Which ONE of the following is TRUE about the eye lens and the position of the image?

	EYE LENS	POSITION OF IMAGE
A	Too round	Behind the retina
B	Too flat	Behind the retina
C	Too round	In front of the retina
D	Too flat	In front of the retina

(2)

3.2 A learner decides to increase the volume on her radio. Which one of the following characteristics of sound will increase if the volume increases?

A wavelength B amplitude

C frequency D velocity (2)

3.3 Two spheres, S and T, on insulated stands, carry charges of +4µC and -2µC respectively and are a distance r apart. The force that sphere S exerts on sphere T is **F.**

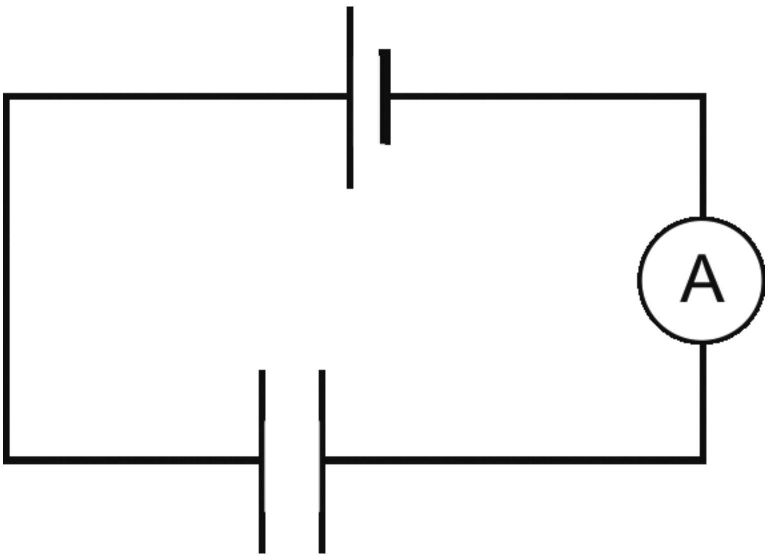
Sphere T is now moved to a distance 2r from sphere S.

What is the force that sphere S will now exert on sphere T?

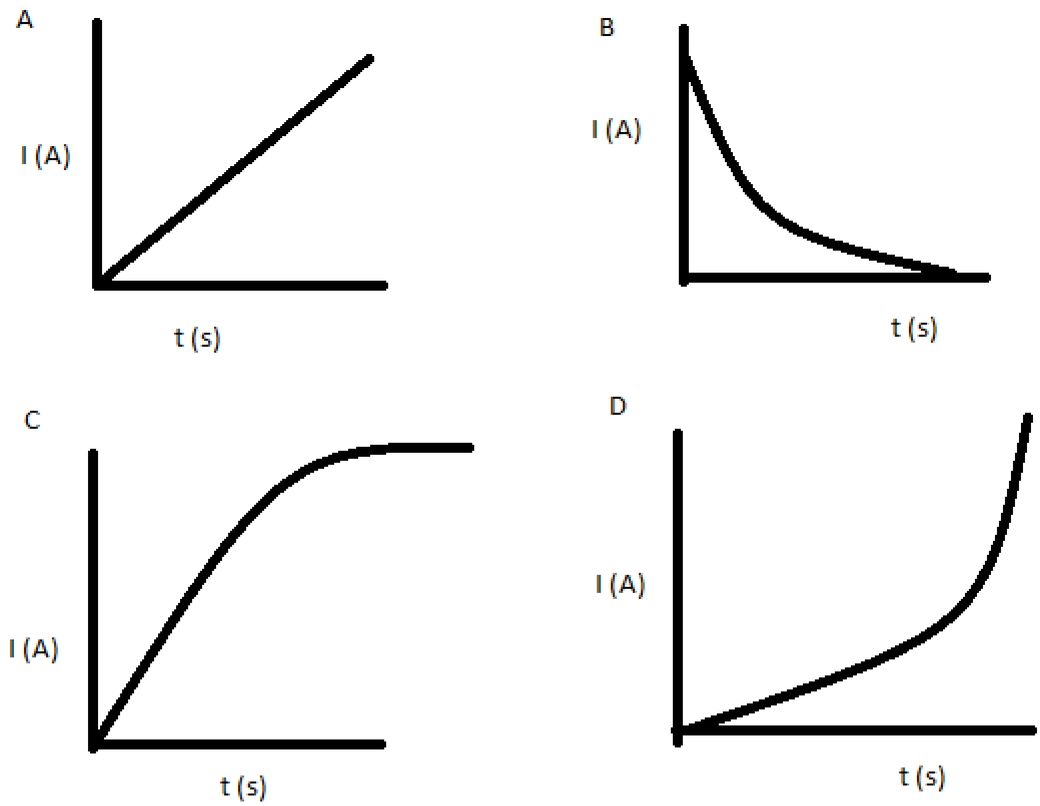
A $\frac{1}{2}F$ B $\frac{1}{4}F$ C 2 F D 4F

(2)

3.4 A capacitor is connected to a battery as shown below.



Which one of the following graphs best explains the change in ammeter reading with time from the instant the uncharged capacitor is connected to the time when it is fully charged?



(2)

3.5 Semi-conductors conduct current by the movement of ...

A positive ions

B negative ions

C de-localised electrons.

D holes and electrons. (2)

[10]

Section B

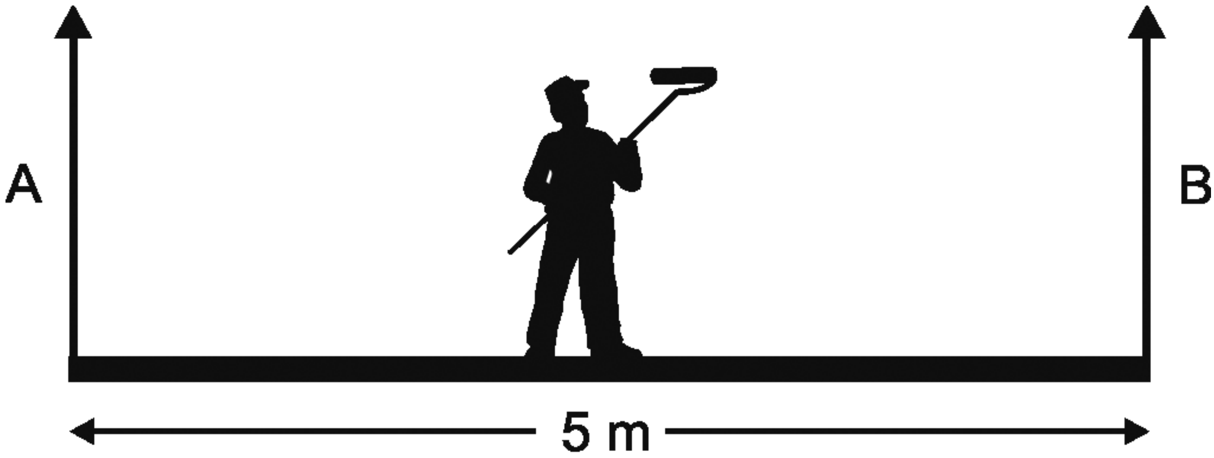
Instructions and information

1. Show formulae and substitutions in ALL your calculations.

2. Round off your answers to TWO decimal places.

QUESTION 4

A painter stands on horizontal, uniform scaffolding that is hung by its ends from two vertical ropes A and B, which are 5 m apart. The scaffold weighs 20 kg. The tension in rope A is 600 N and that in rope B is 200 N.



4.1 Calculate the weight of the painter. (4)

4.2 How far from rope A is the painter standing? (6) **[10]**

Question 5

An object that is 3 mm tall is viewed through a simple reading glass of focal length 20 mm. The object is 10 mm from the lens.

5.1 Define the concept *focal length of a convex lens*. (1)

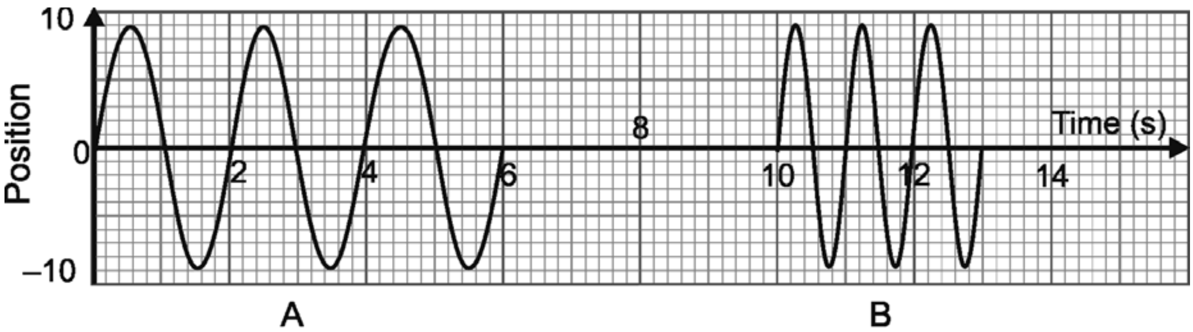
5.2 Draw an accurate ray diagram to determine the position of the image formed by the reading glass. (6)

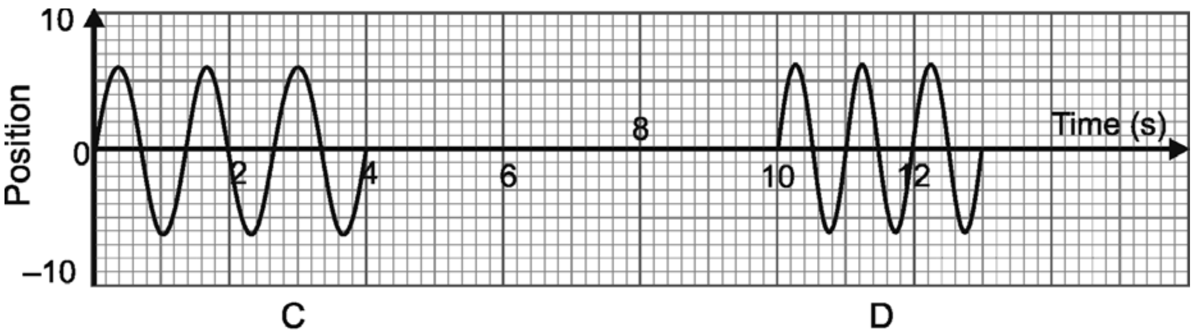
5.3 Write down three properties of this image. (3)

5.4 Calculate the magnification. (3) **[13]**

QUESTION 6

6.1 Study the position–time graphs (A, B, C, D) representing different sound waves.





6.1.1 What type of wave is a sound wave? (1)

6.1.2 Which sound wave has the highest frequency? What is the frequency of this sound wave?

(3)

6.1.3 Which graph represents the loudest sound with the lowest pitch? (1)

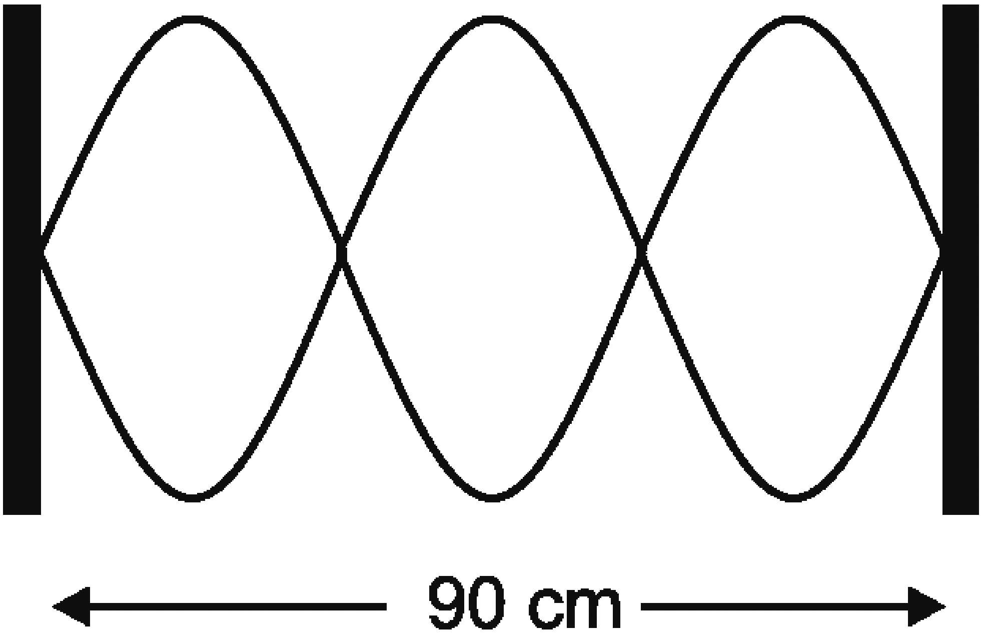
6.1.4 Calculate the speed of the sound in graph A. (4)

6.2 A toy siren makes vibrations of constant frequency. The siren sends out waves 10 cm long through medium A and 15 cm long through medium B. The velocity of the wave in A is 90 $cm \cdot s^{-1}$. Calculate the velocity of the wave in B. (5)

[14]

Question 7

A guitar string vibrates with the standing wave shown below.



7.1 Define the concept *fundamental frequency* of the string. (1)

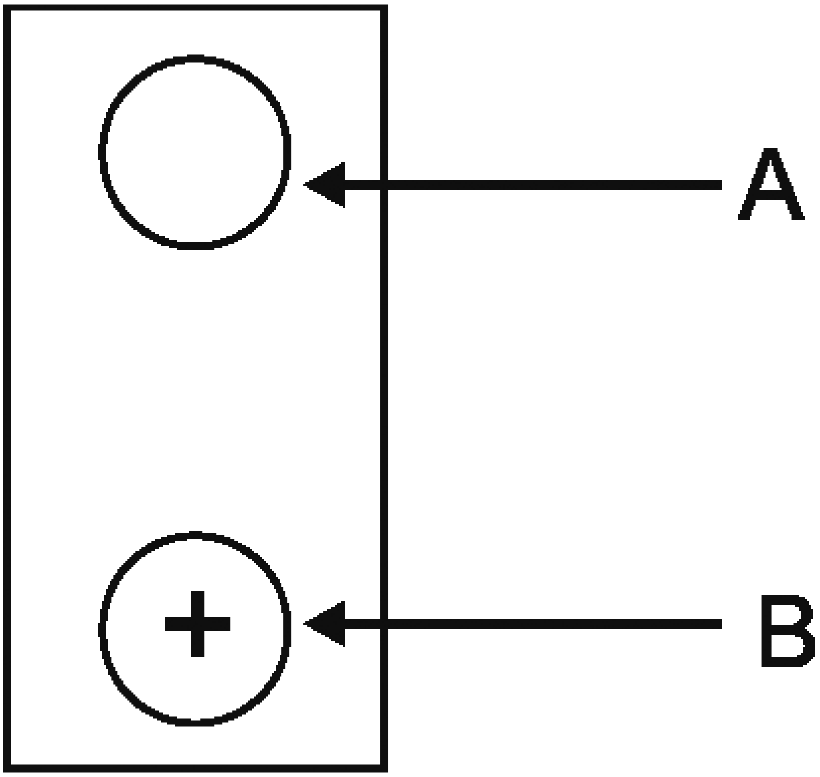
7.2 What is the wavelength of this standing wave? (2)

7.3 Write an expression for the frequency of this harmonic in terms of the length *L* and velocity.

(3) **[6]**

Question 8

Two charged pith balls, A and B, are enclosed in a vacuum as shown below. Pith ball A is suspended above pith ball B. The mass of each pith ball is 2 g. Pith ball B has a charge of 6 μ C.



8.1 What is the charge on pith ball A? Give a reason for your answer. (2)

8.2 If pith ball A is 5 cm above the centre of sphere B, what is the charge on A? (6)

[8]

Question 9

A transformer with negligible power loss is connected to a 120 V input

and the secondary feeds into a load of 2,8 × 105 Ω. The windings have 600 turns in the primary and 15 000 turns in the secondary.

9.1 Calculate the output potential difference. (3)

9.2 Calculate the power delivered to the load. (3)

[6]

Question 10

10.1 Define electric field strength. (3)

10.2 A 370 μF capacitor in a photoflash unit is charged to a potential difference of 330 V.

10.2.1 How much charge is stored on the capacitor? (3)

10.2.2 How much energy is stored? (3)

10.4State TWO practical ways in which the charge stored on the plates of the capacitor can be increased. (2)

[11]

Question 11

Call for MP3 hearing risk warning *MP3 players should carry warnings that users risk damage to their hearing by having the volume too high. The faintest sound that the human ear can hear, called the threshold of hearing, is 0* dB. *At sounds of intensity of 120* dB *the ossicles vibrate so strongly that they strike the walls of the middle ear. A sustained sound level of 85* dB *may cause permanent damage to the inner ear. The table below shows sounds of different intensities.*	
SOUND LEVEL	**dB**
Threshold of hearing	0

Whisper	20
Normal conversation	60
First danger level for ear damage	85
Walkman and MP3 at maximum volume	100
Front rows of rock concert	110
Loud music in a club	110
Threshold of pain	120
Jet aircraft 50 m *away*	130
Instant perforation of ear drum	160

Use the data in the table above and the information in the passage to answer the following questions:

11.1Explain why continuous listening to music through headphones (for example an MP3 player) at maximum volume will affect your hearing. (2)

11.2People working near jet aircrafts sometimes experience pain in their ears. Explain why they experience ear pain. Suggest what they can do to prevent ear damage. (3)

11.3 Suggest a reason why housing developments should NOT be too close to an airport. (2) **[7]**

C: LESSON PLAN (TRADITIONAL DIRECT INSTRUCTION)

Level: Grade 11

Time: 120 minutes (Lecture)

Lesson Objectives:

At the end of the lesson, students should be able to, without any reference or notes:

1. State Newton's First Law of Motion as: "If there is no net resultant force acting on an object, then if it is at rest, it will remain at rest and if it is moving with constant velocity, it will continue to do so."
2. Define force as: "A push or a pull." "An agent that tends to change or changes a body's state of rest or its velocity."
3. Define friction.
4. Identify forces acting on an object.
5. Draw force diagrams.
6. Define inertia as: "as an inherent property of an object that makes it disposed to maintaining its state of motion."
7. Relate the inertia of an object to its mass.

Prior Knowledge

1. Distance as the length of a path (route) taken.
2. Displacement as change in position in space in a specific direction.
3. Speed as distance travelled in a unit time.
4. Velocity as displacement in a unit time.
5. Acceleration as the rate of change of velocity.
6. Mass as the quantity of matter in an object

Learner and Teacher Support Materials

1. Science equipment, Textbooks, Charts

Lesson Presentation

Time/min	Activities	Resources	Rationale
30 min 10 min	**<u>Review of Prior Knowledge</u>** Define distance, displacement, speed, velocity, acceleration and mass. Illustrate each with an example. **<u>Lesson Opening</u>** • Talk about the planets in our universe and how they are held together by forces that keep them in place and on their path of motion • Show scope of the lesson • Show lesson objectives	Chart of our universe	Link old knowledge and skill with the new (Newton's first law). To arouse the interest of students Give structure to the lesson Students know what to expect
20 min	• Define force as a push or a pull.	Iron ball and a magnet	To show that objects can exert

	• Pull iron ball with hand • Pull iron ball with magnet without contact • Define contact and non-contact forces and give examples of each (Contact forces: Normal force, Friction, Woman pushing a pram & Non-contact forces: Gravitational force, Electrostatic force, Magnetic force)		force on each other when in contact and sometimes when they are at a distance from each other
30 min	<u>**Identify forces and Draw force diagrams.**</u> • Place book on the table. Identify forces acting on the book. • Draw force diagram for forces acting on the book • Pull wooden block horizontally over the table with the rope. • Draw force diagram for the wooden block. Tell students that force of gravity has effect on any mass	Book, table Wooden block, rope, chalkboard, chalk Wooden	To show that friction between objects at rest is not the same as

	piece. • Define Friction as the force that opposes motion and acts along the common surface between two surfaces in contact. • Distinguish between static and kinetic friction. • Relate friction to normal force. $f = \mu F_N$	block, spring balance	the friction between objects sliding over each other.
20 min	**<u>Newton's First law of motion</u>** • Put the bowl of water on top of the smooth tablecloth and very quickly pull the table cloth from beneath the bowl of water. The bowl of water should not move. • Pose the question, "Why didn't the bowl of water move?" • Get responses from the students • Direct the responses towards the fact that the bowl of water didn't move because not enough force acted on it for it to move. • Put glass filled with water on table.	Table cloth, bowl of water Glass filled to the brim with water	Attract the attention and interest of the students. Lead the students to induce for themselves the first law of motion

	Quickly move the glass over the table and abruptly bring it to a stop.
	• Pose the question, “Why did the water pour on the table at the starting point and the stopping point only?
	• State Newton’s First law.
	• Use above demonstrations to explain Newton’s First law: Eg. Object at rest will like to remain at rest or an object moving with constant velocity will like to continue doing so unless a net force acts on it.
	• In other words, if the net force acting on an object is zero the following will be true:
	  o The forces are at equilibrium
	  o There is no acceleration
	  o The object is stationary or is moving at a constant velocity.
	
	• Ask the students “If something is
			Lead the students to deduce for themselves the first law of motion
			
			Allow students to deduce for themselves the first law.
			
			Engage students

	moving, what must you do to make it stop, speed up, slow down or change direction?" • Get responses from students.		

20 min	**<u>INERTIA</u>** • Define inertia • Relate inertia to real life examples of car breaking, dropping a ball from a moving vehicle, etc. • Relate inertia of an object to its mass. From Newton's 2nd law, we will show that $Inertia = \frac{F_{net}}{a}$ Inertia of an object is the net force required to accelerate the object by 1 m.s^{-2}. The more massive an object is, the greater the net force needed to change its velocity by 1 m.s^{-1} in every 1 s. From the relationship above, we see that the inertia of an object is equal to its mass (i.e. $m = \frac{F_{net}}{a}$; it is measured in kg).		Link the idea of inertia with the first law

Homework	**Exercise** 1. You need to push a box with a force of 100 N across a carpet at a constant speed. What is the magnitude of the frictional force exerted by the carpet on the box? 2. Explain, using laws of physics, what happens when a passenger standing in a bus is thrown forward when the bus stops. 3. According to Newton's First Law A the acceleration of a body is directly proportional to the force causing the acceleration. B the velocity of a body remains constant unless a net force acts upon it. C the sum of the gravitational potential energy and the kinetic energy of a body is constant. 4 Why do we need safety belts in our		To serve as feedback

	cars? 5 Draw a force diagram showing all the forces acting on a box being pulled up on a rough inclined plane.		

D: LESSON PLAN (ACTIVE LEARNING APPROACH)

Topic: Force, Impulse and Momentum

Sub-topic: Newton's first law of Motion

Level: Grade 11

Time: 120 minutes (Active Learning Approach)

Lesson Objectives:

At the end of the lesson, students should be able to, without any reference or notes:

8. State Newton's First Law of Motion as: "If there is no net resultant force acting on an object, then if it is at rest, it will remain at rest and if it is moving with constant velocity, it will continue to do so."
9. Define force as: "A push or a pull." "An agent that tends to change or changes a body's state of rest or its velocity."
10. Define friction.
11. Identify forces acting on an object.
12. Draw force diagrams.
13. Define inertia as: "as an inherent property of an object that makes it disposed to maintaining its state of motion."
14. Relate the inertia of an object to its mass.

Prior Knowledge

7. Distance as the length of a path (route) taken.
8. Displacement as change in position in space in a specific direction.
9. Speed as distance travelled in a unit time.
10. Velocity as displacement in a unit time.
11. Acceleration as the rate of change of velocity.
12. Mass as the quantity of matter in an object

Learner and Teacher Support Materials

Science equipment, Textbooks, Charts, wooden block, spring balance, dynamic trolley, drinking glass, glass bowl, water, Thread, iron ball and a magnet.

Time / min	**Teacher Activities**	**Learner Activities**	**Rationale**
30	**Prior Knowledge Questions** Call individual learners to present their solutions Call for comments on solutions	Learners present their solutions. Learners comment on solutions	
10	**Lesson Opening** • Talk about the planets in our universe and how they are held together by forces that keep them in place and on their paths of motion.	Observe and ask questions	To arouse the interest of students Give structure to the lesson Students know

	Shows chart of our universe to learners. • Show scope of the lesson • Show lesson objectives		what to expect
50	**Asks** • learner to state what a force is. • learner to distinguish between contact and non-contact forces. • Pull iron ball with hand • Pull iron ball with magnet without contact • Define contact and non-contact forces and give examples of each (Contact forces: Normal force, Friction, Woman pushing a pram & Non-contact forces: Gravitational force, Electrostatic force, Magnetic force)	Defines force Differentiates between contact and non-contact forces with their examples	To show that objects can exert force on each other when in contact and sometimes when they are at a distance from each other
		Work in pairs and	

	• Draw force diagram for the wooden block. Tell students that force of gravity has effect on any mass piece. • Define Friction as the force that opposes motion and acts along the common surface between two surfaces in contact. • Distinguish between static and kinetic friction. • Use a spring balance to pull a block of wood over a surface to show difference between μ_s and μ_k. Relate friction to normal force. $f = \mu F_N$	Draw force diagrams of bodies under system of forces. Define friction. Distinguish between static and kinetic friction. Learners use inclined plane To measure coefficient of static friction.	
30	**<u>Newton's First law of motion</u>** • Put the bowl of water on top of the smooth tablecloth and very quickly pull the table cloth from beneath the bowl of water. The bowl of water should not move.	Observe and ask questions Respond	

	• Pose the question, "Why didn't the bowl of water move?" • Get responses from the students • Direct the responses towards the fact that the bowl of water didn't move because not enough force acted on it for it to move. • Put glass filled with water on table. Quickly move the glass over the table and abruptly bring it to a stop. • Pose the question, "Why did the water pour on the table at the starting point and the stopping point only? • State Newton's First law. • Use above demonstrations to explain Newton's First law: Eg. Object at rest will like to remain at rest or an object moving with constant velocity will like to continue doing so unless a net force acts on it. • In other words, if the net force acting on an object is zero the	Respond Respond to question and state Newton's first law. Learners answer the question: If the net force acting on an object is zero what can be said about the object	

	following will be true: o The forces are at equilibrium o There is no acceleration o The object is stationary or is moving at a constant velocity. • Asks students "Why don't we experience perpetual motion in our daily live? • Ask students "If something is moving, what must you do to make it stop, speed up, slow down or change direction?" • Get and correct responses from students. •	and the forces acting on the object? Respond Respond Respond	
30	**INERTIA** • Define inertia • Relate inertia to real life examples of car breaking,	Learners give	

	dropping a ball from a moving vehicle, etc. • Relate inertia of an object to its mass.	examples of inertia in real life.	
	Exercise 1. You need to push a box with a force of 100 N across a carpet at a constant speed. What is the magnitude of the frictional force exerted by the carpet on the box? 2. Explain, using laws of physics, what happens when a passenger standing in a bus is thrown forward when the bus stops. 3. According to Newton's First Law A the acceleration of a body is directly proportional to the force causing the acceleration. B the velocity of a body		

	remains constant unless a net force acts upon it. C the sum of the gravitational potential energy and the kinetic energy of a body is constant. 4 Why do we need safety belts in our cars? 5 Draw a force diagram showing all the forces acting on a box being pulled up on a rough inclined plane.		

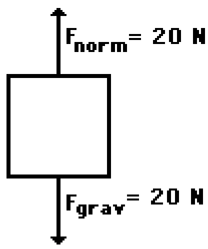
E: SOME PRE-INSTRUCTIONAL QUESTIONS

1. Define the following terms:

Force, contact and non-contact forces, normal force, force of gravity.

2. State, in your own words, Newton's first law of motion.

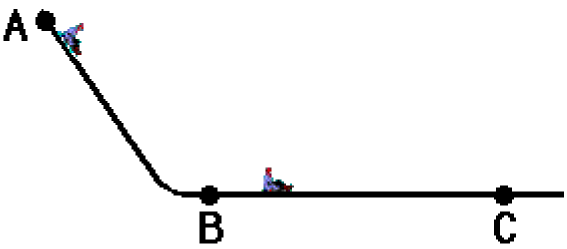
3. Two students are discussing their physics homework prior to class. They are discussing an object that is being acted upon by two individual forces (both in a vertical direction); the free-body diagram for the particular object is shown at the right. During the discussion, Anna Litical suggests to Noah



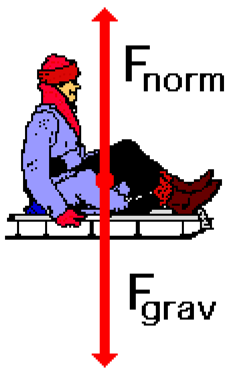
Formula that the object under discussion could be moving. In fact, Anna suggests that if friction and air resistance could be ignored (because of their negligible size), the object could be moving in a horizontal direction. According to Anna, an object experiencing forces as described at the right could be experiencing a horizontal motion as described below.

Noah Formula objects, arguing that the object could not have any horizontal motion if there are only vertical forces acting upon it. Noah claims that the object must be at rest, perhaps on a table or floor. After all, says Noah, an object experiencing a balance of forces will be at rest. Who do you agree with? Explain.

4. Remember last winter when you went sledding down the hill and across the level surface at the local park? (Apologies are extended to those who live in warmer winter climates.)



Imagine a the moment that there was no friction along the level surface from point B to point C and that there was no air resistance to impede your motion.



4.1 How far would your sled travel?

4.2 And what would its motion be like?

F STUDENT ASSESSMENT OF INSTRUCTION: FORM D

STUDENT ASSESSMENT OF INSTRUCTION SYSTEM

THE UNIVERSITY OF TENNESSEE
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211 CONFERENCE CENTER BLDG., 4122
974-4373

FORM
D

DEPARTMENT: ____________________

INSTRUCTOR: ____________________

COURSE NUMBER: ____________________

SECTION NUMBER: ____________________

Use a No. 2 pencil ONLY.
Make no stray marks on this form.
Make solid marks that fill the response completely.

CORRECT: ● INCORRECT: ✓ ⊗ ◒ ⊙

DIRECTIONS: COMPLETION OF THIS QUESTIONNAIRE IS VOLUNTARY.
YOU ARE FREE TO LEAVE SOME OR ALL ITEMS UNANSWERED.

	Excellent	Very Good	Good	Fair	Poor	Very Poor
1. THE COURSE AS A WHOLE WAS:	E	VG	G	F	P	VP
2. THE COURSE CONTENT WAS:	E	VG	G	F	P	VP
3. THE INSTRUCTOR'S CONTRIBUTION TO THE COURSE WAS:	E	VG	G	F	P	VP
4. THE INSTRUCTOR'S EFFECTIVENESS IN TEACHING THE SUBJECT MATTER WAS:	E	VG	G	F	P	VP
5. COURSE ORGANIZATION WAS:	E	VG	G	F	P	VP
6. SEQUENTIAL PRESENTATION OF CONCEPTS WAS:	E	VG	G	F	P	VP
7. EXPLANATIONS BY INSTRUCTOR WERE:	E	VG	G	F	P	VP
8. INSTRUCTOR'S ABILITY TO PRESENT ALTERNATIVE EXPLANATIONS WHEN NEEDED WAS:	E	VG	G	F	P	VP
9. INSTRUCTOR'S USE OF EXAMPLES AND ILLUSTRATIONS WAS:	E	VG	G	F	P	VP
10. QUALITY OF QUESTIONS OR PROBLEMS RAISED BY THE INSTRUCTOR WAS:	E	VG	G	F	P	VP
11. CONTRIBUTION OF ASSIGNMENTS TO UNDERSTANDING COURSE CONTENT WAS:	E	VG	G	F	P	VP
12. INSTRUCTOR'S ENTHUSIASM WAS:	E	VG	G	F	P	VP
13. INSTRUCTOR'S ABILITY TO DEAL WITH STUDENT DIFFICULTIES WAS:	E	VG	G	F	P	VP
14. ANSWERS TO STUDENT QUESTIONS WERE:	E	VG	G	F	P	VP
15. AVAILABILITY OF EXTRA HELP WHEN NEEDED WAS:	E	VG	G	F	P	VP
16. USE OF CLASS TIME WAS:	E	VG	G	F	P	VP
17. INSTRUCTOR'S INTEREST IN WHETHER STUDENTS LEARNED WAS:	E	VG	G	F	P	VP
18. AMOUNT YOU LEARNED IN THE COURSE WAS:	E	VG	G	F	P	VP
19. RELEVANCE AND USEFULNESS OF COURSE CONTENT WERE:	E	VG	G	F	P	VP
20. EVALUATIVE AND GRADING TECHNIQUES (TESTS, PAPERS, PROJECTS, ETC.) WERE:	E	VG	G	F	P	VP
21. REASONABLENESS OF ASSIGNED WORK WAS:	E	VG	G	F	P	VP
22. CLARITY OF STUDENT RESPONSIBILITIES AND REQUIREMENTS WAS:	E	VG	G	F	P	VP

RELATIVE TO OTHER COLLEGE COURSES YOU HAVE TAKEN	MUCH HIGHER			AVERAGE			MUCH LOWER
23. DO YOU EXPECT YOUR GRADE IN THIS COURSE TO BE:	6	5	4	3	2	1	0
24. THE INTELLECTUAL CHALLENGE PRESENTED WAS:	6	5	4	3	2	1	0
25. THE AMOUNT OF EFFORT YOU PUT INTO THIS COURSE WAS:	6	5	4	3	2	1	0
26. THE AMOUNT OF EFFORT TO SUCCEED IN THIS COURSE WAS:	6	5	4	3	2	1	0
27. YOUR INVOLVEMENT IN THIS COURSE (DOING ASSIGNMENTS, ATTENDING CLASSES, ETC.) WAS:	6	5	4	3	2	1	0

28. ON AVERAGE, HOW MANY HOURS PER WEEK HAVE YOU SPENT ON THIS COURSE, INCLUDING ATTENDING CLASSES, DOING READINGS, REVIEWING NOTES, WRITING PAPERS, AND ANY OTHER RELATED COURSE WORK?
   - ○ UNDER 2 ○ 6 - 7 ○ 12 - 13 ○ 18 - 19
   - ○ 2 - 3 ○ 8 - 9 ○ 14 - 15 ○ 20 - 21
   - ○ 4 - 5 ○ 10 - 11 ○ 16 - 17 ○ 22 OR MORE

29. FROM THE TOTAL AVERAGE HOURS ABOVE, HOW MANY DO YOU CONSIDER WERE VALUABLE IN ADVANCING YOUR EDUCATION?
   - ○ UNDER 2 ○ 6 - 7 ○ 12 - 13 ○ 18 - 19
   - ○ 2 - 3 ○ 8 - 9 ○ 14 - 15 ○ 20 - 21
   - ○ 4 - 5 ○ 10 - 11 ○ 16 - 17 ○ 22 OR MORE

30. THE GRADE I EXPECT IN THIS COURSE IS:
   - ○ A ○ D
   - ○ B+ ○ F
   - ○ B ○ SATISFACTORY
   - ○ C+ ○ NO CREDIT
   - ○ C ○ OTHER

31. IN REGARD TO YOUR ACADEMIC PROGRAM, THIS COURSE IS:
   - ○ IN MY MAJOR
   - ○ IN MY MINOR
   - ○ A DISTRIBUTION REQUIREMENT
   - ○ AN ELECTIVE
   - ○ OTHER

32. MY CLASS IS:
   - ○ FRESHMAN
   - ○ SOPHOMORE
   - ○ JUNIOR
   - ○ SENIOR
   - ○ GRADUATE
   - ○ OTHER

33. WHEN REGISTERING, WAS THIS A COURSE YOU WANTED TO TAKE?
   - ○ YES
   - ○ NO
   - ○ NEUTRAL

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G REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Province of the
EASTERN CAPE
EDUCATION

DISTRICT DIRECTOR'S
HOMESTEAD SITE ,2 LIMPOPO DRIVE LAURIE DASHWOOD QUEENSTOWN 5320. Private
Bag X7053 QUEENSTOWN, 5320
REPUBLIC OF SOUTH AFRICA, Website: www.ecdoe.gov.za

Ref.
Enquiries: W.D JONKER
Tel.:0458085712 CELL : 0842510032
Fax:0458588906

TO : Mr I B ABOAGYE

FROM : DISTRICT DIRECTOR

SUBJECT : REQUEST FOR PERMISSION TO CONDUCT RESEARCH

DATE : 15 FEBRUARY 2011

Your letter, undated referring to above matter has reference.

Your request is hereby acknowledged. It will be referred to the office of Mr Heckroodt at the Strategic Management , Monitoring and Evaluation Directorate at Head Office for final approval. We will keep you informed of developments

Yours sincerely

Dr S. LOMBO
ACTING DISTRICT DIRECTOR
QUEENSTOWN DISTRICT

16/02/11
DATE

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PGDP EASTERN CAPE 2004 2014

Ikamva eliqaqambileyo!

Letter of Informed Consent

Title of Study

The effect of An Active Learning Approach on Grade 11 Learners' Achievement in Newton's Laws of Motion: A Case Study in a Selected School in Eastern Cape

Principal Investigator

Name	Mr. I.B. Aboagye
Department	Education
Address	10 Makana Road, Queenstown, 5319
Phone	0823751389
E-mail	ike@exclusivemail.co.za

Background

You are being invited to take part in a research study. Before you decide to participate in this study, it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. Please ask me if there is anything that is not clear of if you need more information.

The purpose of this study is to find out if an Active Learning instructional approach will bring about a better achievement and retention of knowledge in Newton's laws of motion.

Study Procedure

You will be taught Newton's laws of motion using an active learning approach.

Your expected time commitment for this study is 4 weeks, after which you may be expected to write tests, answer a questionnaire and avail yourself for a classroom grouped interview.

Risks

There will be no risks of this study. If you find anything upsetting in the study, do not hesitate to bring it to my notice.

Unforeseeable Risks

There may be risks that are not anticipated. However every effort will be made to minimize any risks.

Benefits

Your active participation in this study will be appreciated since your scores in the test will form part of your continuous assessment marks.

Confidentiality

Your scores on the tests will, however, not be divulged to anyone. Also, your responses to the questionnaire and the interview will be anonymous. Every effort will be made by the researcher to preserve your confidentiality.

Any final publication will not contain your name if you consent to participate in this study. Participants involved in this study will not be identified and their anonymity will be maintained.

Costs to Subject

There are no costs to you for your participation in this study

Compensation

There is no monetary compensation to you for your participation in this study.

Consent

By signing this consent form, I confirm that I have read and understood the information and have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree to take part in this study.

Signature ______________________________________ Date ___________________