The impact of information and communications technology (ICT) in the teaching and learning of kinematics in Grade 11 Physical Science

Kayode Mathews Arowolo

A Research Report

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by coursework and research report

Supervisor: Dr. Fhatuwani J. Mundalamo

Signature: ______________________

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DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Science in Science Education by coursework and research report at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university, nor has it been prepared under the aegis or with the assistance of any other body or organisation outside of the University of the Witwatersrand, Johannesburg. All help received with the preparation and/or presentation of this thesis has been clearly acknowledged on the next page.

Kayode Mathews Arowolo

Signature: ______________________

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ABSTRACT

This research examines the impact of information and communications technology (ICT) in the teaching and learning of kinematics, a section of the high school Physical Science syllabus in Grade 11. The use of simulations in Physical Science teaching served as an intervention. These simulations were used to teach Newton's laws of motion.

In this research, we make use of computer simulations to teach kinematics in Grade 11 in a South African high school. This research uses the constructivist theory of learning which is extended by Vygotsky's (1978) social-cultural theory of learning in which a child is helped to attain his level of potential development. The theoretical framework was formulated in accordance with the work of Vygotsky's (1978) zone of proximal development (ZPD). The simulation was used by the teacher to help a learner reach the level of potential development. The interaction that arises during the use of the simulations by the teacher can bring about some valuable input that other learners will benefit from when they listen to and contribute to the discussions. We use simulations to help the students reach their level of potential development since they are able to visualize the real world, hence making understanding of the concepts easier. The interaction resulting from the use of the simulations can create opportunities for the learner to transform what they can pick from the inter-psychological, which is between the learner, and the peers or the teacher, to the intra-psychological, which becomes a form of internalised learning (Vygotsky, 1978).

A null hypothesis is formulated to help assess the impact on ICT on teaching and learning of kinematics. This is "*the use of CAI (independent variable) does not impact on the teaching and learning (students' achievement) of Physical Science concepts (kinematics)".* The work is guided by the following critical questions:

(i) How does CAI influence the performance of Grade 11 learners in kinematics?

(ii) How does a teacher embrace the use of ICT in the teaching of kinematics to create a pedagogical change from the traditional modes of instruction (teacher-talk method)?

(iii) What are the factors hampering the use of ICT for instructions in Physical Science?

The study used a quasi-experimental research design with a control and an experimental class (with 30 students in the experimental class and 26 in the control group) in one South African high school in the Gauteng province as a case. The two classes formed the groups of average ability in the set (Grade 11) and they were so distributed into the classes based on the previous academic performance in the school. Pretest and posttest were conducted to measure the impact of the simulation instruments developed by *Interactive Physics* and the one developed by the Physics Education Technology (PhET) project based at the University of Colorado at Boulder, Colorado, USA on the performance of the students after the intervention was used in teaching. Classroom observations and post-intervention interviews were conducted to be able to answer research questions 2 & 3.

The data collected from the follow-up interview and classroom observation were coded and analysed using atlas.ti scientific software for qualitative data analysis management and model building. Also, the results of the pretest and the posttest were analysed using t-test and statistical analysis tool available in Microsoft Excel.

Analysis of the pre-test scores shows no statistically significant difference ($p > 0.05$) in the performance of the two groups. Also, the analysis of the posttest scores of the two groups show that there is no statistically significant difference in the performance of the two groups in the test ($t = -0.53375$, $df = 54$, $p = 0.595699$). The interpretation of this analysis is that since the $p > 0.05$, there is no statistically significant difference in the achievement of the experimental and the control groups in the post-test conducted; therefore the null hypothesis which states that "*the use of CAI (independent variable) does not impact on the teaching and learning (students' achievement) of Physical Science concepts (kinematics)"* is upheld.

Analysis of the interviews and classroom observation shows that teachers do not generally embrace the use of ICT in their teaching as a result of many factors one of which is the teacher's attitude and belief in the use of ICT. Teachers generally prefer to use the method they are accustomed to (teacher-talk) rather than learner-centred methods or exploring new grounds that ICT offers.

Factors identified in the study as hampering the use of ICT by teachers are:

- Anxiety about the use of technology:
- Time factor
- Availability of technology
- Pre-service training
- The demand of the curriculum

These factors are consistent with those identified by Stols (2008) and BECTA ICT Research (undated) in their review of what research says about barriers to the use of ICT in teaching.

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Chapter 1: Introduction

The purpose of this research is to examine the impact of information and communication technology (ICT) in the teaching and learning of kinematics, a section of Physical Science in Grade 11. ICT in this context refers specifically to computer simulations. In the context of the study, Physics is regarded as a component of Physical Science with the other component being Chemistry; therefore reference has been made to Physical Science throughout this report although the research was carried out on the Physics component of Physical Science.

Although this research report is not a Physical Science textbook, it is a good idea to examine what kinematics is and the issues around kinematics that students find challenging. **Kinematics** describes the motion of objects without the consideration of the masses or forces that bring out the motion while dynamics deal with the forces responsible for the movement of the objects and reasons why objects move in the way they do. In contrast, kinetics is concerned with the forces and interactions that produce or affect the motion. (Giancoli, 2005).

Much research that has been done in this area of Physical Science indicates that students have some difficulties with understanding the concepts (see for example, Thornton and Sokoloff, 1998). The history of using computer technology for learning is full of promises of improved performance and quick access to information on the one hand and dissatisfactions on the other (Rosenberg, 2001). These promises and disappointments were due to people's belief that the introduction of computers was going to revolutionize the teaching and learning environment (Cuban, 2001). Although computer technologies have gained prominence since their introduction some decades ago and they have permeated every aspect of our lives from communications to financial uses, from space technology to education they have not been effectively implemented in science teaching as a result of various factors ranging from teacher-level and school-level barriers (British Educational Communications and Technology Agency (BECTA), 2003). From the foregoing, it follows that the advantages of computers are enormous for them to be ignored in the teaching and learning of science particularly physics concepts that are considered abstract and difficult to understand by

students as I have observed during my years of teaching and as indicated in literature (see for example, Jimoyiannis and Komis, 2001).

According to Encyclopedia Britannica (2008), the use of computers in education started some decades ago in the 1960's. With the introduction of microcomputers in the 1970's and as they become cheaper and easily affordable, the use of computers in schools has become prevalent from primary schools through to tertiary level of education especially in the developed world such as USA, UK, and Japan (Encyclopedia Britannica, 2008). Computers can provide a means of presenting data or they can be used to test students' understanding if they are used in a tutorial role (Keller, *et al.*, 2005).

Various research studies in computer-aided instruction (CAI) have been conducted on the impact of ICT in education. There is considerable research evidence that learners are more motivated when their learning is supported by ICT (Newton & Rogers, 2001; Trey and Khan, 2008; Finkelstein, *et al.*, 2006). Rotbain *et al.* (2008:54) showed that computer animation "can help students to visualize the abstract concept and processes of molecular genetics by representing the subject matter in a more concrete manner".

Other research findings show that CAI can provide useful learning materials for students which in turn can enhance students' interest in a subject. Trey and Khan (2008:522) combined a computer-based analogy with instructional materials and found that the effectiveness is significant because "it reduces cognitive load". Therefore it is important to combine simulations with other forms of instructional materials.

Research findings (Hartley *et al.,* 2007; Jimoyiannis and Komis, 2001) suggest that CAI can increase a student's access to information because ICT makes more resources available (e.g. the Internet) which in turn enables CAI to increase access to various simulations and visualisation tools. CAI can easily be adaptable to the individual student's abilities and increase the amount of individualized instruction a student receives (http://encarta.msn.com). Research findings (Trey and Khan, 2008; Hartley *et al.* 2007) show that many students generally benefit from the immediate response of interactive simulation and they are pleased with the fact that they can learn at their own pace as they may be able to playback the simulations or visualization tools.

Furthermore, the learning experiences with using ICT often engage the students' interests, thereby motivating them to learn. In a research conducted by Hartley *et al.* (2007), it was reported

> that teachers considered the implementation of CAL in their classes as supportive of their teaching because it served as an additional resource that helped them in their preparation of classes. Computers served as additional tool to their daily teaching. The teachers also see the CAL as helping the students address their academic deficits.

1.2 Definition of concepts

It is necessary to explain some of the concepts used in this research. For example, a clarification of what is meant by ICT in the context of this research needs to be made.

Information and communications technology (ICT) refers to the field that combines computers and digital equipment to accomplish a task. Various computer technologies are now referred to as ICT. Computers are any electronic devices that can store and process data to produce information. This means that there will be some form of input, processing and output. This definition implies that teaching and learning resources such as calculators, microcomputers etc. belong to the group of learning tools called computers.

Initially, the field of computer technology was referred to as information technology (IT) but with the advent of the Internet as a means of global communications, the word 'communications' has been added to IT to become information and communications technology. This highlights the importance of communications in computer-based education or what many may refer to as computer-aided instruction or computer-assisted learning.

In the context of this research, ICT refers to computer simulations which may help to bring learning closer to the students since some of the situations displayed or represented by the simulations may not be readily available in real life.

Computer Assisted Instruction (CAI) which generally refers to drill or practice and tutorials: CAI comes in different forms today and they may be in the form of simulations of questions which provide a feedback to learners as they work through the questions. Also in this group are animated tutorials.

Various terms such as computer-based learning, computer-based teaching, and computer-based instruction are used to describe computer assisted instructions. In this research, I used the term computer-assisted instruction (CAI) to refer to simulations which are used in the classroom for teaching and learning purposes.

Simulation is used in this research report to refer to the program which shows the representation of real life situations and teaching topics that can be presented on the computer. Some of the situations depicted or represented in the simulations may be difficult, if not impossible, to represent with paper or conventional teaching materials. Trey and Khan (2008:522) observed that "student interaction with dynamic, interactive visualizations may contribute to meaningful learning if instructional guidance measures are also incorporated in the technology enhanced experience".

1.3 Rationale for the study

It is common knowledge that computer technology has not been fully utilized and implemented in appropriate, effective and creative ways in education especially in the developing world. The recent South African government efforts to integrate e-learning into the South African curriculum (government's Draft White Paper on e-education, 2003) need to be supported with a research into how the programme can be implemented and the effects such a programme may have on the teaching and learning situations. The White Paper highlights the government's approach to an ICT environment in education. According to the Draft White Paper (2004:17), "the goal of the e-learning is to ensure that every learner is ICT-capable by 2013 (that is, able to use ICTs confidently and creatively to help develop the skills and knowledge they need as lifelong learners), and that all schools are connected to the internet by 2013. Efforts are being made to achieve these goals". The white paper claims that by February 2004, agreements had been signed between the Department of Education and the private sectors, including Microsoft and Symantec (Draft White Paper on e-education, 2004).

If the government is making these efforts, then research should be geared towards how ICT can be fully integrated into teaching and learning and the impact it would have on

teaching and learning science particularly Physical Science concepts which this research is concerned with.

Assessing how effective any educational system is may be a difficult task. Many studies have reported that CAI can increase students' conceptual understanding which may lead to increased examination scores, improved student attitudes, and reducing the amount of time required to master certain concepts (Hartley *et al.*, 2007; Jimoyiannis and Komis, 2001; Windschitl, 1998; BECTA, 2003). There are various study results about the impact of ICT on learning some claiming that it is effective while others claim otherwise, however, there is substantial evidence that CAI can enhance learning at all educational levels (Rotbain *et al.*, 2008; Keengwe and Anyanwu, 2007; Barton, 2005).

This study is important within the field of science education because it is hoped that computers could be used to improve the delivery of instruction as they also had various levels of success in other areas of human endeavour such as the Internet, communications, and banking. Studies conducted elsewhere indicate that huge amounts of money have been invested in equipping schools with computer technologies, but sometimes the positive effect of these technologies in classroom practices and student achievement is not evidence (Zhao *et al.*, 2002). Therefore, this study is of importance in helping to proffer ways of how the computer-based technologies can be appropriately integrated into the teaching and learning of kinematics.

Also, "the poor performance of South African learners in the 1995 and 1999 Trends in International Mathematics and Science Study (TIMSS) tests" (Howie cited in Hartley *et al.*, 2007:2), a decline in the number of those achieving matriculation exemptions in the Senior Certificate Examination and the report of the state of mathematics and science teachers in South Africa (Arnott *et al.* cited in Hartley *et al.*, 2007:2) have all contributed to the fear of what the future holds for South African education. As a result of this, there is the need to look at various ways in which the teaching and learning of science can be enhanced.

Various research suggest that students tend to learn better when they are able to visualize models or real life objects of what they are learning i.e. when learning is made

more concrete to them rather than the teaching in abstract (Trey and Khan, 2008). In Rotbain *et al.*'s, (2008) research on using computer animation to teach high school molecular biology, they found that instruction with animations has the potential of increasing students' conceptual understanding by prompting the formation of mental models of DNA structure. This study will also enable me to encourage my other colleagues in the profession to embrace the use of ICT into the delivery of adequate instruction that will be able to sustain the interest of learners in their various subjects.

This study is important in South Africa because this country cannot afford to take the back seat (while countries like America, UK, Japan, China, Korea etc take the front seat) as far as ICT usage in instruction is concerned. For example, in a study conducted by Park *et al.*, (2008:6) it was stated that "school data available to them revealed that 98% of the students enrolled in the school under investigation had computers connected to high speed Internet at home". In a similar vein, a study by Corbett & Willms (2002) indicates that nearly 9 out of every 10 (88%) of Canadian students have a computer at home, and 8 out of every 10 (80%) use a computer at home nearly every day.

South Africa is making various efforts to incorporate e-learning into the curriculum (government white paper on e-learning, 2003) and every attempt to support this initiative in any form should be welcome. Furthermore, "South Africa's weak showing in the rankings of the World Competitiveness Report and the independent confirmation of the serious shortcomings in science and mathematics education in the Presidential Education Initiative Research Report" (Department of Education, 1999 cited in Hartley *et al.*, 2007) makes this study imperative.

1.4 Aim of Research

In my proposed work, I intend to focus on the impact of ICT in the teaching and learning of Physical Science concepts specifically kinematics. Thus focusing on the general hypothesis, *"the use of CAI (independent variable) does not impact on the teaching and learning (students' achievement) of Physical Science concepts (kinematics)"*

1.5 Research Problem

This research is necessitated because of the perceived difficulty of Physical Science concepts by teachers and students in South Africa. For example, Hartley *et al.*, (2008) reported that there is continued poor performance in science in the South African Matriculation examination. This report is an indication that students may find the subject more difficult than the other subjects. Also as reported elsewhere in this document, 9 out of the 10 students interviewed indicated that they find Physical Science more difficult than all the other subjects they take in school. Much educational research has been directed towards the exploration of students' ideas and difficulties on Physical Science concepts and processes (Thornton and Sokoloff, 1998) and how to help the students in better conceptual understanding of those perceived difficult concepts. In a similar study, Rotbain *et al.*, (2008) reported that the teachers in their study claim that the simulation was helpful for them because they were able to teach the abstract subject matter in concrete way, and it also gave them an opportunity to gain insight into students' learning process.

1.5.1 Research questions

The work will be guided by the following critical questions:

- How does CAI influence the performance of Grade 11 learners in kinematics?
- How does a teacher embrace the use of ICT in the teaching of kinematics to create a pedagogical change from the traditional modes of instruction (teacher-talk method)?
- What are the factors hampering the use of ICT for instructions in Physical Science?

1.6 Limitation

The master's programme is a 1-year full-time study or a 2-year part-time study, as a result this research study is of limited scope and it is expected to be concluded within a time frame of 1 year. The sample size of thirty (30) in the experimental group and twenty-six (26) in the control group is a limitation and the time for the students to use

the simulation is only for a few lessons. The duration of the use and the inability of the learners to directly interact with the simulations are regarded as other forms of limitations which make the results not generalisable.

Other factors such as age of participants, maturation, sex, teacher that may be responsible for conceptual change in the learners are not taken into consideration. Other factors other than the use of the computer simulations to promote conceptual understanding of learners are regarded as independent variables, thus limiting the generalisability of the findings.

Only a few schools in the area of research use computers or technology for instruction therefore the sample had to be taken from the very few schools available, this is therefore considered as a limiting factor because of a small sample size.

Another limiting factor is the appropriateness of the simulation software. The simulations were not designed for the South African curriculum therefore it became necessary for them to be adapted for use in the teaching of Physical Science in a South Africa school. The limitation in this is that much time is spent by the teacher in trying to adapt the software instead of using the software without adjustments.

Another limitation was that there were also no individual question scores for the pretest and posttest therefore it was no possible to analyse how the students performed in each of the test items.

Chapter 2: Literature Review

2.1 Introduction

The current trends in the development of technology and the willingness of the government of South Africa to integrate information and communication technology (ICT) into the curriculum and into the teaching and learning environment led to a review of the current literature regarding the effectiveness of computer-assisted instruction (CAI). This chapter looks into a brief history of the introduction of computers (educational technology) into teaching. After the reviews of the history of computers in education, the chapter examines the reasons why the government of South Africa has considered integrating ICT into the teaching and learning environment especially into the science classroom. The chapter also looks at what the literature say about the impact of ICT in teaching and learning in general, and more specifically in teaching Physical Science.

Despite the perceived effectiveness of computers in teaching, it has been observed that computers and related technologies have not been properly integrated into the teaching and learning environment (Stols, 2008). An attempt is made to examine the various obstacles to the integration of computers into teaching, which have been identified in the literature.

In this chapter I will explain the theoretical framework that guided the study. Theoretical frameworks generally provide the lenses with which the researcher sees and analyses the data and subsequently draws findings. The specific type of ICT being used in this study is ‘simulation’ and hence its use in the school environment is discussed.

Conceptual change is relevant to this study because the introduction of an intervention into the classroom is intended to create some form of conceptual understanding in the learners based on their prior knowledge as opposed to their alternative conceptions. A discussion of conceptions and conceptual change follows.

2.2 History of information and communication technology (ICT) in science education

According to Murdock (2004) the history of technology in the classroom dates back to 1951 when television basically was used in the United States primary schools. In 1958, the National Defense Education Act of US brought some new technology into schools, but primarily in vocational education. The 1960's saw some growth in the usage of technology in the classroom in the United States as more money was being set aside for that purpose. For example, in 1963 the Vocational Education Act was passed with more money supporting the use of technology in schools. With the manufacture of the first personal computers by International Business Machines (IBM) in the 1980's drill and practice, computer-assisted instruction (CAI) gained acceptance in schools; and the first educational drill and practice programs are now developed for personal computers.

The 1990's saw the development of multimedia PCs and simulations, educational databases and other types of CAI programs are being produced on CD-ROM disks, many with animation and sound (Murdock, 2004). There was proliferation of web pages as the Internet and the World Wide Web began to gain ground. Many schools in the US started introducing graphics and multimedia tools for the delivery of information and instruction using the Internet. During this time more educational software were being packaged in CDs and DVDs (Murdock, 2004).

There is little available in the literature about the history and development of computers in the classroom in Africa but the presence of Zietsman's (1984) master's research report which evaluated diagnostic and remedial aspects of a microcomputer program on speed in South Africa is an indication that technology and computer simulations have been in use in South African schools as far back as that period (1984). South Africa witnessed an increase in the use of technology in the classroom following the government's White Paper in 2004 titled "Transforming learning and teaching through information and communications technologies". The Department of Education sets a framework for the collaboration of government and the private sector in the provision of ICTs in education through the white paper (Government White Paper on e-education,

2004). The Department of Education believes that ICTs "have the potential to improve the quality of education and training".

Today there are many instructional materials for teaching science and other subjects that are available on the World Wide Web.

2.3 Access to technology in education

Hartley *et al.* (2007) observed that there has been increased access to ICT in the educational environment which now creates a number of challenges to educators who are interested in making use of these tools in their daily teaching. This increased access has posed challenges in the sense that there are now many technologies and instructional materials available which require that the teacher be competent and comfortable in their use before he is able to incorporate them into his teaching. One of the challenges that comes to mind is the issue of 'choice of technology and instructional material among the many that are available in the market' and integrating ICT into the teaching and learning process. Other "researchers report that these developing technologies (ICTs) can illuminate the structure of complex scientific phenomena that have been difficult for students to understand using traditional modes of instruction clearer" (Lavonen et al.; Snir *et al.*,; Soderberg, cited in Hartley *et al.*, 2007). The implication of these reports is that ICT, if properly used, helps the students to construct knowledge.

Given the difficulties in Physical Science concepts, Gilbert *et al.* (2003) recommend enhancing the teaching of concepts through educational methods that integrate modeling and visualization as opposed to the traditional teaching methods. The National Science Foundation (2001) in the United States of America as cited in Rotbain *et al*. (2008: 1) states that

> visualisation tools such as animations can be used to give an accurate and rich picture of the dynamic nature of molecules and molecular interaction, which are often very hard to grasp from text-based presentations of information.

This position of the effect of visualisation in learning molecular biology is consistent for Physical Science concepts as observed by Finkelstein *et al.* (2006) in their study of

the effect of substituting computer simulations for laboratory equipment. The image extends to the integration of ICT, such as computers, in science education.

2.4 Effectiveness of Computer-Assisted Instruction in Science Education

There are divergent opinions and research findings on the effectiveness of CAI in science teaching. Some researchers submit that CAI does not have a significant impact on the achievement of students in Physical Science while others indicate that CAI is effective in the teaching and learning of science. This section examines the divergent opinions on the effectiveness of CAI.

2.4.1 Literature that supports the effectiveness of CAI

Bayraktar's (2001) large-scale meta-analysis of the effectiveness of CAI in science education which was conducted to determine the overall effectiveness of CAI on student achievement in secondary and college science education in the United States between 1970 and 1999 when compared to traditional instruction reported that secondary students' achievement in science improved when CAI was used. Bayraktar's (2001) meta-analysis from 42 studies indicated that a student's achievement level improved from the 50^{th} percentile to 62^{nd} percentile when CAI was used in science teaching. This meta-analysis is of significance to this study because it examined those studies that utilized experimental and quasi-experimental methods in their research. The meta-analysis found simulation in science content areas to be the most effective of the three types of CAI being considered. Bayraktar (2001) found that physics had the largest mean effect and concluded that CAI was most effective in physics compared to the other science subjects (chemistry, biology and general science).

Webb (2005) suggests that one way to bring about conceptual change in learners is by using CAI which is interactive and contains graphical user interfaces (GUI) and scientific visualization for understanding concepts in science. According to Khan (2005) cited in Park *et al.* (2008: 6) "computers can generate patterns, animate particles and processes, and display trends that trigger dissatisfaction with a prior concept, support the plausibility of a new idea, and suggest intelligibility and fruitfulness of this idea". This implies that computers can be used to generate different simulations and

visualization tools which can make more sense and appeal to the students by explaining concepts better thereby resulting in discontent with what they already know and students would be willing to change their prior concepts. Khan (2002) cited in Trey and Khan (2008:519) found that "using computer simulations in instructional contexts" gives students the privilege of increasing their conceptual understanding of those phenomena that they cannot ordinarily see in the real world.

Trey and Khan (2008) studied the effect of computer-based analogies on students' learning of unobservable phenomena and found that there was significant relationship between instructional computer simulation and the achievement of students in the content taught. Students who were taught using the computer simulations performed better (90%) than those taught (68%) with non-analogical computer simulation. This result indicates the effectiveness of computer simulations when combined with other modes of instructional strategies such as analogies, and method of inquiry being proposed by McDermott *et al.* (2000)**.**

Park *et al.* (2008) studied the effect information and communication technology (specifically CAI) in science education on the achievement of Korean middle school students and found significant difference ($t(233) = 2.401$, $p = 0.017$) in the achievement level of the control and experimental class. This implies that there was a significant difference in pre- and post-achievement level of students after the computer-assisted instruction was carried out. The pre-achievement test was conducted after the computer-assisted instruction was implemented in the classroom. Students performed better after CAI was implemented in their class for the experimental group while there was no statistically significant difference in the achievement level of the control group in pre- and post-achievement tests (Park *et al.,* 2008).

Rotbain *et al*. (2008), in their research which focuses on the use of computer animation to teach high school molecular biology found significant difference in the achievement level of the experimental and control group in the various sub-topics covered by the study. The experimental group performed better than the control group which is an indication that the computer animation results in better conceptual understanding. Also the work of Jimoyiannis and Komis (2001) provided supportive evidence that the use of

computer simulations in physics teaching and learning is effective in raising students' achievement levels because they found significant difference between those students who engaged with the simulation software and those who did not.

From the foregoing, it follows that there is substantial evidence available in literature to indicate that CAI is effective in the teaching of science concepts.

2.4.2 Literature that do not support the effectiveness of CAI

There is still debate on the question of whether ICT has made significant impact or not on students' achievement. Many research findings report that there is significant impact while other studies show that ICT does not have much significant impact on students' achievement in science. This disparity may be due to assumptions that many research studies make and the degree of reliability and validity of some of the research methods used (Cox and Marshall, 2007).

Though many research work claim that CAI is effective in the teaching and learning of science concepts, the work cited below did not find any significant difference between students taught with CAI (experimental group) and those who used the traditional method of instruction (control group).

Hsu and Thomas (2002) conducted a research on 117 students divided into three groups (with-log group, the without-log group and the control group) and reported that there were no significant differences on post-test scores of the three groups. They found that the follow-up interview reveals that although there were no significant differences in achievement levels, the students in the experimental group report that the simulation used supported their learning because they could complete the given exercises on time.

Also, in a meta-analysis on the effectiveness of CAI in science education conducted by Bayraktar (2001), it was reported that only one out of the forty-two (0.023%) studies reviewed showed no significant difference between students taught using CAI and those that were taught using the traditional instruction methods in terms of the achievement level. The implication of this finding is that CAI is beneficial because only one study

reported that there was no statistically significant difference in the achievement levels of the control and experimental groups after the use of the CAI.

Furthermore, it can be deduced from the report in the meta-analysis that there is dearth of research reports that claim that there is no significant difference in the achievement levels of the experiment and control groups. This explains why there is limited research literature reported in this section of my work.

2.5 Obstacles to the use of technology in teaching

I decided to include this section in my literature review because of one of my research questions which examines the factors that impede the use of technology in instruction even though various research suggest that CAI is effective in instruction. Information and communications technology (ICT) play a very important role in teaching but they have not been effectively incorporated into teaching in South Africa as a result of the following factors identified in the literature. My aim is to see if the outcome of my study will be consistent with these factors.

1. *Teachers' perception about the significance of computers*: some teachers do not see computers and technology to be of any significant use or having any significant impact on learning and therefore do not see the need to incorporate them into their instruction. BECTA ICT Research (2003) also identified this barrier to the use of ICT in their review of what research says about barriers to the use of ICT in teaching.

2. *Teachers' attitudes*: teachers' attitudes to the use of technology are obstacles because if a teacher does not have a positive attitude to the use of ICT, he is not encouraged or disposed to using it in his teaching and does not spend the necessary time required in incorporating it into his teaching. BECTA ICT Research (2003) reported that Fabry and Higgs (1997) classified attitudes into three groups: "self-confidence with ICT, perceived relevance of ICT and innovativeness". Closely related to the teachers' attitudes is their resistance to change. Many teachers do not want to leave their comfort zone.

Fabry and Higgs (1997) identified resistance to change as one of the obstacles to technology usage in instruction. Studies show that some teachers are not easily adaptable to change because they simply want to continue with their traditional or "long-standing pedagogical methods" (Snoeyink & Ertmer, 2001) of teaching even when it is generally perceived and reported in literature that ICT has significant impact on learning (Toprakci, 2006). Fletcher-Flynn and Gravatt (1995) in their meta-analysis of the efficacy of CAI also identified this factor as a barrier.

Teachers do not know what the change holds for them so they simply stick to their traditional methods of teaching. Russel and Bradley cited in British Educational Communications and Technology Agency (BECTA) ICT Research (2003) identified factors such as "fear of embarrassment when using computers" and "fear of losing professional status" which may cause anxiety and stress for the teacher when using technology.

Hew and Bush cited in Stols (2008, no page number) "examined barriers effecting teachers' use of technology for instruction and identified attitudes and beliefs about teaching, learning, and technology as one of the six main categories of barriers".

3. *Teachers' training*: teachers do not have the requisite training to be able to use technology in their classroom. Guha in BECTA ICT Research (2003) identified time and training as major obstacles to technology usage in instruction. Many pre-service teacher training courses do not prepare teachers to incorporate technology in their teaching. Teachers who do not have adequate training in the use of technology find it difficult to commit any more time to doing personal training and for preparing ICT resources for lessons (Preston *et al.* cited in BECTA ICT Research (2003)).

4. *Cost*: a major obstacle to the use of technology in instruction is the cost involved in procuring the technology – hardware, software, installation, services etc. Maintenance involved in the technology is also an issue here. Only a few schools (especially in Africa) can afford the technology which is considered to be technologically disadvantaged compared to the Western and Asian countries. For

example, Oppenheimer (1997) reported that New Jersey spent $10 million on classroom computers. Not many school districts or education departments can afford such a budget on computers alone. This factor results in shortage of equipment.

5. *Choice of technology*: there are many technologies available, especially software, that teachers find it difficult to choose the one that is appropriate for their classroom. As noted above, the time required making choices between available technologies and adapting this technology to their instruction is enormous. The time to do this, many teachers claim, is not available. Fabry and Higgs (1997) reported that teachers ranked time among the barriers inhibiting the integration of computers to teaching.

6. *Access to computers*: research show that many computers have found their way into the classrooms especially in the United States and UK. For example, Fabry & Higgs (1997) report that Apple Computers started a project called Apple Classrooms of Tomorrow as far back as 1985. In spite of this, access to computers is still an issue. Fabry & Higgs (1997) noted that access "involves locating the proper amount and right types of technology where teachers and students can effectively use them". If teachers have access to the internet and other resources within and outside the school then they may be able to locate relevant materials for teaching. Also, some of the technology resources that are accessible are not appropriate for use in the classroom.

7. *Learners' technology skill*: the learners' technology skill could also constitute an obstacle. Research shows that many students especially in the rural areas and disadvantaged schools do not possess the necessary skills to use technology therefore the teacher needs to train them in using the technology before actually using it for his lesson. The Scottish HM Inspectorate of Education (2004:3) observed that "the pupils' ICT skills should complement pupils' ICT-based coursework in a wide range of subjects".

8. *Obsolete equipment*: BECTA ICT Research (2003) identified the obsolescence of software and hardware as one of the obstacles to the use of technology in instruction. In a field that much of one's knowledge and available hardware and software resources become obsolete before you have mastered the use of the technology, then this factor is a major obstacle. It is a painful experience to acquire expensive technology and later on find that it becomes obsolete after a few years.

9. *Demographics*: Literature indicates that age and gender affect the rate of use of technology in instruction. For example, van Braak, (2001:42) reports that "males seem to be more involved in computing and have more favourable attitudes towards technology than females".

10. *Organization constraints*: The organization in which one works can affect a teacher's interest or motivation to use technology in instruction. For example, if the management shows commitment to the use of technology and encourages the teachers to integrate technology in their teaching, the teachers are likely to use technology in teaching. van Braak, (2001) notes that "teachers cannot use technology if they lack training, time and support". If the organization or management provides some form of support to the teachers such as organizing training programmes, and providing the enabling environment, teachers are more likely to incorporate technology into teaching.

2.6 Conceptions and conceptual change

Many studies have been conducted on the use of Information and Communications Technology (ICT) in teaching and learning in general and specifically in science education. It is believed that students learn better when they construct their own knowledge by forming mental pictures or framework of the concept. Computer-Aided Instruction (CAI) designed in line with the constructivist theory has been helpful resource to educators. Zacharia and Anderson (2003:1) studied the effects of an interactive-based computer simulation prior to performing inquiry-based experiments

on students' conceptual understanding of physics and found that simulations promoted a major conceptual change "in the physics content areas that were studied"

Webb (2005) observed that results from various studies indicate that children usually develop their own theories which they use to explain various natural occurrences around them though the theories may not be consistent with scientifically accepted theories. The alternative conceptions that students possess often require some form of constructivist approach to pedagogy so that they can construct plausible ideas (Webb, 2005). These theories which students develop may be as a result of their daily experience of some phenomena or what they are being told by their friends and colleagues in school. Such alternative conceptions become etched in their conscious minds such that they will require some other conceptions which are strong enough to make them change their previous conceptions.

Many research studies have been conducted on the constructivist learning theory and the position that constructivists normally adopt in learning. According to Cobb (1994); Denver *et al*. (1994); Lin & Hsieh (2001) cited in Park *et al.*, (2008), "constructivists generally adopt the position that knowledge is not received, accumulated and stored, but instead acquired through a process that involves active interaction of learners with their physical and social environment and a constant reorganization of mental concepts and structures".

Zacharia & Anderson (2003) suggest that for a physics instruction to be effective, it should embrace the kind of learning that leads students to better conceptual understanding whereby the students are able to construct their own knowledge. In this way students can be involved in collaborative and interactive tasks that will help them in constructing conceptual understanding.

Park *et al.*, (2008) noted that one of the ways of ensuring conceptual change in science education is to give students the opportunity to experience science concepts through laboratory activities and to link the concepts to everyday life. Conceptual change learning theorists believe that knowledge is personally and socially constructed (Driver, 1989; Vygotsky, 1978). This implies that the individual learner is responsible for his/her own learning, which can only take place if the learner is able to construct new

understanding on previous experience possibly by restructuring the existing knowledge. Computer simulations can be used in a way that makes the students to be involved in knowledge construction which invariably may result in conceptual change. Webb (2005:709) noted that “some studies of the use of ICT-based simulations and modeling software have focused on promoting conceptual change and confronting specific alternative conceptions”

In looking at how to bring about conceptual change in learners, Scott, Asoko and Driver cited in Georghiades (2000:121) provide for two main groups of strategies which are “strategies based on cognitive conflict and the resolution of conflicting perspectives, and strategies which build on students’ existing ideas and gradually extend to new domains”. I will use the second grouping, where emphasis is placed on the design of appropriate intervention by the teacher, rather than on the role of accommodation by the learner, in my research. Another way of promoting conceptual change in learners is by using interactive multimedia with computer graphical user interfaces which provides a learning environment useful for teachers and learners of science (Ardac and Akaygun; Hansel *et al.*; cited in Hartley *et al.*, 2007).

For conceptual change to occur in learners many researchers suggest that there has to be some cognitive conflict in the learner whereby the existing preconceptions or alternative conceptions, as they may be called, are confronted with some form of new conceptions where learners are able to make choices between the concepts based on which is more appealing (Georghiades, 2000). According to Georghiades (2000:121) “different models of conceptual change learning are available in the literature such as the one put forward by Nussbaum & Novick (1981) which involves the teacher first making the students aware of their alternative conceptions, presenting some form of evidence which does not fit the conceptions thereby making the students become dissatisfied and then presenting the new conception which is based on acceptable scientific theory; and that advocated by Strike & Posner (1985) where new conceptions have to be “intelligible, plausible, and fruitful to the learner”.

2.7 Theoretical Framework

This study is framed by the constructivist theory which originated from Piaget (1978) but extended in some way by Vygotsky's (1978) zone of proximal development. In other words, this study is guided by the social constructist theory which was first thought of by Vygotsky (1978). In a constructivist approach to learning, students learn new concepts by building on their prior understanding through a series of "constrained and supportive explorations" (von Glasersfeld, 1989). Furthermore, students often build (virtual) objects in the simulation, which serves to motivate, ground, and support their learning (Papert and Harel, 1991). Erickson (2001:7) notes that constructivism has been helpful in recognizing that "all learners are capable of constructing plausible conceptions while engaging with their physical and social worlds".

Cognitive constructivism is associated with the theory that meaningful understanding has as its basis real life experiences since each person is able to make his/her own mental models to create room for new experiences (Department of Elementary Education, NCERT, 2005). In a constructivist learning environment the role of the teacher is to facilitate learning rather than being a source of knowledge as opposed to the traditional teaching method in which the teacher passes knowledge to the learners, that is, the teacher is viewed as the fountain of knowledge (Ng'ambi & Johnston, 2006). According to Ng'ambi and Johnston (2006) the constructivist learning environment is viewed as complementary to the traditional learning environment. In the constructivists theory students' responses are not disregarded but considered as their alternative conceptions which may form the framework for new conceptions.

According to Khine (2003) students should not be left alone to explore but rather the teacher should serve as a guide or facilitator to students' knowledge construction as they use simulations or learn in ICT-mediated learning environment so that they do not get lost as they make an effort to construct knowledge.

In extending the constructivist perspective to teaching and learning, Vygotsky (1978) came up with the concept of zone of proximal development (ZPD) in which he identified two developmental levels in a child: the level of actual development and the level of potential development. According to Vygotsky (1978) the level of actual

development is the level of development that the learner has already reached, and is the level at which the learner is capable of solving problems independently. The level of potential development is the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers, where conditions are created that allow for learning beyond where the learner can get to on their own.

According to Brodie and Pournara, (2005:41-42) "the ZPD is a transformative space where learning and development happen, in collaboration with a more capable other, a peer or teacher. The ZPD is created through interaction where communication enables participants to shift their understanding and to internalize ways of speaking and representing ideas which further mediate their thinking". This theoretical framework will be utilized in this study through the use of simulations by the teacher to create an environment that will possibly help the learners to reach their level of potential development which Vygotsky's (1978) work suggested can be reached by the help of a teacher or a more capable peer. In my experience as a science and technology teacher I observe that, computer simulations and visualization tools can serve as tools to help learners attain the level of potential development because the simulation tools enable the learners to comprehend beyond what they ordinarily have been able to comprehend. Also, I observed from my teaching experience that any tools that allow learners to share their understanding in such a way that they are able to discuss their understanding and conception in the classroom can aid general understanding and the construction of knowledge. Simulations can help learners to discuss in a collaborative way in the classroom (Jimoyiannis & Komis, 2001).

2.8 Simulations and models

Jimoyiannis and Komis (2001: 185) see simulation as a tool which can "provide a bridge between students' prior knowledge and the learning of new physical concepts, helping students develop scientific understanding through an active reformulation of their alternative conceptions". They noted that "simulations can provide learning environments that enable students to isolate and manipulate parameters whereby they are able to see the effects of such manipulations". Simulations can be used to create

different collaborative classroom activities where the learner can be helped to reach the level of potential development. Similarly, conceptual change theory (Hewson, 1992) “suggests that changes can be fostered when a new conception is intelligible and plausible”.

Simulations help the students to visualise the real world hence making understanding of concepts easier. Simulations can be used where phenomena cannot be observed and explored in the real world. Trey and Khan (2008) used simulations in her study to help students observe a phenomenon which cannot be observed in the real world and found that students achieved better after the instruction. However, Ng’ambi and Johnston (2006) note that using technology alone does not guarantee learning in a constructivist environment.

Simulations can be used in many different ways in the teaching and learning environment. They may be used in conjunction with or to augment teacher chalk-talk or demonstration activities. As a result of this, they can be adapted into a number of pedagogical reforms found in Physical Science classes, such as “Interactive Lecture Demonstrations” (Thornton & Sokoloff, 1998) or “Peer Instruction” (Mazur, 1997).

Sewell *et al.* and Windschitl cited in Rotbain *et al.* (2008) argue that

> Interactive models can address core ideas in a visually engaging way that makes them accessible to students with vastly differing learning styles. Computer animations and modeling incorporated into interactive simulations can offer the user a chance to manipulate variables in order to observe the effect on the system’s behaviour.

Berenfeld *et al.,* (2004) noted that when students work with the models and concrete object, it is more likely that they will remember and transfer their learning to new situations. This is an indication that knowledge has been constructed which is in line with my theoretical framework of social constructivism which is based on the premise that the learner takes responsibility for his own learning as a result of his interaction with the environment and the people in the environment. The simulation is to be used in helping the learners with knowledge construction whereby they make their interpretations of the interactions with the simulation software.

Windschitl (1998), in his practical guide for incorporating computer-based simulations into science instruction, reported that many teachers have found virtual learning environments to be powerful and indispensable tools for developing conceptual understanding.

In their research, Rotbain *et al.* (2008:54) reported four major advantages from the students' perspective of working with computer animation.

> "The first one is that the activity helped the students to visualize the abstract concepts and processes of molecular genetics by representing the subject matter in a more concrete manner. Secondly, it enabled them to work individually in their own time, to run the animation over and over as much as they needed, while controlling the pace of the simulation. Also, the individual animation activity freed the teachers to move between the students and give them direct feedback as they worked. The last of the advantages was the contribution of the activities to the diversification of the lessons and the interactivity and the immediate feedback of the animation".

There needs to be proper planning in the use of ICT if the expected learning outcome is to be achieved. Tolmie (2001) noted that the same technology or software may have unexpectedly diverse effects, according to specific context. If the objective is to exercise some control over outcome, then the conditions for use of the technology need to be planned for within its design and implementation. In order to do this, the research needs to collect data on how outcomes may be affected by the interaction between the technology and where it is being used (Hartley *et al.*, 2007).

This chapter examined a number of literature related to the use of information and communication technology (ICT) in the teaching of science as well as those factors that hinder the use of technology in the teaching and learning environment as situated in various literature. Furthermore, the chapter examined the impact of ICT in the teaching and learning of science and examined the general effectiveness of ICT. The framework that guided the study was also discussed and the chapter concluded by examining simulations and models in science teaching.

The next chapter looks at the methodology applied in the research and explains in detail the participants, instruments, data collections, and analysis.

Chapter 3: Methodology and Research Design

3.1 Introduction

This chapter describes the methodology adopted in carrying out the research. It describes the instruments that were used in collecting data. In this chapter, an attempt is also made to describe the method adopted for analysing the data collected. Finally, the ethics procedure followed was described.

3.2 Research Design

This study combines both quantitative and qualitative techniques. This is consistent with many other research studies, for example, Dawson (2008) used both questionnaire and teacher interview to collect data for a study in which he examined the use of ICT by early career science teachers in Western Australia. The research design used in this study is a quasi-experimental pretest-posttest method which involved an experimental group and a control group. This method was used for the collection of data. Although, quasi-experimental research design is used, the study is a case study of a school with computer facilities.

"A quasi-experimental research design is an experimental design that does not meet all requirements necessary for controlling influences of extraneous variables" (HCC Education Digital Library, retrieved on 10/11/08). From this definition, it follows that the researcher may not be able to control some variables in the experiment as opposed to an experimental study where the researcher has control of the variables involved. For example, in an experimental study, the researcher may be able to allocate participants to various groups (experimental or control groups). This is not the case in a quasi-experimental research design.

According to the HCC Education Digital Library, retrieved on 10/11/08 "quasi-experimental research design is a type of experimental design where random assignment of participants to groups is not employed for either ethical or practical reasons, but certain methods of control are employed and the independent variable is manipulated".

According to the World Health Organisation's (2001:55) Health Research Methodology guidebook:

> the experimenter (investigator) has control of the subjects, the intervention, outcome measurements, and sets the conditions under which the experiment is conducted particularly the investigator determines who will be exposed to the intervention and who will not.

In this study, the researcher carried out a quasi-experiment, in which the performances of participants in control and experimental classes were used to establish and explain the impact of ICT to science education. My study focused particularly on the teaching and learning of kinematics in a Grade 11 class at a high school in Gauteng Province, South Africa. Quasi-experimental research designs can provide information about participants' changes and give a reliable picture of achievement before and after an intervention (Gribbons and Herman, 1997).

There are various design methodologies as outlined in educational research literature (Opie, 2004; Neuman, 1994), with each of them having advantages and disadvantages. These advantages, peculiarities and disadvantages determine what technique to adopt for any planned research and depending on the questions to be answered (Opie, 2004). According to McMillan & Schumacher (2001:87), the peculiarities of the different techniques for data collection should guide the researcher in "selecting appropriate method for gathering of information". Some of the techniques for data collection include achievement test, questionnaire, interview, and observation (McMillan & Schumacher, 2001).

The procedure followed in this study is captured in the flow chart below. This diagram represents the procedure that should be followed in an experimental design and has been adapted for my study. The first stage in an experimental design is to determine the target population out of which there could be a random sampling or consent to determine those that would be part of the experimental group. In this study, after identifying the school where the study was to be conducted, I discussed with the head of the science department to determine a suitable group for the experiment and based on the reason that the two classes identified are of similar academic ability we decided to

work with them. The other two groups of Grade 11 were excluded from the study so they formed the non-participants' group.
The class taught by the head of the department of science (Grade 11C) served as the experimental class and the Grade 11D served as the control class.

The stage which deals with randomized allocation of participants into groups was not applied in this study because the intention was to go with the school's programme rather than disrupt it in any way. The pre-test and posttest results were compared in order to determine the impact of the intervention on the groups that participated in the study. This procedure, as outlined by the World Health Organisation (2001), guided study.

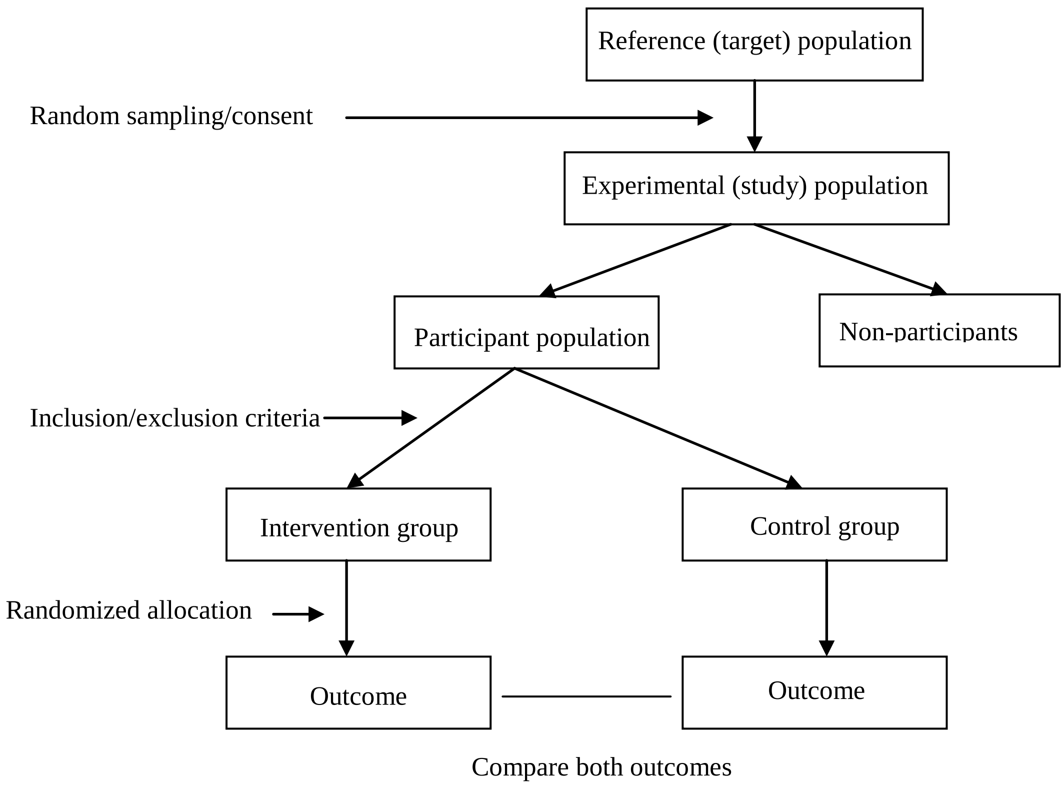


Fig. 3.1: Procedure in an experimental study
Source: World Health Organisation (2001:57)

3.2.1 Dependent and independent variables

In this study, the dependent variables are: the students' achievement or performance, the learning outcome and the attitudes or perception of the students about the integration of ICT in Physical Science instruction. The learning outcome and students' achievement were measured before and after the use of the simulation to determine or assess the impact of the simulation on the learners.

"The independent variable is the variable that is assumed to cause or influence the dependent variable(s) or outcome. The independent variable is manipulated in experimental research to observe its effect on the dependent variable(s). The name treatment variable is used for the independent variable because it serves to test the effect of the variable on the outcome (which is the dependent variable). The independent variables identified in my study are: age, gender, and the teaching method used (between the traditional methods and the intervention i.e. the simulation. The teaching method was varied and the effect of this variation on the achievement or performance of the students was observed and measured using the design of pre-test and posttest instruments.

3.2.2 Instruments used for data collection

I used three instruments to collect data in my study. They are achievement test (pre-test and posttest) for students, observation of computer lessons and interviews for students and teachers as follow-up to the observation of the lessons. This is consistent with the method adopted by Hartley *et al.* (2007) in their study which focused on the application of computer-assisted learning strategy in science and mathematics for disadvantaged Grade 12 learners in South Africa. They used classroom observation and interviews to collect data necessary to assess the effectiveness of the CAL strategy. The pretest and posttest (Appendix P) consisted of multiple choice items and short answer items on kinematics. The items in the pretest and posttest for students were developed and adapted from three sources: (a) from South African's matriculation past exam papers in Physical Science and (b) from the teachers' question bank. The researcher collaborated with the teachers to grade the test in order to ensure that grading was appropriate.

The interviews for teachers and students enabled the researcher to gather data about students' experience during instruction and about the simulation's contribution to their learning as well as about the teachers' perception on the use of ICT during kinematics instruction.

The justification for the chosen instruments is that there is no other more reliable and valid method which could be used in such a study which examines cause-and-effect relationships. Other similar studies have used the same instruments (Yotbain, Marbach-Ad & Stavy, 2008; Sorensen *et al.*, 2007; Park *et al.*, 2008). Although many of these studies make use of questionnaires, questionnaires are not problem-free as Bell, cited in Opie (2004:95) noted that a "questionnaire can provide answers to the question, What? Where? When? and How? but it is not easy to find out why? Causal relationships can rarely if ever be proved by the data collected through a questionnaire. The main emphasis of questionnaires is on fact-finding".

The interview method is chosen as one of the research methods in this study because it has the potential to help the researcher answer his second and third research questions. The interview method can be used to elicit the 'Why' of a problem because it allows the interviewer to probe further for clarifications (Opie, 2004). According to Opie (2004:111), "interviews can encourage respondents to develop their own ideas, feelings, insights, expectations or attitudes and in so doing "allowing respondents to say what they think and to do so with greater richness and spontaneity"

Other instruments such as classroom observation and interview schedule are only supportive to the quasi-experimental design in this research. This is because they do not fit exactly to the specific need of data collection in this study since the study involves the measurement of the impact of an intervention on the performance of learners as a result will require the administration of some tests to determine the effectiveness of the instrument and a single method is not appropriate to help me in answering all the research questions. Park *et al*. (2008) utilised quasi-experimental research design in their study which involves the measurement of the impact of ICT in science education. The quasi-experimental method was combined with questionnaire method in Park *et al*'s (2008) study and this enabled them to gather data necessary for their study.

In addition, the semi-structured interview enabled the researcher to follow up on the responses and data gathered from the pretest and posttest and observation. He collected data from two Physical Science teachers. One of the teachers was the teacher in the experimental group while the other teacher was in the control group during the study. Three students from the control and seven from the experimental were interviewed method. The researcher interviewed the two teachers on their perceptions on the use of ICT in instructions and on the factors hampering their use of ICT in their Physical Science instructions. Teachers were asked a list of semi-structured questions surrounding the factors (third research question) that may influence their use of ICT (Dawson, 2008). Also teachers were required to respond to some questions bothering on teachers' use of ICT and their background training in ICT. The interview questions for both the teachers and the students were adapted from Dawson (2008).

The researcher used a suite of computer simulations from the Physics Education Technology (PhET) project, University of Colorado at Boulder, Boulder, Colorado, USA and simulation software developed by *Interactive Physics* based in the United States of America as intervention instruments. The PhET simulations are freely available on the Internet at http://phet.colorado.edu. These instruments have been used in similar studies and they have been adjudged as being valid and reliable. For example, Jimoyiannis and Komis (2001) used *Interactive Physics* simulations in their study which examines students' understanding of trajectory motion and found that students who used simulations performed better than their counterparts who did not use simulations. Also, the PhET simulations were used by Finkelstein *et al.* (2004) in their research paper titled "Can computer simulations replace real laboratory equipment?" Their conclusion was that simulations can replace real lab equipment because the students mastered the concepts better and they showed greater skills in assembling circuits after the simulations have been used.

The researcher observed the simulation software being used by the Physical Science teacher in the experimental class. The PhET simulations (sims) according to PhET are "animated, interactive, and in game-like environments where students are able to learn through exploration". According to Perkins *et al.* (2006:1) "in designing the

simulations, emphasis is placed on the connections between real-life phenomena and the underlying science, and the simulations seek to make the visual and conceptual models of expert physicists accessible to students".

Prior to the administration of the instrument, training was given to the teacher of the experimental group on how to use the instrument. The researcher showed the teacher in the experimental group how the simulations work after they have been installed on the computer. This is to enable to teacher master the use of the instrument before the actual use in lessons. The amount of class time to be used for the administration of the intervention (simulation) and how to prevent the students from getting distracted with other activities during the lessons was discussed before the CAI lessons. During the use of these instruments, classroom observations were carried out of the lessons in the classroom and observation notes were taken.

The two teachers identified for the research were chosen for the reason of comparable standard in the two classes. Mr. C's class was comparable with Mr. D's class in terms of academic achievements in previous tests. Mr. C was willing and cooperative with the researcher in receiving training on the two simulation software and offered assistance with the research (handing out consent forms to the students and with student interview). Mr. C is an experienced Physical Science teacher who has taught the subject for ten years and interacted well with the subject matter.

The two classes formed the groups of average ability in the set (Grade 11) and they were so distributed into the classes based on the previous academic performance in the school.

There are many simulation software available for use to teach different Physical Science concepts but the PhET simulations and the *Interactive Physics* simulations were selected for availability and suitability to the topic being investigated which is kinematics which has been identified in the literature as a topic where students have many misconceptions (Thornton and Sokoloff, 1998). The *Interactive physics* was made available to the researcher at no charge, although it is for sale, for the purpose of the research by *design simulations* based in the United States of America.

The researcher and the teacher in the experimental class (Mr. C) decided to use the two simulations together in the research because none of the simulations could singularly be used to teach the topic because they were written for different curricula. Mr. C noted during the interview with the researcher that what he did not like about the simulations is that they had to be adapted somehow before they could be used in the South African context.

Observation of the lessons and the use of computers during the Physical Science instruction enabled me to gather relevant data for this study. Lesson observation began in August 2008 and lasted for seven weeks. The observation was followed by interviews for teachers and learners.

To ensure validity of the data collected from the interviews, pilot study was conducted using a convenient sample of three practicing teachers, who were part-time students in my Master’s Research Methods and Design class. The pilot study was used to check on the interpretation of questions and to inform modification where necessary. After the pilot study, the interview protocol was reviewed and the revised version of the protocol guided me in the conduct of the interviews survey. The interview schedule was administered to the intended study sample. The pilot study also helped to ascertain how long the interview will take to complete as well as it helped to improve the validity and reliability of the instrument. The researcher is central in data collection procedure in any research as well as in data analysis (Merriam 1998; Yin, 1994); therefore, the interview will be self-conducted.

Prior to the administration of the instrument to the teachers and students, it was piloted among the students in my master’s class at the University of Witwatersrand, Johannesburg to test the reliability and also to remove ambiguity from the questions.

All efforts were made to improve on the questions in order to obtain valid information from the teachers and students. For example the question in the teacher interview schedule which says “how often do you use Information Technology in your classroom

was rephrased to read "in the past year, did you use any and how often have you used these examples of ICT in your science teaching?"

3.2.2 Participants

This study was conducted in a single-sex school in Gauteng Province of South African. The school is a well-resourced school in the province since there are ICT equipment such as interactive whiteboard, data projector, overhead projector, and computers as well as laboratory equipment. Participants are Physical Science students in two Grade 11 classes (about 15-17 year olds). There are thirty students in the experimental class and twenty-six students in the control class. The total number of students in Grade 11 is about 110.

The school has a policy of streaming students according to their abilities. Therefore the two groups involved in the study were of comparable ability level as evident in their previous performance in various tests and examinations. There were four classes of Grade 11 and only two classes of the Grade 11's participated in the study. As indicated elsewhere in this report, this is due to the fact that this study is of limited scope. The participants were of average ability as identified and classified by the school. There was no random assignment of learners to groups because the researcher did not want to disrupt the school academic programme and the intention of the researcher was to follow the normal school programme but simply introduce the intervention programme.

This research was carried out during the third term (August-October) of 2008 academic year. The academic calendar of South Africa runs from January to December with holidays within the terms. The school year is divided into four terms each of which is comprised of about eight weeks. This study was conducted in the third term of the academic year because the researcher had to do a research methods course which ran from January to June before he could carry out any research and the Gauteng Department of Education stipulates that research could only be carried out in the first three terms because the fourth term is reserved for end-of-year examinations.

The participants had earlier had some lessons in the concepts of kinematics which include the concepts of displacement, velocity, acceleration and equations of motion

while they were in Grade 10 according to the South African curriculum. The two teachers involved in this study indicated that they taught the concepts of kinematics in Grade 10 in accordance with the requirements of the curriculum. Also these two teachers are teaching the same class which gave a sort of continuity in the teaching and made the teachers to be more familiar with the learners and their conceptions.

3.3 Analysis of data

The data collected from the follow-up interview and classroom observation were coded and analysed using atlas.ti scientific software for qualitative data analysis management and model building. Also the posttest was analysed statistically using statistical packages called Statistica and Microsoft Excel statistical analysis tool. In particular, the researcher used both descriptive and inferential statistical tools.

In order to analyse the results of the pretest and posttest, descriptive and inferential statistical techniques (i.e. mean, standard deviation, paired-sample t-test) were used. The pretest and posttest were marked and the results compared with the pre-test results which are taken as their pre-achievement level. The second term examination results and previous school performances were used as the criteria for grouping learners into their classes. This is a long-standing school policy according to one of the teachers interviewed. This approach is considered a reasonable comparison because the previous term’s results could establish a baseline to compare future science performance. The dependent variables in this research are the pre- and post-test achievement scores.

For the aspects concerned with my second and third research questions, the data obtained were analysed qualitatively using atlas.ti scientific software for data analysis.

This allowed for easy identification of the factors that may be responsible for non-use of ICT in instructions in Physical Science and whether teachers are embracing ICT in their teaching. In a similar research conducted by Barton (2005), measures of central tendency were used to measure the students’ experience with computers and the students’ use of ICT. To explore the effect of ICT after the intervention, the same statistical analysis was used by the researcher in his study. This method is considered very useful as it allows for easy calibration of the factors involved. The first aspect of

the research which concerns the impact of ICT in the teaching and learning of physics concepts were approached quantitatively because this aspect is more of quantitative data, that is, it has to do with post-intervention test.

At the end of the research, the researcher will be looking for an improvement or otherwise in the performance of students in the analysis of the data. This will enable the researcher to either accept or reject the null hypothesis which was put forward in chapter 1 of the research. The researcher will also be looking for those factors that may promote or inhibit the use of ICT in Physical Science instruction and if teachers are embracing the use of ICT in their instruction.

3.4 Ethical Issues

3.4.1 Official ethics permission

I applied for ethics clearance and received approval from the School of Education Ethics Committee of the University of the Witwatersrand (Protocol number: 2008ECE51), and also applied to the Gauteng Department of Education for permission to conduct research in a GDE school. These documents can be found in Appendices Q and R respectively. This is a requirement before any research can be carried out in the University of the Witwatersrand, Johannesburg. The reason for this requirement is to ensure that the research done by the students of the university complies with the protection of the rights of the subjects as well as to ensure that due process is followed. In the following paragraphs, I describe how I conducted myself ethically in relation to the participants in the study.

3.4.2 Teachers, learners and parents

Since teachers and learners as well as parents (because they are required to give consent in the case of minors) normally play a major role in any research project and since they are instrumental to the success or failure of any research, the researcher believes that he has particular responsibility to the teachers and learners as subjects of his study. One of the responsibilities of the researcher to the participants in this study is to see that they are protected from any victimisation, information distortions, biases, or any other form

of practices that may infringe on their rights as participants in the study, or as human beings.

According to Verma and Mallick (1999:147) on issues relating to Ethical Guidelines as outlined by The British Educational Research Association (BERA, 1992), the responsibility of participants in any study is stated in the guiding principle. The researcher was guided by one of the issues outlined by Verma and Mallick (1999:147) as stated here

> Participants in a research study have the right to be informed about the aims, purposes and likely publication of findings involved in the research and of potential consequences for participants, and to give their informed consent before participating in research.

As a result of the above requirement, the researcher made an arrangement to meet with the teachers and the students involved in the study and explained to them what will be required of them in the research. He also emphasized to them that participation in the study is voluntary and that nobody will be victimized in any way. Consent forms (please refer to Appendices C to L for copies of consent forms) were later filled and signed by the teachers, learners, parents and the principal to allow the research. The researcher explained to them his interest in their teaching and learning and why he wanted to observe them during the use of the simulation software in their teaching. Official letters to the teachers and their principal were written to ask them for permission to conduct the research in their school. The principal and teachers consented to the conduct of the research in their school.

During this stage, the researcher's hope was that all learners and parents would agree to his requests for consent to conduct research in the school which they did except for five learners who did not give consent for their exercise books to be photocopied. The learners who did not wish to be have their note books photocopied, nonetheless participated in the class.

At the early stages of the observation, the learners did not feel free having a stranger in their classroom but as the research progressed they became comfortable and used to having the researcher around. Because the teachers and the students were aware that the collection of data was for research, they could have changed their teaching or their

"usual practice" in class to suit the research study, and they could have experienced some discomfort in the process which may have positively or negatively affected my data and their teaching. The researcher owes it to the participants in his study to interact in ways that he would expect and appreciate if he was in their positions. This understanding helped him to get the maximum cooperation from the participants in his study, and this helped him to get data that is valid and reliable.

In the next chapter, the data collected during the research was presented and analysed in order to be able to answer the research questions.

Chapter 4: Presentation and analysis of data

4.1 Introduction

In this chapter I present data and analysis. The analysis thereof is conducted in order to answer the three research questions. The three research questions are:

- How does CAI influence the performance of Grade 11 learners in kinematics?
- How does a teacher embrace the use of ICT in the teaching of kinematics to create a pedagogical change from the traditional modes of instruction (teacher-talk method)?
- What are the factors hampering the use of ICT for instructions in Physical Science?

Also, in this chapter, I will give a brief description of the lessons in the two groups. For purposes of identification and ethical reasons, I refer to the teacher of the experimental class as Mr. C, and to the teacher of the control group as Mr. D.

The use of the simulations in Physical Science teaching served as an intervention in my study. The analyses of data collected will enable me to explore the impact of the intervention on students' achievement. The first set of data to be presented and analysed was the results of the two tests (copies of the two tests which were used in the study can be found in the Appendices) conducted during the research. The researcher collaborated with the two teachers to set the pretest and posttest. The tests formed part of the assessment of the students for the term. As stated earlier in chapter 3, the research followed the normal school programme as every effort was made not to interrupt the normal course of the school programme. One of the tests was the normal cycle test which is conducted regularly to assess students' progress. The teachers marked the tests and provided the researcher with the test scores.

The first test was conducted about two weeks (four classes per week out of which two are 30-minute lessons and the other two are of one-hour duration) after the teacher in the experimental class started using the simulations (the researcher started observing the lessons three weeks before the first test was conducted). The second test was conducted

towards the end of the research after the teacher had used the simulations for about six weeks (four classes per week out of which two are 30-minute lessons and the other two are of one-hour duration). The sets of test scores were analysed quantitatively using t-test to form the basis for comparison of the two groups involved in the research (the experimental and the control groups). The t-test was used to assess whether the means of two groups are statistically different from each other. The results of the analysis of test scores were used to determine whether the null hypothesis should be accepted or rejected. The null hypothesis was stated in chapter 1 as "*the use of CAI (independent variable) does not impact on the teaching and learning (students' achievement) of Physical Science concepts (kinematics)".*

The other data collected by classroom observation and interview was analysed qualitatively in order to be able to answer the second and the third research questions.

The interviews conducted with the learners serve to indicate the level of perception of the learners as well as to explore what and how the learners feel about the simulations. The ten students interviewed are distributed in the ratio of seven in the experimental group to three in the control group. It was decided that since the number of students in the experimental class was more than that of the control class and because the intervention was actually used by the treatment group, the ratio of 7:3 in the proportion of 7 students from the experimental group to 3 students in the control group should be interviewed. Although the students in the control group did not experience the use of the simulations in their lessons, one of the things the interview sought to know was whether they ever learned science using any form of technology or simulations.

4.2 Description of lessons

4.2.1 Mr. C's lessons

The two teachers involved in this research study were both teaching Grade 11 at the time of data collection. Mr. C's lessons are characterized by the use of the intervention, whenever and wherever possible, as well as the use of analogies and various forms of representations to explain the different Physical Science concepts to the learners. The researcher observed ten lessons of Mr. C's class, six 1-hour lessons and four lessons of

30-minute lessons. There are 30 learners in Mr. C's class. The researcher was present when Mr. C started each lesson. In the first lesson, the teacher reviewed the concepts learnt in the previous year. The lessons covered in the previous year were on motion and equations of motion. He explained that kinematics is concerned with the motion of objects and he arranged students work in groups to draw mind maps to indicate motion and the related terms. The few lessons before the use of the intervention were characterized by the use of teacher-talk and algorithmic solutions to problems. The teacher gave the equations of motion and exercises to the students to solve using those equations and said to the students:

These are the equations of motion that you learnt in Grade 10;

1. $V_f = V_i + at$
2. $\Delta x = V_i t + ½ at^2$
3. $V_f{}^2 = V_i{}^2 + 2ax$
4. $\Delta x = ½(V_f + V_i)t$

Now solve the following problems:

1. The velocity of a train is 26.4 ms^{-1}. At an average acceleration of -1.5 ms^{-2}. How much time is required for the train to decrease its velocity to 9.72 ms^{-1}
2. A skier starting from rest accelerates down a slope at 1.6 ms^{-2}

   a. What does 1.6 ms^{-2} mean?

   b. What is the velocity at the end of;

      i. 1 sec
      ii. 2 sec
      iii. 5 sec
      iv. How far has he traveled at the end of 5.0 sec?
3. A stone is dropped from a bridge that is 20 m above a river. What is the stone's velocity just before it hits the river? Take g = 10 ms^{-2}

The teacher did not dwell so much on this section because according to him it was a review of previous year's work. I think the teacher should have given the section more time because the students appeared to have forgotten what they learnt in Grade 10. For example, when the teacher gave the exercises some students were observed to be

struggling with the problems and the teacher had to come to their aid at some time before they could solve the problem. There are various ways the teacher should have used to teach this section such as the use of ICT, experiments, or by inquiry method such as that proposed by McDermott *et al.* (2000) for teaching electric circuits. The use of ICT is not the only method of instruction in this topic that could be used to aid student learning because ICT in itself cannot aid students’ conceptual understanding if not properly implemented as noted by Hartley *et al.* (2007).

Some other researches (e.g. Trey and Khan, 2008; Vavougios and Karakasidis, 2008) that have been done in similar topic suggested the use of visualization tools such as high-tech tools (ICT) because when these tools were used in their studies they found an improvement in the performance of the students in the posttest. For example, using tools such as the PhET’s “moving man” could have made a difference because it simulates the “movement of a character, tracking position, velocity and acceleration” (Finkelstein *et al.*,, 2006, p. 6).

Jimoyiannis and Komis (2001) who carried out a research into using computer simulations in the teaching and learning of trajectory motion used a framework according to the order of first identifying students’ alternative conceptions in the topic concerned and then applying some teaching interventions to correct or change the conceptions. The result of the study showed that the students changed their alternative conceptions after the use of the teaching intervention (*Interactive Physics* simulation).

Mr. C then walked around the class to see how the students were faring on the problems. After the students have made some attempt, he discussed the solutions to the problems in whole-class teaching.

The lessons on Newton’s laws began with the use of some stories and analogies of Newton to arouse students’ interest in science discoveries. Mr. C further described some of the work done by Sir Isaac Newton and stated his first law of motion. The teacher used two balls of different masses to demonstrate the meaning of inertia and used this demonstration to engage with the learners in discussion of the effect of larger masses on inertia.

The knowledge of the history and philosophy of science could enable learners to understand the historical development of science and how this can aid their understanding of science. The knowledge could also generate some interest in science in the learner. Mr. C's use of the above teaching strategy was based on his belief, as noted by Justi and Gilbert (2000:1), that

> if students understand how scientific knowledge is developed, and how historical, philosophical and technological contexts influence its development, then they will acquire a more comprehensive view of science and as a consequence, become more engaged by the learning of science.

Mr. C started using the simulations after he spent four lessons revising the lessons on motion and equations of motion. He used the simulations by choosing between the two interventions (*Interactive Physics* simulation and PhET simulations) provided. He showed a simulation of objects falling under gravity and used the selections provided in the simulation to adjust or vary the magnitude of the gravitational force. For example, the gravity on the moon as compared to the gravity on earth is lower and objects tend to fall faster. The learners in the experimental class did not show any observable difficulties when their teacher was using the simulations but rather they showed increased attention and interest except for the student who asked about Mr. C if gravity is the same everywhere. Many research studies indicate that students generally have misconceptions in the topic of kinematics. For example, Thornton and Sokoloff (1998) indicate that students have misconceptions that are consistent with Aristotelian mechanics. Examples of such misconceptions are that force implies motion and that the force is in the direction of motion.

Although some difficulties may exist in the students which I could not immediately see during instruction, the use of ICT could have created an environment that beclouded the difficulties. Thornton and Sokoloff (1998) observed some difficulties in the students who participated in their research on which they claim may have been as a result of the traditional approach to teaching. After the intervention was used for the students they reported that analysis of the results indicated a significant improvement on the performance of the students in the posttest.

Other lessons of Mr. C were follow-up of the intervention lessons where he gave various problems to the learners to solve. He would give learners some class work to do and walk around the class checking what the learners were doing. After a while, he went to the board for a general class discussion of what he had observed as he was walking around the class. Sometimes he provided personal attention to the learners as they are busy solving the problems. His lessons were also characterized by first giving the problems which may be projected onto the interactive whiteboard and asking the learners to solve them. After this, he discussed the solution to the problems in a whole-class teacher solution where the learners are able to check their answers.

Mr. C said "what are your answers to the problems I gave you to solve? We need to check the answers together in order to be sure that you have done them correctly". The students brought out their answers and the questions were discussed in a whole-class method. Research reports show that students are more comfortable with lessons where they are able to interact and make their contributions to the lessons (that is, learner-centred lessons). In this way they are able to construct their knowledge as indicated by Piaget (1978).

4.2.2 Mr. D's lessons

The researcher observed two lessons of Mr. D's class. He decided to observe two lessons in Mr. D's class as compared to the ten he observed in Mr. C's class because the lessons are sometimes held simultaneously and also because he wanted to be able to analyze how Mr. C was using the simulations. By observing fewer lessons of Mr. D, the researcher was able to spend more time observing Mr. C's class where the simulations were actually used. This act has no negative effect on the results of the study. Each of the lessons lasted for 1 hour (two double-period lessons of 30 minutes each). There were 26 learners in Mr. D's class and the lessons were conducted in the Physical Science laboratory. Mr. D's lessons are characterized by the use of the teacher-talk method to solve problems. In a teacher-talk or teacher dominated classroom, learners become passive participants in the classroom. This method is against research recommendations such as those by Piaget (1978) and Vygotsky (1978) which propose that learners should be actively engaged in their knowledge construction and the teacher

should only play the role of a facilitator. The teacher-talk method as opposed to teacher-led class discussion may be used to introduce relatively new concepts to the learners or where the teacher is trying to present a relatively new terrain to the learners. The revised national curriculum statement (RNCS) of South Africa also recommends the use of instructional methods that are learner-centred. During the interview with Mr. D, he stated that he uses technology from time-to-time as the topic permits or requires. During the period of the research Mr. D was not using technology in his teaching.

The first lesson the researcher observed was on pulleys and resolution of forces. Mr. D draws diagrams of pulleys and asks the students to identify the forces present. The lesson followed the structure of initiate-response-evaluate/feedback (Mehan, 1979 and adapted by Brodie, 2004) where Mr. D asks the students questions which he expects them to respond to. If he did not get the required (correct) response, he provides a feedback on the inappropriate response and provides the correct answer. Mr. D's teaching pace seemed slower than that of Mr. C. At the time Mr. C was teaching Newton's second law; Mr. D was only starting to teach Newton's first law.

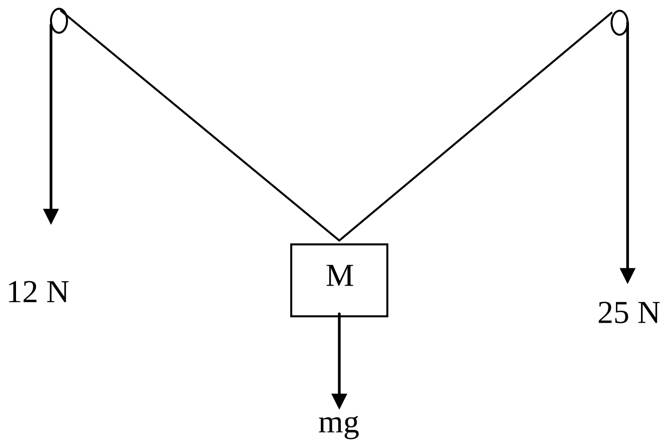
Mr. D stated Newton's first law of motion in his own words and represented this mathematically as;

> If $F_{RES} = 0$, the $\vec{v}$ is constant and $\vec{a} = 0$. Where 'v' is the constant velocity and 'a' is the acceleration of the body

Mr. D's method seems to be different from how Mr. C approaches his teaching. The level of interaction between the teacher and the students and between the students in Mr. D's class is low compared to that of Mr. C as observed by the researcher. This may be as a result of Mr. D's teacher-talk or teacher dominated teaching. Mr. C differs from Mr. D in teaching this section of work in the sense that Mr. C's class is more involving as I observed, that is, the students interacted better in Mr. C's class. This interaction could be as a result of Mr. C's use of ICT or representations and analogies that led to discussions from the students. These discussions enabled the students in Mr. C's class to share their thinking with other students which may result in correction or reconstruction of the ideas they hold.

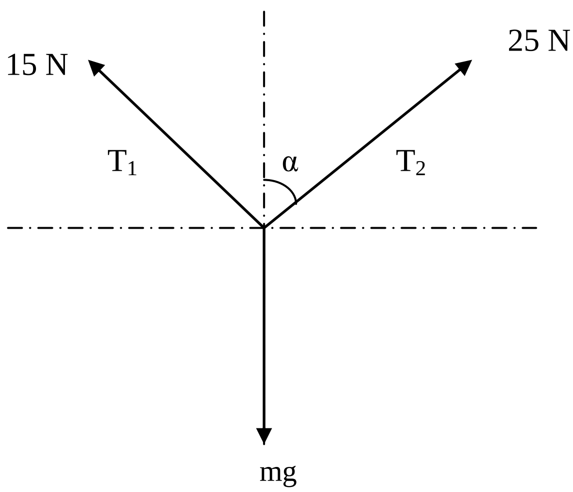
The second lesson of Mr. D that the researcher observed was a follow-up to the first lesson because the lesson was on solving further problems on resolution of forces in a pulley system and Newton's first law of motion. In the example shown below, the angle between the lines of action of the two forces is 90°.The following quotation indicates what the teacher said and wrote.

> In order to solve this type of problem, you need to analyse the forces acting on the body. I want you to identify the forces acting on the mass M shown in the diagram".



A student answered that "there is a force of gravity and other forces in the ropes (tension)"

The teacher then drew the diagram of the forces on the whiteboard.

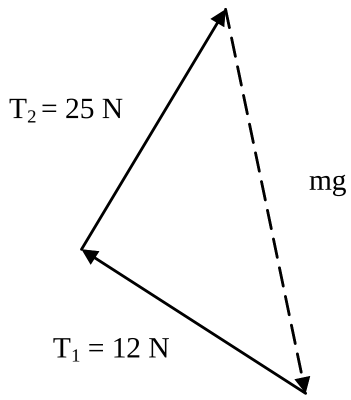


Mr. D said “the resultant forces must be equal to zero if the system is in equilibrium”.

Vertical component $T_1 \cos(90- \alpha) + T_2 \cos \alpha = mg$

Horizontal component $T_2 \sin \alpha = T_1 \sin(90- \alpha)$

He then drew a diagram to indicate the triangle of forces.



4.2.3 Comparison of Mr. C’s and Mr. D’s teaching

Mr. C’s use of ICT helped him to be able to explain concepts quicker than Mr. D because of the increased visualisation that the simulations provided to the students. Mr. C’s teaching method and the use of the simulations is in line with the framework of this study which proposes that environments should be created to help learners reach their level of potential development from their actual level of development. In the zone of proximal development, the learners are helped by Mr. C’s use of simulations. The simulations are interactive and resulted in discussions and participation among the students. Seaman and Fellenz (1989:119) noted that when students discuss and share they are given the opportunities to “react to the ideas, experience, insights, and knowledge of the teacher or of peer learners and to generate alternative ways of thinking and feeling”. Students learn from the teacher and their fellow students.

4.3 The intervention (simulations)

During the lessons, the researcher only served as an observer while the teachers taught the lessons. The researcher did not interfere in any way with the instruction. The initial

intention was to install the software on the computers in the laboratory so that individual students could interact directly with the simulations but the researcher could not get multiple or network license for the *Interactive Physics* simulation therefore it became impossible to install the software for the learners to have individualized contact with the simulations. Also, the students interviewed said they preferred the way the teacher used the simulations to teach them the concepts and they did not see anything wrong with the usage. They said they did not think it would make any difference to them because they have all interacted with computers before. Students generally respond positively to the use of methods that differ from the one they are used to, this was the view of Mr. C when he was interviewed. According to Hartley *et al.* (2007) who carried out a research on the application of computer-assisted learning strategy in science and mathematics for disadvantaged Grade 12 learners in South Africa students were excited during the use of ICT in their teaching. They indicate that a student interviewed said that “we were excited because we were going to be the first ones to try out computers in our area….” (p. 10). Zachariah (2003) who reviewed a number of literature on the attitudes toward computer simulations in science education states that much literature reviewed conclude that “the use of computer simulations also has been successful in promoting development of favourable attitudes toward science across fields” (p. 5).

4.3.1 Teacher knowledge of the content and pedagogical content knowledge

Teacher knowledge is in different domains, but I focus on content knowledge and pedagogical content knowledge because they represent the core knowledge domains that teachers use in their teaching practices. Pedagogical content knowledge (PCK), as described by Shulman (1986) refers to how teachers transform the knowledge of content into a form that learners can understand. In other words, it is the knowledge that the teacher invokes when transforming the subject knowledge into an understandable form for the learners. Shulman (1986) argues that PCK is one of the components that make up the teacher knowledge and it is the aspect of teacher knowledge that is most relevant in the domains of teacher knowledge because it represents the knowledge created/used during the transformation of subject knowledge into a teachable form. The

components of PCK as outlined by Shulman (1987, p. 10) are “subject matter representations which include analogies, illustrations, examples etc., understanding of students’ conceptions and pre-conceptions, and instructional strategies to overcome students’ initial conceptions”.

The way Mr. C communicated the content to the students with the use of representations and analogies was an indication that he possessed the subject matter knowledge and the necessary PCK to enable the students understand what he intended teaching them. For example, Mr. C filled some sand in a ball and the other was filled with water and threw the ball one at the same time for a student to catch. The student was asked which of the ball was easier to catch and the response was that the ball that contains water because it is lighter in weight.

Harrison and Treagust (2000) note that analogical models appear in almost every lesson as they are used in explaining some scientific concepts. These analogical models can be presented in different ways such as still pictures or animated pictures. Although Harrison and Treagust (2000) report that there are problems involved in the use of analogical models in the teaching and learning of school science, but concluded that analogical models make learning possible.

When defining Newton’s first law, Mr. C referred to the law as the law of inertia and defined the law as a body’s resistance or reluctance to motion.

4.3.2 Student-teacher interaction

Mr. C seemed to know his students very well judging by the way in which he interacted with them. The teacher’s knowledge of the learners is considered as one of the domains of teacher knowledge which Shulman (1986) identified. Mr. C adequately demonstrated the knowledge of his learners as well as their prior knowledge and he utilized this knowledge in his lesson which was reflected in the way he moved around during the lessons asking specific questions such as ‘what do you think motion is?.....and attended to the students’ needs as soon as he identified them. Mr. C utilized the students’ prior knowledge when he grouped the learners according to their ability and told them to produce a mind map of motion and its related terms after considering the fact that they

had studied motion the previous year. The students were also free with Mr. C which was evident in the way they asked questions and the way they interacted whenever they worked in groups. In other words my observation of the lessons, and the subsequent analysis showed that good rapport and interaction existed between Mr. C and his students.

4.3.3 The teacher's use of the simulation software

Although Mr. C said that he has never used simulations or interactive software in any of his science teaching before the research, he was able to use the simulation with ease judging by what he was able to accomplish with the simulation. Mr. C noted that he was able to teach the Newton's first and second laws with ease and also very quickly. For example, Mr. C said that he decided to devote more time to learning how the simulations work after the initial training which was provided by the researcher. The transcript below (Mr. C's interview) shows an excerpt from the interview with Mr. C where he gave reasons why he decided to study the simulation software further in order to be able to incorporate it into his lessons.

> Interviewer (line 181): You seem to have grasped the simulations and the way you incorporated it into your teaching even though you had not used it before.
>
> Mr. C (line 184): Yeah I enjoyed it so I spent a little bit of time going through the simulations after the training you provided because I saw that the learners were enjoying it so that's why I spent a bit of time going through it. It was good to use

Mr. C utilized part of the simulation from PhET with the window shown below to illustrate Newton's first law which states according to one of the students "that a body continues in its state of rest or uniform motion unless acted upon by an unbalanced or external force". As mentioned elsewhere in this report, the students did not interact with the simulations directly. They were shown the simulations and the teacher explained to them what was going on.

The teacher, using the simulation, indicated that if an object starts from a certain point it goes back to the same height if there is no external force acting on it. He showed various situations of what happens when the skater moves in various gravitational stations such as space, moon, earth and Jupiter.

Learning this topic without the use of ICT or other visualisation tools can make students' understanding of the concepts difficult because they are not able to see easily what the teacher is trying to pass across. For example, Trey and Khan (2008) examined how computer-based analogies can help science students to learn unobservable phenomena and reported that students showed statistically significant gain in achievement in the posttest.

Figure 4.1 below shows a screenshot from PhET simulation used by Mr. C during one of his instructions.

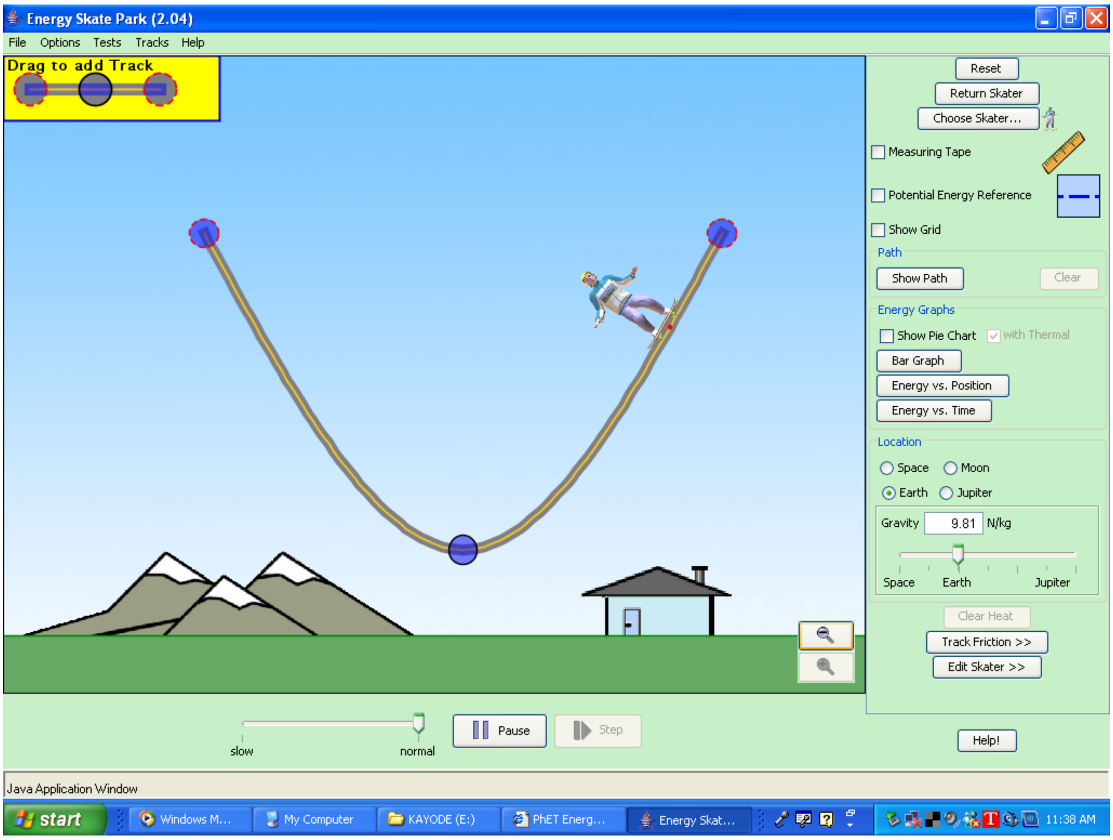


Figure 4.1: *Screenshot from PhET simulation showing the effect of gravity on a body*

Figure 4.1 indicates a screenshot which was taken from the PhET simulation. This simulation was used by the teacher to show the effect of friction and gravity on a moving body. It shows that when a body moves from a certain height, it moves to the same height when it goes round to the other side of the rope but if there is no gravity,

the body continues to move. Mr. C indicated that if the object starts from a certain position it goes back to the same height if there is no external force acting on it.

For example, when Mr. C changed the location of the moving object to space the object continued to move without any stoppage. The rope on which the moving person stands can be adjusted in different forms in such a way that it could form, for example, a flat surface or a completely round surface. The skater (the man shown in the diagram) can be changed to other objects. The simulation is interactive in the sense that it allows the teacher to choose those factors he wishes to control and those properties he wanted to display. It is possible to show in the simulation various energy graphs such as a bar graph or a pie chart to demonstrate the movement of the skater. It is also possible to show the energy versus position or energy versus time graphs.

When Mr. C started using the above simulation, I observed that the students' reaction was captivating and they showed increased attention to the teacher as he demonstrated the simulation. The interaction in the class can be described as interesting and full of fun as a student interviewed at the end of the lessons commented when he was being interviewed. When Mr. C added friction to the object, it eventually stopped. A student noted that this is an illustration of Newton's first law. The other members of the class seemed to agree with him as they said "yes". Mr. C spent a bit of time showing this section of the simulation because he could see that the students were interested as he noted in his interview. He could not let this section pass without carefully explaining to the students what was going on. For example, Mr. C said, when he was being interviewed, said that (line 107)

> I think they really enjoyed it. There was a lot of interaction between me and them. Em..It also got me to explain things very very quickly because all the content was already....context was already done so could see straight away. It allowed me to explain things very quickly and also they enjoyed seeing something different in the class because they are so used to me standing up in the class and just talking. I think they enjoyed seeing something different. Also I was able to do a few different things that like the simulation wasn't designed for like making a skateboard fly and then they enjoyed that kind of stuff.

Mr. C would have spent the same amount of time or even less on this section of work if he did things differently. That is, if he did not use ICT, he may have spent less time but the understanding of the students may be limited as he noted in the transcript excerpt above that he could see that the students enjoyed it and he did things differently.

Various situations where such sections have been taught with ICT showed that the students performed better in the posttest after the intervention was used. See for example, Thornton and Sokoloff (1998).

Mr. C also used the *Interactive Physics* simulation software to show the effect of gravity on an apple according to Newton's law of motion which deals with objects under the effect of gravity. After showing the simulation, one of the students said that "F_g = mg where the m represents mass and the g represents acceleration due to gravity". This statement by the student is consistent with what is available in physics textbooks. It is possible for the student to come up with such a statement without interacting with ICT but the statement may not become too obvious to him if the simulation did not show graphically what happens when the apple falls. Simulations are considered to be visualization tools that aid students' conceptual understanding when used in Physical Science teaching. For example, Khan (2007) used simulation combined with analogies and found the effect on the performance of the students to be significant.

The simulation (see Figure 4.3) shows the mass of apples in a weighing scale and it shows what happens when more apples are added on the weighing scale. If the number of apples in the scale is increased, the reading for the mass is increased. A student asked if the gravity is the same everywhere but the teacher indicated that gravity is different from place to place.

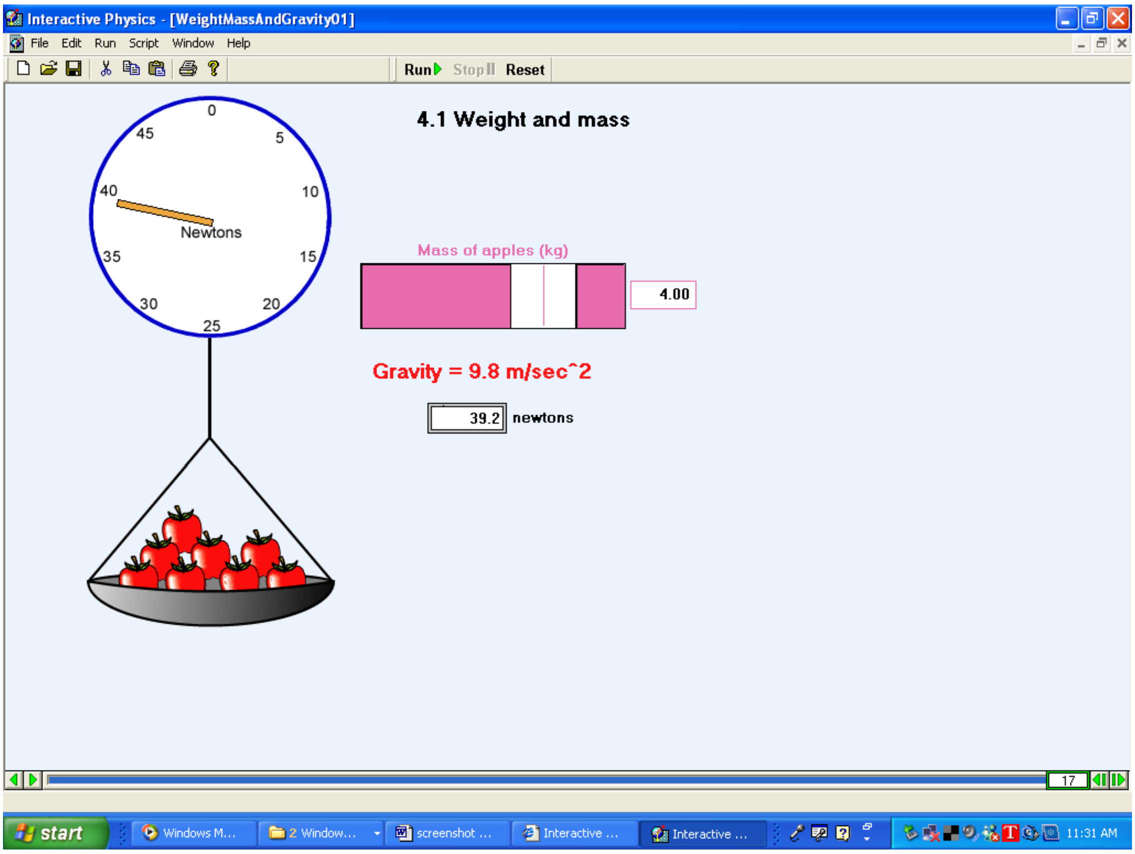


Figure 4.2: *Screenshot from Interactive Physics simulation showing Newton's second law*

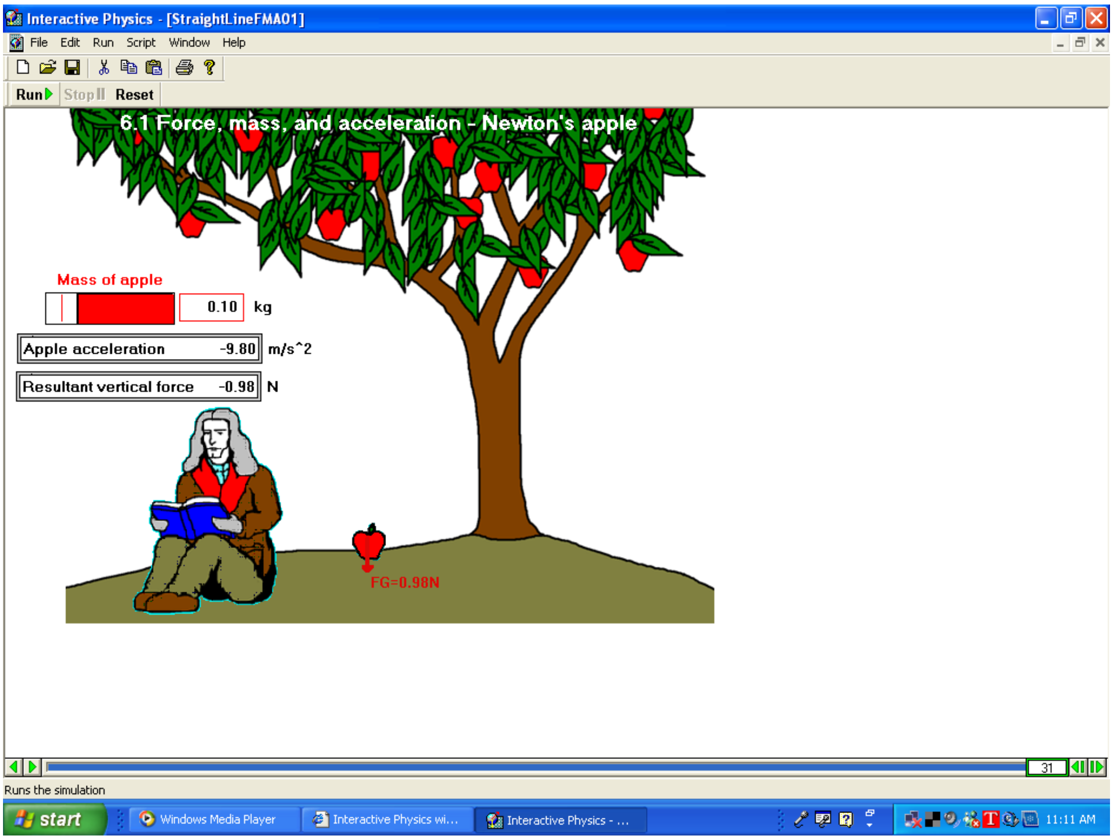


Figure 4.3: *Screenshot from Interactive Physics simulation showing a falling apple under gravity*

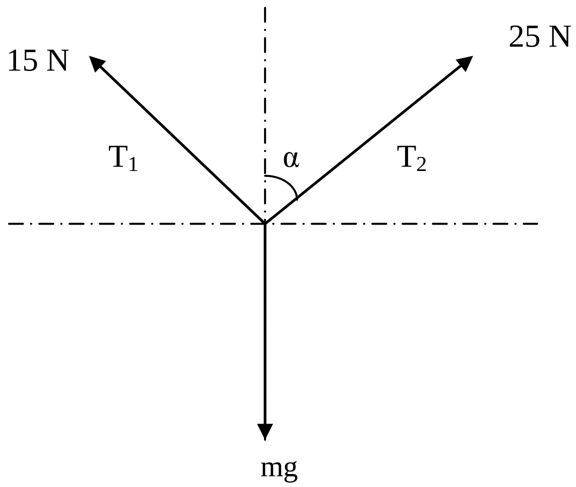
Figure 4.3 is an illustration of Sir Isaac Newton sitting under a tree and reading a book. As he was concentrating on his book, an apple fell from the tree and he started wondering why the apple fell. This led him to come up with the concept of gravity as being responsible for the dropping of the apple from the tree. The simulation allows the students to observe the apple falling under gravity. The downward acceleration is shown in negative and the mass of apple can be increase. As the mass of the apple is increased, the students are able to see how fast the apple drops from the tree.

Teacher C: How does this help us? He said “this shows the weight measured in Newton (N). The mass measured in kg. Therefore acceleration is measured in ms^{-2}”. He requested the students to state a formula to relate mass, force and acceleration. A student stated the formula F = ma where m = mass of object, a = acceleration and F = force.

The teacher then asked the students to state in words the definition for Newton's second law. The general consensus among the student is that Force (F) = ma which means that a α F and a α $^{1}/_{m}$. The students said this means that acceleration is directly proportional to the applied force and inversely proportional to the mass of the object. From my observation of Mr. C's lesson when he was teaching the above concept, I can say that he taught the section well judging by the students' response during instruction because the students used their calculators to check the results obtained from the simulation and came up with the formula for Newton's second law before the teacher stated the law. The following was the comment of Mr. C about the activities that transpired in the classroom. An excerpt from the transcript is given below.

> Line 191 Mr. C: The one that we are talking about I think is the Newton 2 practical or the Newton 2 simulation that we did. Yeah, it was very good because the guys even came out with the Newton's second law in words by themselves. They've never been introduced to it. Yeah, I think they enjoyed it, it was very good.

Mr. C and his students benefited from the use of ICT because it increased conceptual understanding of the students as noted by the students and the teacher when they were interviewed. Mr. D's students on the other hand asked many questions about a diagram that he was explaining during one of the lessons I observed. This is an indication that the students did not understand the concepts involved in solving the problem. The diagram referred to in this lesson is shown below.



4.4 Analysis of test results

In this section, the results of the two achievement tests conducted which form part of the students' assessment for the third term is analysed. As noted earlier in the chapter, the teachers set the tests in collaboration with the researcher and were administered by the two teachers. The sections of work covered by the pre-test are kinematics concepts such as velocity, displacement, acceleration, and calculations involving the use of the equations of motion while the sections of work covered in the posttest are Newton's first and second laws. Most of the questions in the pre- and post-test are based on testing students' conceptual understanding while some other ones required that the students apply some formula to solve problems. Please refer to Appendix M for the pre-test and posttest. The questions for the pretest and posttest were taken from past matric question papers as well as the recommended physics text books. The questions were validated by Mr. C and Mr. D. Mr. C was the one that set the pretest and it was validated by Mr. D and the researcher while Mr. D set the posttest which was validated by Mr. C and the researcher. The questions were used in past examinations and textbooks so they are considered reliable and suitable for the Grade 11 class.

The teachers scored the tests and gave the researcher the results. The researcher then analysed the results using two statistical tools (statistical analysis tool in Microsoft excel to compute the mean, median, the standard deviation and t-test and another programme called statistical to determine the level of significance of the difference in performance of the learners in the experimental and control groups. The researcher used these two tools so that he can compare the results obtained from both of them. The tools gave similar results though the results were presented in different ways.

The scores analysed are the final percentages of the two groups as well as the performance in each of the tests in order to determine the level of significance of the scores. The researcher further analysed the two tests within each group in order to be able to compare the performance of the learners from one test to the other as the teacher used the simulations.

The tables below show the results obtained from the analyses.

Analysis of percentage scores

Research question 1: The question is how does CAI influence the performance of Grade 11 learners in kinematics?

The analysis of percentage scores of the two groups shows that there is no statistically significant difference in the performance of the two groups in the tests when compared on the overall score for the third term ($t = -0.53375$, $df = 54$, $p = 0.595699$). The interpretation of this analysis is that since the $p > 0.05$, there is no statistically significant difference in the performance of the experimental and the control groups in the two tests conducted; therefore the null hypothesis which states that "*there will be no statistically significant difference in the performance of students taught Physical Science concepts (kinematics) using CAI and those that were taught without CAI*" is upheld. Therefore, it follows that CAI does not influence the performance of Grade 11 learners in kinematics.

Analysis of the pre-test scores shows no statistically significant difference ($p > 0.05$) in the performance of the two groups.

T-test for Independent Samples (Spreadsheet1) Note: Variables were treated as independent samples											
Pre-test	**Mean**	**Mean**	**t-value**	**df**	**p**	**Valid N**	**Valid N**	**Std. Dev.**	**Std. Dev.**	**F-ratio**	**P Variance**
cycle test (experimental) vs. cycle test (control)	35.7000	34.7301	0.2537	54	0.8007	30	26	13.76189	14.8150	1.1589	0.6952

Table 4.1: *Statistical analysis of pre-test of the two groups*

Also analysis of the post-test scores indicates that there was no statistically significant difference ($p > 0.05$) in the achievement of the learners in the two groups. The table shows the result of the calculated values.

T-test for Independent Samples (Spreadsheet1) Note: Variables were treated as independent samples											
Post-test	**Mean**	**Mean**	**t-value**	**df**	**p**	**Valid N**	**Valid N**	**Std. Dev.**	**Std. Dev.**	**F-ratio**	**P Variance**
class test (experimental) vs. class test (control)	38.2033	44.2308	-1.5257	54	0.1329	30	26	15.6564	13.6097	1.3234	0.4801

Table 4.2: *Statistical analysis of posttest of the experimental and control groups*

Therefore in answering research question 1 which says that "how does CAI influence the performance of Grade 11 learners in kinematics?" the results of the analysis indicate that CAI does not influence the performance of the learners in the topic treated because the results of the tests do not indicate any statistically significant difference in the performance at $p > 0.05$.

T-test for Independent Samples (Spreadsheet1) Note: Variables were treated as independent samples											
Overall percentage score	**Mean**	**Mean**	**t-value**	**df**	**p**	**Valid N**	**Valid N**	**Std. Dev.**	**Std. Dev.**	**F-ratio**	**P variance**
Percent (experimental) vs. percent (control)	36.7667	38.500	-0.5338	54	0.5957	30	26	12.1646	12.0673	1.0162	0.9748

Table 4.3: *Statistical analysis of final percentage of the experimental and control groups*

Analysis of the cycle test (pre-test) and the class test (post-test) shows that there is also no statistically significant difference in the performance of the learners within the experimental group ($t = -0.6578$, $df = 58$, $p = 0.5133$) after the simulations have been used for teaching them, although the mean scores and standard deviations show some difference (that is, the means and standard deviations increased from 35.7 to 38.2033 and the standard deviations from 13.76189 to 15.65641 respectively). There is no statistically significant difference in this analysed results because the $p > 0.05$. This is

an indication that some of the learners made significant improvement in their performance between the cycle test (pre-test) and the class test (posttest). For example, 18 students from the experimental group representing 60% of the students performed better in the posttest as compared to their pre-test's 46%. Although this percentage of learners with increased score is more than those whose score decreased, many learners recorded a higher decrease in their performance as shown in Table 4.5 below. The chart below indicates the difference in the performance of the learners from pre-test and post-test.

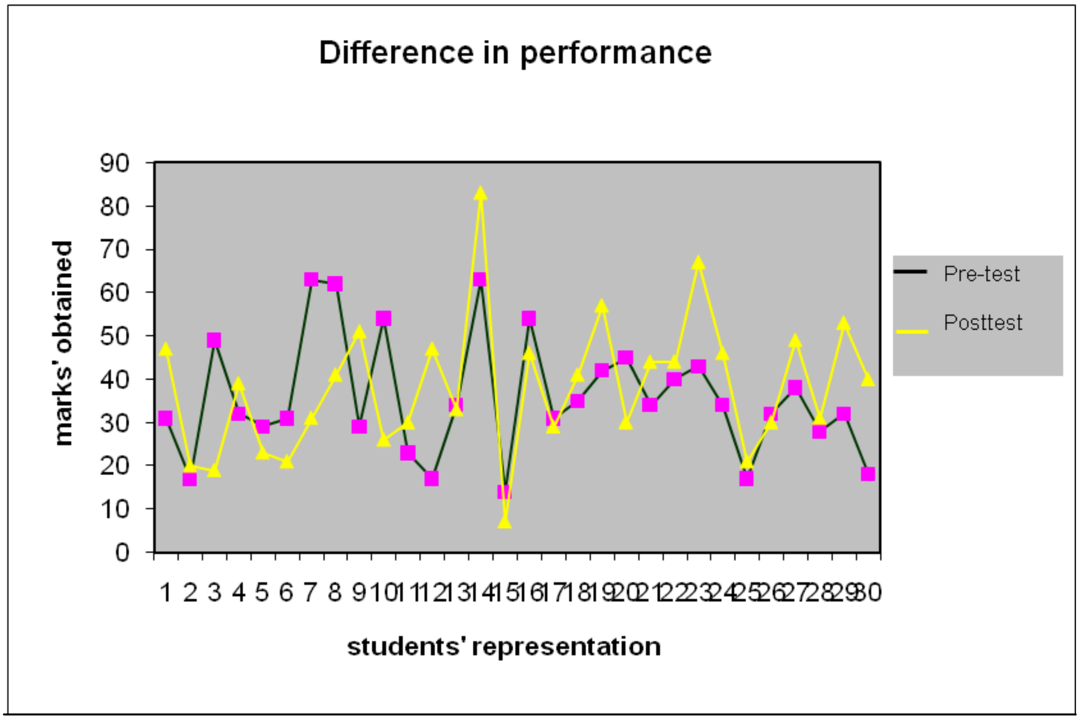


Table 4.4: *Graphical representation of pre-test and post-test of the experimental group*

Table 4.5 below shows a summary of the analysis obtained from the pre- and post-test scores of the two groups.

Index	Statistics in pretest		Statistics in posttest		Gain score statistics	
	Experimental group	**Control group**	**Experimental group**	**Control group**	**Experimental group**	**Control group**
Mean	35.7	34.731	38.203	44.231	2.503	9.00
SD	13.762	12.165	15.656	14.815	16.356	15.662
Highest score	63	65	83	74	30	36
Least score	14	15	7.1	21	-32	-22
Range	49	50	75.9	53	62	58
Coefficient of variation	0.386	0.350	0.41	0.335	6.535	1.74

Table 4.5: *Description of group performances in pretest and posttest*

As can be deduced from Table 4.5 above, the analyses of the mean scores, standard deviations and the coefficients of variation in the two groups indicate that students in the control group and the experimental group performed almost equally in the pretest. Although the highest score (65%) in the pretest was from the control group, however the highest score (83%) in the posttest was from the experimental group. The range of the scores obtained by the experimental group in the posttest was 75.9% compared to the control group's 53% in the posttest. This indicates a higher increase in terms of performance when the two groups are compared in the posttest. Comparing the groups' performance in the posttest using the descriptive tools above shows that students in the control group performed better than their counterparts in the experimental group but these performances were not enough to result in a statistically significant difference between the two groups.

Another analysis of the scores which the researcher conducted was that of the gain score which is presented in the last two columns of Table 4.5. The gain score was calculated by subtracting individual student's score in the pretest from her/his score in the posttest. An in-depth look at the gain score statistics shows that as in the posttest scores, students in the experimental group had almost the same positive shift in their

achievement as the control group. The negative gain score indicated in the 'least score' row is as a result of the overall better performance in the pretest than the posttest.

The bar graph shown in figure 4.6 below gives a comparison of the performance of the two groups in the pretest and posttest. A careful look at the chart reveals that the mean score for the experimental group in the pretest is a little higher than that of the control group while the mean score of the experimental group is lower than that of the control group in the posttest.

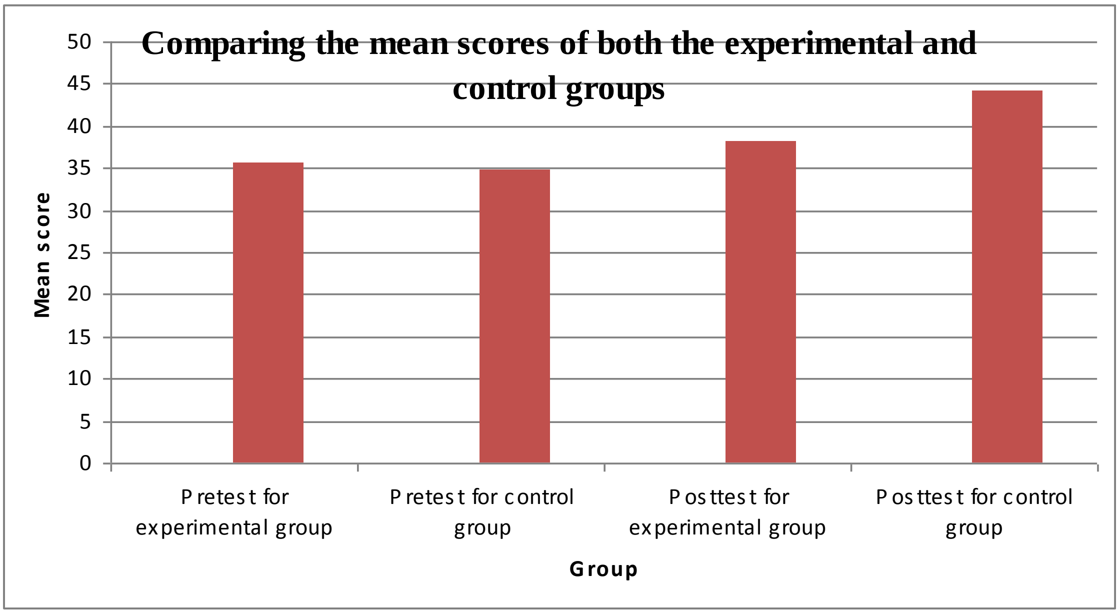


Figure 4.6: Mean performance of students in the pretest and post test

Student Interviews

All the students interviewed (approximately 20% of the students involved in the study) were selected at random from the sample therefore there was no decision made to select those students that performed better than the others in the tests. This number is considered a convenient number for the research of limited scope for a master's course. All of the students interviewed claim that they have access to computers at home and that their computers are connected to the Internet. Two students (20%) out of the ten students interviewed said they make use of the computer laboratory in the school for their school-based research (school assignments) because they live in the school

residence. This is an indication that all the learners who participated in the research do not see the use of technology or simulations in science teaching as a strange teaching method.

Although, all the students interviewed said that the use of simulations (interactive software) in their teaching was done for the first time during the research, they indicated that the use of simulation to teach Physical Science was a good idea and that they enjoyed it because it was more fun than the usual teacher-talk method. In one of the interviews, a student summarized his impression of the use of simulations in teaching as follows:

Interviewer (line 68):	Is there anything you think is not adequate or you don't like about the simulations?
Student D (line 70):	No. It's a decent way of teaching.
Interviewer (line 71):	Ok. A decent way of teaching. What would you like to see?
Student D (line 72):	All subjects taught like that.
Interviewer (line 73):	Ok, all subjects taught like that.
Student D (line 74):	Yeah

Another student has this to say about the simulation lessons "The simulation lessons they are quite interesting because you can give proper examples of something and you can demonstrate it with program on the computer".

Teacher interviews

The teachers of both groups corroborated this view by saying that whenever they used technology (computer presentation with the interactive whiteboard) to teach their learners they normally see improved interest and excitement in the learners. Mr. D made this comment when asked about the perception of his learners whenever he uses technology to teach science. This question was asked to Mr. D because the researcher intended to find out if he had used technology before in his lessons since as noted elsewhere in the report that the school in which the research was conducted is a well-resourced school in terms of the availability of technology.

> Line 210 It's good because it's actually much better than to do it in the whiteboard or…because it's very difficult you have to have a lot of drawing skills to do something appropriate to show what is going on there but of course in the Internet I actually found there are very nice drawings and graphs showing how it works. Very well

> explained and then of course the learners saw it by themselves and it's very much easier for them to internalise what was going on in the theory, to visualise and to see how it is expressed in reality

Mr. D would like to use technology in his teaching as much as he can, depending on the topic to be treated but he said that he prefers to use the whiteboard because it gives him more flexibility to change things quickly than when he uses technology like simulations.

4.4.2 Teachers' and students' views about the simulations

Although there is no significant difference in performance levels as indicated by the statistical analysis, the analysis of the interview conducted with the learners in both groups reveal that learners in the experimental group were able to understand the concepts being taught because, according to the learners, the simulations enabled them to visualize the situation without having to only listen to the teacher describing the phenomenon. I make the claim that the students could understand the concepts being taught by the teacher based on the data gathered from the students during the interviews. For example, the transcript below shows part of the students' response when asked how they feel when the simulations were introduced:

Interviewer (line 72)	Let's go to the simulations. The lessons you had with the simulations, is there anything you enjoyed about the simulations?
Student A (line 75)	Yeah…yeah…It was actually quite interesting. Being able to see what actually happens. We used to see it in a way whereby they explain it to us, draw it and you sort of like have to visualise it. Now seeing it makes it quite interesting.

Another student interviewed summarized the effect of the simulation in this way:

Interviewer (line 43)	Let's come to the simulation lessons. What do you enjoy about the simulations?
Student B (line 45)	It's more visual. You can see what you have to do instead of just hearing what you have to do
Interviewer (line 47)	Ok, now in terms of the kind of lessons that the simulations showed you, how do you compare it with the normal or the kind of methods that the teacher always use?
Student B (line 50)	I find them a lot more interesting and a lot easier to understand

The teacher of the experimental group (Mr. C) stated that the students, in his opinion, enjoyed the simulation lessons and they were able to state Newton's second law of motion in words and using mathematical formula.

Interviewer	What are you views about…. How do you view the learners' perception about the simulation lessons?
Mr. C (line 107)	I think they really enjoyed it. There was a lot of interaction between me and them. Em, it also got me to explain things very, very quickly because like you said all the content was already....context was already done so you could see straight away. It allowed me to explain things very quickly and also they enjoyed seeing something different in the class because they are so used to me standing up in the class and just talking. I think they enjoyed seeing something different. Also I was able to do a few different things that like the simulation wasn't designed for like making a skateboard fly and then they enjoyed that kind of stuff.

From here, it follows that the learners could learn more conceptually although this did not translate to increased performance in their tests results. A couple of other reasons such as the students' level of preparedness for the tests could be responsible for this performance level which is not the focus of this research. Other similar studies conducted report that there was statistically significant difference between the control and experimental groups.

For example, Kumar and Sherwood (2007) conducted a study of the effect of science teaching with a multimedia simulation called River of Life on water quality on the science conceptual understanding of 83 students in an undergraduate science education (K-9) course and they reported that there was statistically significant difference between the pre-, post- and delayed post-tests administered to the participants involved in the study ($p < 0.05$).

The study reported in Kumar and Sherwood (2007) research contrasts with my study in the sense that there was a larger sample involved (83 compared to my study with 30 students in the experimental group), the study was conducted on 'composition of air, macro invertebrates, dissolved oxygen, classes of organisms that form a river ecosystem, and graph reading skills' with some undergraduate students in a science education programme while my study was on the teaching of kinematics in Physical

Science in a Grade 11 class. Some other research studies have also reported that the use of CAI ensures significant difference in the achievement of the learners.

Research question 2: The question is how does a teacher embrace the use of ICT in the teaching of kinematics to create a pedagogical change from the traditional modes of instruction (teacher-talk method)?

In order to answer this research question, the data from the interview and classroom observation was analysed. Observation of Mr. C's lessons shows that the simulations were not frequently used in the lessons. Mr. C sited the problem of adaptation as the reason for not constantly using the simulations because according to him since the simulations were not written for the South African curriculum it became necessary to adapt it to suit the particular lesson at hand. Although he reported that he enjoys using technology and that he uses technology in his lessons almost every time. The transcript below shows the exchanges between the interviewer and Mr. C during the interview.

Mr. C (line 184):	Yeah I enjoyed it so I spent a little bit of time because I saw that the learners were enjoying it so that's why I spent a bit of time going through it. It was good to use
Interviewer (line 187):	Some of the things I got from the learners were that that was a very good thing because they were able to see some things really in action rather than the normal method of being told how it works and things like that.
Mr. C (line 191):	The one that we are talking about I think is the Newton 2 practical or the Newton 2 simulation that we did. Yeah, it was very good because the guys even came out with the Newton's second law in words by themselves. They've never been introduced to it. Yeah, I think they enjoyed it, it was very good.
Interviewer (line 196):	Ok. So we are moving on to the last part of the questions. This part we just want to know in the past year how well did you use technology? Not simulations this time around but you using technology maybe typing things or whatever how often or how well do you use technology?
Mr. C (line 201):	I use technology every single day. I type their worksheet, I prepare assignments, I use the smart board. Every single day I'm using technology.

In Mr. D's class technology is used rarely because he is more accustomed to the traditional teacher-talk method. He mentioned a few occasions when he has used technology in teaching such as using it to teach the human body system and indicated

that the use of technology to him depends on the topic at hand. According to him some topics are amenable to the use of technology while others are not. He sees technology in the classroom learning environment as a very useful tool but fears that over-reliance on it could make teachers to lose sight of the real content teaching and creating conceptual understanding in the learners. He sees the use of technology such as simulations as a complement of the other teaching method.

> Line 138 Of course, em.. it's like in every other field it could happen for some teachers for example that they rely too much in the technology or in animation or what they can show graphically through the computer and perhaps people could lose sight of the real teaching or concern for the understanding of the learning so it's easy to just spend time showing animation or showing things through the computer but perhaps I mean it shouldn't stop there you have to make sure that the learning process is taking place and you have to also evaluate how what you have been doing is useful or for the learners also and so yeah it's like a medical doctor who has the machine to, I don't know, that helps to know what is going on with a patient but of course they have to look further and they have to apply what they think in their knowledge for it to really work properly.

Mr. D's concern for the use of technology in teaching may have been responsible for his less use of technology to create a pedagogical change from the traditional teacher-talk method. He identified a couple of advantages of the use of technology and simulations in teaching such as the simulations helping to create better visualization of the situation. For example, the transcript below shows one of the cases mentioned by Mr. D:

> Line 196 Ok, in Grade 11 and 12, it was very interesting to use electromagnetism animation and simulation especially concerning generators and motors because it's very difficult to show the learners really in the white board or to…I mean you need to have a lot of materials really, lab materials to show it. And actually it's difficult to show it even if you have it but the simulation in the computer, the way current produces the magnetic field and the way the coils rotate was really, really good and you can show actually the direction of the magnetic field and the direction of the current. How it changes with the commutator and that in the computer was fantastic.
>
> Especially it was very good for me to use technology in biology which is very nice to show the systems in the human body and functioning of some systems within the different organs within the human body. That was fantastic really.

Research question 3: The question states that what are the factors hampering the use of ICT for instructions in Physical Science? In order to answer the research question 3, analysis of the interviews with the two teachers involved in the study (Mr. C and Mr. D)

was conducted. Both teachers identified a number of factors which are consistent with the factors that hinder the use of technology in the teaching of Physical Science that are available in the literature:

- Anxiety about the use of technology: Mr. C observed that some teachers are nervous to try out new things, therefore they stick to the old method they are used to which they may have tested over and over and can trust any time because the method will not fail them. According to the teacher, he feels that this factor is one of those that hinder the use of technology in teaching Physical Science even though the technology may be available. This transcript below shows the response of Mr. C to issues that relate to the researcher's question.

…………also can I add in something not only time wise, but I think that educators are quite nervous to try out new things as well as time wise I think it's difficult for them to have the confidence to go out to the Internet and look for new software. I don't think teachers are comfortable in researching that stuff. I think if they were introduced to it as I've been introduced to it I think they would be more comfortable and willing to do more research more...look for more software to use.

- Time factor: another factor identified by the two teachers is the issue of time. Mr. C claims that he teaches 38 periods out of the available 50 periods in a week and addition to other duties he has in the school such as being a sports master. He said he hardly has time for other things. This factor is consistent with Stols' (2008) findings about why teachers don't use ICT in their classrooms. Stols (2008) observed that the didactic teaching period is already long enough that teachers may consider the use of technology as an additional time requirement which may prevent them from covering the content which is specified in the curriculum. Mr. C explains in this extract response why time is a factor that hinders the use of technology in Physical Science teaching.

Yeah it's true eh..I think that's why teachers stick to what they know and they don't have the time to go and look out stuff but as well as that I think we could make the time because I think that time must not be used as an excuse but you're right it is a heavy timetable but also we could do a research properly and you could save the time at the end of the day.

- Availability of technology: The two teachers indicated that theirs is one of the well-resourced schools and that the township schools are not as privileged as theirs so the availability of the appropriate technology is not an issue with the teachers. They note however that making choices between the available technologies could create a challenge. Mr. D did not see much importance or success in the Department of Education’s online programme which is referred to as Gauteng online. He thinks that more effort should be concentrated on uplifting of teachers and training.

- Pre-service training: The two teachers interviewed were privileged in their pre-service training days to have been trained in the use of ICT. They however observed that not many teachers had similar privilege in their pre-service days to be trained in the used of ICT. For example, Mr. D was trained as an engineer and he said that he had the opportunity to use different types of ICT when he was in school. These are the words of Mr. D when asked about his undergraduate training in the use of technology.

  > Line 178 Yeah. The thing is that my case is a little different especially because I am an engineer. I didn't study to be a teacher really in an undergraduate degree programme. I studied engineering and in engineering of course you do have plenty of possibilities to manage ...to use high level technology so it makes it very easy to implement that technology in the classroom. I don't know what's going on with the teachers really.

  Mr. C on the other hand said he had training in the use of various technology tools as well as some training in programming in his pre-service days. Mr. D gave his words in the interview and below is an excerpt from the interview.

  > Line 152 Ok, mine is quite big because I actually did a computer course at university so one of the years at varsity I actually did a computer course but when I think about the guys in my course even in my honours course out of about 19 people this is the first year that about 6 people have even submitted an assignment that have been word processed. So even at honours’ level people haven't used computers. Even though I have proper training in computers and I have used them for a long time, other people my age in this same job as me they haven't even used Microsoft word before. So yeah...

- Attitudes and beliefs of teachers: There is much literature about the attitudes and beliefs of teachers as being hindrances to their use of technology in teaching. For example, Zachariah (2003) who studied the beliefs, attitudes,

and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics reported that generally "beliefs affect attitudes, and these attitudes then affect intentions and behaviours" (p. 812). The views that attitudes and beliefs of teachers hinder the use of ICT in teaching of Physical Science were corroborated by the two teachers interviewed. They noted that teachers sometimes are not convinced that ICT is capable of making any difference in their teaching so they are not convinced to use it.

4.5 Summary

In this chapter, I have described the data collected during the research and presented an the analysis of the data. The quasi-experimental design was used in the study to establish the effects of the intervention (the use of simulations) on students' learning outcomes. Two groups which are comparable in terms of academic ability in previous school examinations which form the yardstick for placement in the middle class of the grade. Learners in the two groups were involved in the study, and identified as experimental and control groups. The experimental group used the intervention while the control group followed the normal method of teaching adopted by Mr. D. There was no intervention by the researcher on the method of teaching adopted by Mr. D.

Analysis of the data indicated that there was no statistically significant difference in the achievement of the two groups after the treatment which results in upholding the null hypothesis. Although the student interviews indicate that the simulations were helpful in helping them to visualize the concepts being explained by the teacher, this did not translate to improved or better performance for the experimental group.

The teachers claim that technology helps them to teach better because the time they would have spent on creating complex representations could be saved by the use of simulations and they can spend that time concentrating on explaining further concepts. Mr. D noted that if the teacher is to show complex diagrams on the board, then he should be competent in diagrammatic representations but the time needed to make the drawings can become a challenge.

Finally, the two teachers identified some factors which may hinder them from using technology in their classroom. Some of the factors identified are consistent with those that are available in the literature.

Chapter 5 summarises the findings from this study and provides answers to the research questions based on the data collected and analysed. It also provides recommendations and suggestions for further study.

Chapter 5: Discussions and conclusions

5.1 Summary of findings

This research study has examined mainly the impact of information and communications technology (ICT) in science teaching and learning and the way in which teachers are embracing the use of ICT in their teaching. Specifically, the ICT used in this research is simulation which is an instructional programme written to be played on the computer and it contains information that helps one to be able to teach since the information is presented in a form that encourages interaction with it such as in text or multimedia formats (http://encarta.msn.com).

Simulations are fast growing computer technologies which can assist the student in learning as well as the teacher in teaching Physical Science concepts. Multimedia learning can be incorporated into computer-assisted instruction whereby there will be photographs, videos, animation, speech, and music embedded in the multimedia learning tool. Computer simulations can support the modeling of Physical Science concepts and processes.

In chapter 1, I laid the foundation for the work to be done and gave some background to the research. The government's effort at incorporating information and communications technology into the curriculum must have been necessitated by the belief that ICT has the potential to revolutionise the teaching and learning environment. Research evidence abound that ICT is effective in raising students' interest and achievement in Physical Science which is generally considered to be a relatively difficult subject compared to other subjects and where students have many misconceptions as identified by literature. For example, Bayraktar (2001) who conducted a meta-analysis of the effectiveness of computer-assisted instruction in science education found an overall effect size of 0.273 which implies that a student can move from the 50th percentile to the 62nd percentile in science when CAI was used. Although this analysis covered various aspects of science education, the evidence from the analysis suggests that CAI is effective. In chapter 1, I also proposed a null hypothesis which was tested to determine if CAI had any effect in students' achievement when used in Physical Science instruction.

In chapter 2, I examined a number of literature on CAI and various studies that have been conducted on the integration and effects of information and communications technology on the teaching of Physical Science in high schools. The theoretical framework guiding the study was formulated in chapter 2. This theoretical framework was according to the work Vygotsky's (1978) zone of proximal development (ZPD). The ZPD is a transformative space where the learner can be helped by a more capable peer or adult to reach the potential development level. The simulation was used by the teacher to help a learner reach the level of potential development. This was evident during the teaching and learning process where a learner responded that he could see what the teacher was saying after he (Mr. C) used the simulation to explain what happens when an apple falls from a tree. The student was able to quickly respond that the formula for determining the force acting on a falling object is equal to the mass of the object x acceleration due to gravity. The criteria used to determine that the level of potential development was reached was based on the response of the learners during instruction as they made comments such as "I understand now….I see what you mean…etc". The interaction that arises during the use of the simulations by the teacher can bring about some valuable input that other learners will benefit from when they listen to and contribute to the discussions. This creates opportunities for the learners to transform what they can pick from the inter-psychological, which is between the learner, and the peers or the teacher, to the intra-psychological, which become internalised learning (Vygotsky, 1978). Vygotsky's (1978) work was an extension of the cognitive constructivism because the learner rather than just constructing his own mental structures as proposed by Piaget (1978) not in the reference list is helped to reach that zone of proximal development by a more capable peer or the teacher.

In chapter 3, I discussed the methodology to be followed in the research. The research design used for the study is a quasi-experimental design because I was not able to control the variables involved in the study. The quasi-experimental research design formed the basis for the investigation of the hypothesis. It made use of a pretest and posttest design instruments where the learners were given a test before the treatment or intervention (simulation) was used and a posttest was also given after the simulation had been used to instruct the learners. Other data collection methods used in this study

were classroom observation and interview techniques. These methods enabled me to gather data on the way the teachers embrace the use of ICT in their teaching of Physical Science as well as the factors that may hinder teachers from using ICT in their teaching. These methods have been used by other similar research studies such as Jimoyiannis and Komis (2001) who studied the use of computer simulations in physics teaching and learning using students' understanding trajectory motion as a case study. The instruments used in the study were piloted so that their validity and reliability can be tested and ensured. The pilot study enabled the review of some of the items in the interview questions for clarity and also allowed me to test the simulation before the actual implementation in the classroom. The class used for the pilot study is a Grade10 class in the same school. The pilot study also enabled the teacher and the researcher to examine the appropriateness of the simulations.

In chapter 4, I presented the data obtained from both the classroom observation and the interview schedules with the teachers and students. A detailed description of how Mr. C used the simulation instrument in his class was provided in chapter 4. The data collected was analysed both qualitatively and quantitatively in order to answer my three research questions. To be able to answer research question 1, statistical methods (descriptive and inferential) were used to determine the level of significance of the students' performance in the pretest and posttest. The results of these analyses show that there was no statistically significant difference between the experimental and the control groups in the pretest and posttest. This suggests that the null hypothesis which states that "*the use of CAI does not impact on the teaching and learning of Physical Science concepts (kinematics) in Grade11"* was therefore accepted. Although, the results of the analyses show that there was no statistically significant difference in the performance of the two groups, the students in the experimental group reported that the simulations enabled them to understand the complex structures that the teacher was teaching more easily and that the lesson was more fun. This is similar to the result obtained by Hsu and Thomas (2002) who conducted a research and found no significant differences on post-test scores of the experimental and control groups. They also conducted post-intervention interviews which shed more light on the thinking of the students as well as how the CAI impacted their learning in other ways. They were able

to understand the concepts being taught by the teacher well and this helped them in completing the worksheet more quickly.

5.2 Answering the research questions.

The first research question which guided my study was “how does computer-assisted instruction (CAI) influence the performance of Grade 11 learners in kinematics?

In answering this research question, the analysis of the results of the posttest shows that even though the two groups show no statistically significant difference in the performance in the pretest, they also show no statistically significant difference in performance in the posttest which leads to the acceptance of the null hypothesis. Other research findings reviewed in the literature reported statistically significant differences in the achievement levels of the control and experimental groups after the use of an intervention such as simulations in students’ teaching. Although the reason why the students showed no statistically significant differences in their performance in the posttest is not the focus of this research, there could be a number of reasons responsible for this. For example, eight out of the ten students interviewed consider Physical Science as a difficult subject when compared with the other subjects they take. The reason being adduced here could be that of attitude of the students to the subject.

Mr. C who was the teacher of the experimental class was able to use the simulations adequately because he spent some more time in addition to the training provided by me to learn how to properly integrate the simulations into his lessons. Analysis of the interview shows that the students in the experimental class preferred to learn with the simulation. For example, a learner said he would like to see all subjects taught with some kind of technology because the simulations helped him to be able to visualize the concepts that the teacher was teaching. The teachers said that whenever they use any form of ICT to teach their learners they always notice that the learners are more receptive and interested in what they are teaching. Mr. D described the ICT he has used in his teaching before as “amazing” and suggested that the traditional teaching method and the use of technology should complement each other. The activities in the simulations are learner-centred and can promote individualized teaching especially when the learners are able to interact with them directly.

The second question that guided my research was:

> "How does a teacher embrace the use of ICT in the teaching of kinematics to create a pedagogical change from the traditional modes of instruction (teacher-talk method)?"

In order to answer this question, the data collected from classroom observation and teacher interview was analysed. Results of the analysis show that although the teachers perceive information and communications technology (ICT) as a useful tool in the classroom, however, they still prefer to use the traditional method which they are more acquainted with and they are resistant to change which makes them to continue to use the old method. This attitude may be due to many reasons which have been identified in literature. For example, Stols (2008:1) reviewed a number of literature and found that the literature is full of examples of "teachers' negative attitudes, negative feelings and negative perceptions towards computer use for instructional purposes". Mr. D said that he often prefers to use the traditional teacher-talk method together with the chalkboard because it is faster and becomes handy as it does not require a lot of planning as compared to using ICT in the classroom. He noted that sometimes you do not want to take a risk of using a technology that you are not competent in to teach a lesson and end up being disappointed and frustrated.

The third question that guided my research was:

What are the factors hampering the use of ICT for instructions in Physical Science?

In order to answer this question, the data collected from teacher interview was transcribed and coded to determine common occurrences in the factors which may be responsible for the non-use of ICT in instructions. Analysis of the interviews and classroom observation shows that teachers do not generally embrace the use of ICT in their teaching as a result of many factors one of which is the teacher's attitude and belief in the use of ICT. Teachers generally prefer to use the method they are accustomed to (teacher-talk) rather than learner-centred methods or exploring new grounds that ICT offers.

Factors identified in the study as hampering the use of ICT by teachers are:

- Anxiety about the use of technology:
- Time factor

- Availability of technology
- Pre-service training
- The demand of the curriculum

These factors are consistent with those identified by Stols (2008) and BECTA ICT Research (undated) in their review of what research says about barriers to the use of ICT in teaching.

5.3 Implications and Recommendations

Science teachers all over the world are looking for ways to make science learning meaningful and more understandable to learners. Various approaches to achieve this have been put forward in literature but teachers may not be able to decide which of the methods will work for them unless they are tried out. The use of ICT such as CAI is one approach that has been recommended for use by teachers in order to promote students' conceptual understanding.

The method of use or the way it is implemented in the classroom is of utmost importance. It is recommended that CAI be used to complement other methods such as tutorials, analogies, and practical and not wholly as a method that is capable of achieving full understanding of concepts by the learners. Teachers need to consider the topic to be taught carefully before adopting a particular method of teaching as corroborated by one of the teachers interviewed (Mr. D).

More work needs to be done on the development of simulation software that adequately addresses the South African curriculum in Physical Science. As noted earlier in this report, it was a herculean task getting simulation software that covered the concepts in kinematics very well.

A number of challenges do arise as teachers try to implement ICT usage in their classroom, it is recommended that they prepare adequately to use whatever ICT available before implementing it in the classroom. Some teachers receive training to use ICT in their undergraduate course while some other teachers do not receive any training in the use of ICT therefore the government should incorporate and encourage teachers to do in-service training for teachers in the use of ICT.

Teachers' attitudes to the use of ICT has been identified in the literature as a barrier to ICT usage in instruction, therefore every effort should be made to encourage teachers to use ICT in teaching.

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Appendices

Appendix A: Teacher Interview Schedule

Dear respondent,

This interview has been designed as part of instruments in a Master's course research looking at the impact of information and communication technology (ICT) in the teaching and learning of physics concepts in Grade 11. ICT in this context refers to any technology that aids teaching and learning but with particular emphasis on simulation software or computer assisted learning software.

Your responses will be strictly confidential and data from this research will be reported only in the research report and paper presentations at conferences. Your information will be coded and will remain confidential.

Thank you very much for your time and support.

Question 1: What are the factors hampering or promoting the use of ICT for instructions in physics?

1.1 Have you ever used any form of Information and communication technology (ICT) such as DVD, models etc. in your science teaching?

1.2 What kinds of teaching aid have used in your teaching?

1.3 Do you have access to computers after school?

1.4 Do you have access to the Internet in school or at home?

1.5 What computer applications e.g Ms Office suite etc. do you use?

1.6 How many periods of teaching do you do?

1.7 What other duties are you assigned in the school?

1.8 How do you think computers can be used in teaching or to aid students' conceptual understanding?

1.9 What would be your concerns in an ICT teaching and learning environment?

1.10 What are your opinions about the government e-learning incorporation into the curriculum in South Africa?

Question 2: How well did your pre-service science and mathematics education training prepare you to use the following examples of ICT in your science teaching? Were you taught how to use any of the following examples of ICT in your pre-service training?

1. CDs of science/mathematics concepts 2. Databases 3. Data projector 4. Digital camera

5. Data projector 6. Simulations 7. PowerPoint 8. Word documents 9. Excel spreadsheets

10. Internet research/email communication 11. Online learning/assessment

2.12. E-journal/electronic textbooks

Question 3: In the past year, did you use any and how often have you used these examples of ICT in your science teaching?

1. CDs of science/mathematics concepts, 2. Databases 3. Data projector 4. Digital camera 5. Data projector 6. Simulations 7. PowerPoint 8. Word documents 9. Excel spreadsheets 10. Internet research/email communication 11. Online learning/assessment 12. E-journal/electronic textbooks

Question 4: How do you view the learners' reception of the simulation?

4.1 What is your opinion about the simulation lessons when compared to the traditional methods of instruction?

Question 5

If you have the opportunity to use ICT in your instruction, how often would you like to use it?

Appendix B: Students' interview schedule

1. Do you have access to a computer at home?
2. How long have you been using computers?
3. What is your general opinion about Physical Science in terms of difficulty level?
4. Have you ever learnt science using ICT such as Internet, DVD etc.?
5. If you use computers at home, what do you do with your computer?
6. Do you go to the computer lab for any lessons?
7. Do you have internet access at home?
8. What type of software do you use regularly?
9. What do you enjoy about the simulation lessons?
10. What don't you like about the simulation lessons?
11. If you compare the simulation lessons with the other methods used by your teacher, which would you prefer?

Appendix C: Letter to the headmaster/principal

To the headmaster/principal,

My name is Kayode Mathews Arowolo, a full time Master's student at the University of the Witwatersrand, Johannesburg. I am investigating the impact of Information and Communication Technology (ICT) on the learning and teaching of kinematics in Grade 11 Physical Science. I would like to request for your permission to use a computer simulation to teach learners in Grade 11 Physical Science, interview and collect data from the Grade 11 Physical Science teachers and learners.

There would be no interruption of your normal school programme, I would follow the normal school timetable and the Physical Science teachers would use the computer animation to teach kinematics in the computer lab. After the intervention, I would collect data by interviewing learners and teachers. The data collected will be treated with confidentiality and the names of your school, the teachers and the learners will not be used in the analysis of the data.

The teachers will benefit from the research since they would be trained in the use of the intervention. The learners would also benefit from the method of instruction as it is hoped that this would enhance their understanding of the concepts.

Please do not hesitate to contact me if you have any further queries or clarifications to make. My contact details are:

Cell number: 079 611 4755, Home: 011-359-6073 email: kmarowolo@yahoo.co.uk

I look forward to your anticipated positive response.

Thank you.

Yours faithfully,

K. M. Arowolo

Consent form for principal/headmaster

I_______________________________________ the headmaster/principal of _______________________________________ school hereby grant consent to Mr. Kayode Mathews Arowolo to involve the Grade 11 learners and teachers in his research.

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

Signature:____ Date: ______________

Appendix D: Letter to the educator

Dear educator,

My name is Kayode Mathews Arowolo, a full time Master's student at the University of the Witwatersrand, Johannesburg. As part of the requirements for the award of a Master of Science degree in Science Education, I am investigating the impact of Information and Communication Technology (ICT) on the learning and teaching of kinematics in Grade 11 Physical Science. I would like to request you to be part of my study. The study will involve the use a computer simulation to teach learners in Grade 11 Physical Science. I would collect data by observation of the lessons and interview you after the intervention programme.

Participation in this research is voluntary and there will be no victimization whatsoever for refusal to participate.

There would be no interruption of your normal school programme, I would follow the normal school timetable and you would use the computer simulation to teach kinematics in the computer lab. After the intervention, I would also collect data by interviewing the learners. The data collected will be treated with confidentiality and the names of your school, yourself and learners will not be divulged.

It is hoped that you will benefit from the research since you would be trained in the use of the intervention. The learners would also benefit from the method of instruction as it is hoped that this would enhance their understanding of the concepts.

Please do not hesitate to contact me if you have any further queries or clarifications to make. My contact details are:

Cell number: 079 611 4755, Home: 011-359-6073. email: kmarowolo@yahoo.co.uk

I look forward to your anticipated positive response.

Thank you.

Yours faithfully,

K.M. Arowolo

Appendix E: Consent form for teachers to participate

I__________________________________ a teacher at

_____________________________________ school hereby grant consent to Mr. Kayode Mathews Arowolo to be part of his research. The data that will be collected from me and my class should only be used for research purposes and conferences.

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

Signature: _______________________________________ Date: _______________

Appendix F: Interview Consent form for teachers

Please complete, sign and return the form below

Put a tick in the box if you are consenting

- ☐ I am willing to be interviewed for my opinion on the computer simulation lessons
- ☐ I am willing to be interviewed on access to computers
- ☐ I am willing to be involved in lesson reflection interviews
- ☐ I give consent for audio recording of these interviews
- ☐ I give consent for the use of such audio recording of these interviews with me in them for purposes of research, publications, teacher-education and training.

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

The extra copy of this form is for you to keep.

Thank you.

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

Signature of teacher **Date**

Name *(Please print)*

Appendix G: Recording Consent form for teachers

Please complete, sign and return the form below

Put a tick in the appropriate box

☐ I give consent for being audio taped during the interview

☐ I give consent for audio and video tapes with me in them resulting from this study to be shown at academic conferences, workshops and seminars

☐ I give consent for audio tapes with me in them resulting from this study to be used for purposes of research and publications, teacher-education and teacher-training programmes

☐ I give consent for audio tapes with me in them resulting from this study to be kept for up to three years if necessary

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

The extra copy of this form is for you to keep.

Thank you.

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

Signature of teacher ***Date***

Please print your name

Appendix H: Letter to the parent

Dear parent,

My name is Kayode Mathews Arowolo, a full time Master's student at the University of the Witwatersrand, Johannesburg. As part of the requirements for the award of a Master of Science degree in Science Education, I am investigating the impact of Information and Communication Technology (ICT) on the learning and teaching of kinematics in Grade 11 Physical Science. I will like to seek your consent for your child to be part of my study. The study will involve the use a computer simulation to teach learners in Grade 11 Physical Science. I will collect data by observation of the lessons and interview your child, which will be **audio taped**, after the intervention programme. Participation in this research is voluntary and there will be no victimization whatsoever for refusal to participate.

There will be no interruption of your child's normal school programme, I will follow the normal school timetable and your child will be taught with the use of computer simulation in the computer lab. The data collected will be treated with confidentiality and the name of your child will not be mentioned in the analysis of the data. That is, the name and identity of your child will be protected in this study.

It is hoped that your child will benefit from the research since the simulation is to enhance the learners' understanding of Physics concepts.

Please do not hesitate to contact me if you have any further queries or clarifications to make. My contact details are:

Cell number: 079 611 4755, Home: 011-359-6073 email: kmarowolo@yahoo.co.uk

I look forward to your anticipated positive response.

Thank you.

Yours faithfully,

K.M. Arowolo

Appendix I: Consent form for parents

I ________________________________ the parent of ________________________________ hereby grant consent to Kayode Mathews Arowolo to allow my child to be part of his research. The data that will be collected from my child and his/her class should only be used for research purposes and paper presentation at conferences. The data collected will be treated with confidentiality and neither the name of the school, your child or the teacher will be mentioned in the analysis of the data.

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

Signature: ____________________________ Date: _____________

Child's name ________________________ Signature: _________Date: _________

Appendix J: Consent form for students' participation in the study

I,……………………………….of ……………………………………………(school) have read and understood the procedures involved in the study and what is expected of me as a participant. I understand that my name and identity will be protected in the study. I willingly give the following consents:

Please put a tick in the appropriate box

☐ I am willing to participate in the study

☐ I give consent for being observed during my Physical Science lessons

☐ I give consent for my Physical Science notebook being checked

☐ I give consent for part(s) of my Physical Science notebook to be photocopied if necessary

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

The extra copy of this form is for you to keep.

Thank you.

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

Signature of student ***Date***

Name *(Please print)*

Appendix K: Recording Consent form for students

Please put a tick in the appropriate box

☐ I give consent for being audio taped during the interview

☐ I give consent for audio tapes with me in them resulting from this study to be used at academic conferences, workshops and seminars

☐ I give consent for audio tapes with me in them resulting from this study to be used for purposes of research, publications, teacher education and training programmes

☐ I give consent for audio tapes with me in them resulting from this study to be kept for up to three years if necessary

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

The extra copy of this form is for you to keep.

Thank you.

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

Signature of student ***Date***

Please print your name

Appendix L: Interview Consent form for students

Please complete, sign and return the form below

Put a tick in the box to indicate that you are consenting

☐ I am willing to be interviewed for my opinion on my Physical Science lessons

☐ I am willing to be involved in lesson reflection interviews

☐ I give consent for audio recording of these interviews

☐ I give consent for the use of the analysis of such audio recordings the interview with me for purposes of research, publications, teacher-education and training.

The data collected will be treated with confidentiality and the name of the participants (teachers and learners) will not be mentioned in the analysis of the data. The participants (teachers and learners) may withdraw from the study at any time.

The extra copy of this form is for you to keep.

Thank you.

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

Signature of student **Date**

Name *(Please print)*

Appendix M: Student Interview Transcript

STUDENT A

Interviewer: Ok can you please introduce yourself?
Student: I am student A, (school name deleted for confidentiality), I'm in 11C
Interviewer: Great?
Student: I'm great here
Interviewer: Grade?
Student: Grade 11
Interviewer: Eh…Can you have access to internet…..computers at home?
Student: Yes I do
Interviewer: Oh you do.
Interviewer: How long have you been using computers?
Student: I've been using computers since primary school if I think correctly since Grade 5
Interviewer: Ok when you look at it how many years would that be?
Student: About 6 years
Interviewer: When you look at physical science….you said you do subjects like accounting, business studies……when you look at physical science how do you compare it with other subjects in terms of difficulty level?
Student: Compared to other subjects physical science has got its own level of difficulty. It's a subject whereby if you understand what is going on and you have got that inquisitive mind you will find interest in it…if you work on it everything would fall into place.
Interviewer: Ok. So from there it means that you don't find it difficult
Student: Up till now NO.. Let's just say certain sections of it.
Interviewer: Ok then good. The next thing we need to look at is ICT in your teaching in science. You know what I mean by ICT. Information and communications technology…Be it Internet, DVD, videos. Any kind of technology in teaching, simulations…that's technology in teaching. So have you ever learnt science with any of these technologies?
Student: Before you introduced it…..No. It has always been the proper way of doing it. The most commonly used way.
Interviewer: What do you mean by the most commonly used way? Can you try to break it down?
Student: Commonly used way I mean teacher comes to class explains it as best as he could, writes on the board and do practicals
Interviewer: If you use computers at home, what do you do with computers at home?

40.	Student:	I use computers at home on the Internet searching information, downloading music and movies, getting to find out what's like hot and what's not
43.	Interviewer:	Ok.What average time on the computer which time do you spend on academic stuff?
45.	Student:	Average time I spend on the computer?
46.	Interviewer:	Just average
47.	Student:	Not much. Let me give you in percent. About 20% - 30%
48.	Interviewer:	which means if you spend 30% for academics the other thing go for social life. Ok.
50.	Interviewer:	Do you go to the computer lab for any lessons? Any science lessons?
52.	Student:	Not until you introduced the electronic system. No
53.	Interviewer:	Do you do computers in school? Maybe computer lessons or whatever it is?
55.	Student:	Yeah. Only ICT in Grade 8 because it was compulsory. After that I didn't do it.
57.	Interviewer:	What do you call it then?
58.	Student:	I call it….Do you mean what we called it?
59.	Interviewer:	yeah.
60.	Student:	IT…Information Technology
61.	Interviewer:	Ok then, you have Internet at home, you get resources and only 30% are for academic purposes. What type of software do you regularly use?
64.	Student:	I'm not particularly used to a type of software, as long as I can just get on to the Internet. I am telling you right now I'll not know what type of software I use
67.	Interviewer:	Do you something like MS Office, Excel….
68.	Student:	It depends 'cos it depends on the computers available..My dad uses Microsoft professional and it appears we might use Microsoft windows
71.	Interviewer:	Ok..
72.	Interviewer:	Let's go to the simulations. The lessons you had with the simulations. Is there anything you enjoyed about the simulations?
75.	Student:	yeah…yeah…It was actually quite interesting. Being able to see what actually happens. We used to see it in a way whereby they explain it to us, draw it and you sort of like have to visualise it. Now seeing it makes it quite interesting
79.	Interviewer:	Ok.
80.	Interviewer:	What do you think is not good about the simulations? What would you have loved to have that you didn't have?
82.	Student:	I don't know…Nothing really heh..It was the first time it was introduced so I think everything was perfect.

84.	Interviewer:	Would you have loved to see you as a student interacting with the simulations rather than the teacher showing you what is happening?
87	Student:	The teacher showing us what was happening was a very, very good idea because if you leave us with electronic stuff we're going to figure something else.
90.	Interviewer:	Ok...
91.	Interviewer:	Compared to your performance in the previous….because what we are trying to do we are trying to see is there any improvement or how does it effect your learning, things like that? That's the basic thing we are trying to do with this research. So if you compare your previous performance and the after test....Any difference.
97.	Student:	I would say there is improvement particularly in the understanding of Newton's law. The first couple of tests I wrote they were actually quite okay…quite good..And we wrote a cycle test just after this whole thing had been introduced and the performance was quite impressive
102.	Interviewer:	Ok. Now comparing the simulations with the other methods which you mentioned that the teacher was using, how do they compare? What's your impression?
105.	Student:	I believe comparing them you can't just compare them together because the one with the simulation, great understanding. Actually it evokes that understanding
108.	Interviewer:	Great! I'm really grateful for your time because you have really given me a lot of things to think about in my analysis
110.	Student:	It was a pleasure.
111.	Interviewer:	Cheers
112.	Student:	Cheers

STUDENT B

1.	Interviewer:	You are welcome. Please can you introduce yourself?
2.	Student	I'm Student B, Grade 11C
3.	Interviewer:	What are the subjects you do?
4.	Student	Geograph, Maths, Science, English, Afrikaans, Guidance
5.	Interviewer:	Do you have access to computers at home?
6.	Student:	Yes, I do
7.	Interviewer:	Ok, you do have access to computers at home.
8.	Interviewer:	How long have you been using computers?
9.	Student:	About 5 years
10.	Interviewer:	Ok, about 5 years
11.	Interviewer:	When you look at physical science compared to all the other subjects you do in terms of difficulty level, how do you see physical science?

14.	Student:	I find it pretty hard
15.	Interviewer:	Ok you find physical science pretty hard compared to your other subjects ok.
17.	Interviewer:	Have you ever learnt……learnt science using the so called technologies…any of the so called technologies. That is, information and communications technology. I would give you examples like watching science lessons on DVD, using simulations, things like that?
22.	Student:	Yes, I have.
23.	Interviewer:	Please can you be specific about the kind of technology you have used?
25.	Student:	We've watched shows on DVD's
26.	Interviewer:	Ok. Now if you use computers at home, what do you do with computers at home?
28.	Student:	I listen to music, go on facebook
29.	Interviewer:	Ok thank you for being honest with that. Which means that your academic or research work do not really function much
31.	Student:	Yeah…
32.	Interviewer:	Ok. Ehh…Do you go to computer labs for any lessons in school?
34.	Student:	Lessons on computers
35.	Interviewer:	At home you have access to the Internet. You don't use the internet to do any researches?
37.	Student:	Occasionally when I have research for school I do. Then I use it for researches.
39.	Interviewer:	It means is only when you have research to do…
40.	Student:	It's only when I have research for school
41.	Interviewer:	You are not motivated to start looking for school stuff.
42.	Student:	No, not really.
43.	Interviewer:	Let's come to the simulation lessons. What do you enjoy about the simulations?
45.	Student:	It's more visual. You can see what you have to do instead of just hearing what you have to do
47.	Interviewer:	Ok..now in terms of the kind of lessons that the simulations showed you, how do you compare it with the normal or the kind of methods that the teacher always use?
50.	Student:	I find them a lot more interesting and a lot easier to understand
51.	Interviewer:	Ok.
52.	Interviewer:	At home what kind of software do you use?
53.	Student:	Windows media player and then the Internet
54.	Interviewer:	So basically you don't use Excel, Microsoft word
55.	Student:	No, not that stuff.
56.	Interviewer:	Now what is it about the simulations that you don't like? Is there anything?

58. Student: Not really, I enjoyed them
59. Interviewer: Ok, you enjoyed them.
60. Interviewer: Ehh….So I want you to be specific now the simulations. Any particular one that you really liked..That made your understanding to be quite clear? Maybe any particular aspect of the simulations. The way the teacher was teaching…Any particular aspect?
65. Student: All the visual things helped a lot because it shows you what you're supposed to be doing
67. Interviewer: Ok, so give me an example please
68. Student: So like if..instead of just getting told what to do…like you open that program on the board…on the small thing and it shows you what really happens and stuff
71. Interviewer: Great…So if you look at it when you were learning Newton's law, so how did you find……
73. Student: It showed the apple falling and how you can increase the apple's speed when falling and you can increase its mass and stuff.
76. Interviewer: Thank you very much….Thank you for your time.

STUDENT C

1. Interviewer: Ok, please first thing I would like to tell you about the research. I've already told you about the research and you know what it's all about so I'm just going to ask you a few questions. Can you please introduce yourself?
5. Student: Student C, (school name deleted for confidentiality), Grade 11C
6. Interviewer: Great. Can you tell me what subjects you do?
7. Student: I'm doing Maths, Science, Geography, Accounting, Life Orientation, English, Afrikaans
9. Interviewer: Do you have access to computers at home?
10. Student: Yes, I do
11. Interviewer: So you do have access to computers at home. How long have you been using computers?
13. Student: eh….since Grade 4
14. Interviewer: Grade 4…can you in terms of number of years
15. Student: 8 years
16. Interviewer: 8 years. That's quite a long time, which means you should be very good with the computers.
18. Student: Yeah, I know the basic stuff
19. Interviewer: haha…the basic stuff.
20. Interviewer: eh….coming to physical science..you do some other subjects…would you be able to tell me the kind of difficulty level you see compared to all your other subjects

23.	Student:	I would probably put it as one of the tougher subjects compared to others. It’s probably just learning so I would say it's quite a hard subject
26.	Interviewer:	Ok. Have you ever learnt science using ICT - information and communication technology like DVD, like simulations, like any kinds of technology in teaching science?
29.	Student:	Yes.
30.	Interviewer:	Can you give examples?
31.	Student:	eh… I've used Newton's law. I've seen a lot of diagram of it. Em…em the electricity section. That's pretty much it.
33.	Interviewer:	Those are the ones that you saw in the class but my question now is before that were you using technology to learn science?
35.	Student:	Not really
36.	Interviewer:	Now you use computers at home. What do you use computers to do at home?
38.	Student:	ehh..mainly for Internet..school projects..Yeah pretty much that
39.	Interviewer:	school projects. So when you try to assess the level of school projects that you do, how..in terms of percentage can you place it? Maybe when I go to the Internet I do school stuff for this number of time or this amount of time..
43.	Student:	hmmmm…probably come home. If there is any project to do I google it and whatever information I find I would use that
45.	Interviewer:	So ordinarily you don't go to the Internet looking for school stuff if there is no project
47.	Student:	No, not really.
48.	Interviewer:	Not really? Which means there are other things that are more interesting?
50.	Student:	Yeah, probably check my emails and do some other basic stuff
51.	Interviewer:	ok. In school here do you go to the computer lab for any lessons?
53.	Student:	hmm..not now
54.	Interviewer:	But you were going before
55.	Student:	yeah. Grade 8 & 9.
56.	Interviewer:	So what subjects were you doing then?
57.	Student:	All subjects
58.	Interviewer:	All the subjects..So IT was one of them?
59.	Student:	Yeah
60.	Interviewer:	Which type of software? Like Microsoft word, excel are you good at basically?
62.	Student:	em…Microsoft word…
63.	Interviewer:	Just that?

64.	Student:	Probably Ms word and excel
65.	Interviewer:	Ok. Eh…Now coming to the lessons..to the simulation lessons that you did. What do you enjoy about the lessons?
67.	Student:	I can say it's different. Like you can say a bit more fun with the lessons and I think it gives you a bigger outlook on the section probably more than a verbal lesson would be able to do. So you can obviously see what different things and what is happening. This increases, that decreases. So it's like more strategy
72.	Interviewer:	Ok. Eh..The simulations..Is there any bad or anything you don't like about it.
74.	Student:	No, not in particular. I thought the whole thing was actually very good
76.	Interviewer:	Now eh since you have not been using technology or ICT to learn science before, the normal thing you been doing is the teacher comes to class maybe he teaches you he gives you some exercises. That's the normal method.
80.	Student:	Yeah
81.	Interviewer:	Now when you compared this simulation method with the other normal method that you talked about, how do they compare what's the difference?
84.	Student:	Like I said it's probably the difference is more strategy. The normal lessons are good in our standard. Simulations provide extra bit of information that maybe is much easier to catch on to.
88.	Interviewer:	Ok. Eh now we are on the last question. In terms of your performance how because you did a test before then and we wanted to see if there any improvement so in terms of your performance how did you find the questions after the simulations?
93.	Student:	I find it much more understandable. Em..first question I didn't really know what was going on after the simulations it's like it was much more understandable. So you know what they are asking you know what the answer should be.
97.	Interviewer:	So now in terms of your performance so what do you say? Was there any improvement in the tests. First you had a test and then another cycle test. So compared to your previous performance.
100.	Student:	Yeah I'm not sure of the exact marks but there was an increase.
101.	Interviewer:	There was an improvement in the marks?
102.	Student:	Yeah
103.	Interviewer:	Any final comments?
104.	Student:	Good luck with your research.
105.	Interviewer:	Thank you very much.

STUDENT D

1.	Interviewer:	Good morning
2.	Student:	morning
3.	Interviewer:	Eh can you please introduce yourself? First you know what this research is about
5.	Student:	Yeah
6.	Interviewer:	You attended all the lessons for the…….
7.	Student:	Yeah
8.	Interviewer:	Let's begin by first getting your name.
9.	Student:	Student D, Grade 11C
10.	Interviewer:	Ok.
11.	Interviewer:	Eh do you have access to computers at home?
12.	Student:	Yes, I do.
13.	Interviewer:	Ok, you do have access to computers at home so how long have you been using computers?
15.	Student:	Since Grade 1
16.	Interviewer:	Since Grade 1 so that's approximately how many years?
17.	Student:	em.. 11
18.	Interviewer:	Ok that's quite a long time which means that you must be very good with IT stuff. Very good
20.	Student:	I just play games on them mostly
21.	Interviewer:	Ok so you play games mostly. Can you tell me what subjects you do here?
23.	Student:	English, afrikaans, maths, geography, history, science and life orientation
25.	Interviewer:	That's 7. Now if you look at physical science compared to all these other subjects how do you rate the level of difficulty?
27.	Student:	Science is a lot easier than maths but it's a lot harder than history, geography and english
29.	Interviewer:	Ok, great then you see science as something that is easier than maths but some other people see it the other way round.
31.	Student:	I'm not good at maths
32.	Interviewer:	Ok now do you have Internet at home?
33.	Student:	Yes, I do.
34.	Interviewer:	Ok. Now what do you do when you are on the Internet?
35.	Student:	Eh…facebook mainly
36.	Interviewer:	Ok, any other thing?
37.	Interviewer:	Great so you don't use the Internet for academic stuff
38.	Student:	Only when I have a project to do
39.	Interviewer:	Alright great. When you have a project then you can use the Internet to do searches and things like that.

41. Interviewer: Now if I may ask you have you ever learnt science with some kind of technology maybe watching some simulations or DVD or whatever it is.. Any kind of technology.
44. Student: No. Only in class
45. Interviewer: Apart from the ones we did any other time that your teacher has used this technology in teaching you?
47. Student: No.
48. Interviewer: Ok.
49. Interviewer: Now do you go to computer lab for any lessons here in school
50. Student: No
51. Interviewer: So you don't do IT at all?
52. Student: No
53. Interviewer: In your Grade 8
54. Student: I did it in Grade 8 & 9
55. Interviewer: Just Grade 8 & 9
56. Student: Yeah.
57. Interviewer: Can you give me some idea of the software you learnt?
58. Student: Word, excel and powerpoint.
59. Interviewer: Ok.
60. Interviewer: Excel and PowerPoint. Now you attended the simulation lessons
62. Student: Yeah.
63. Interviewer: Now looking at the simulation lessons, what do you like or what do you enjoy about them?
65. Student: They are more interactive than normal lessons and they are more interesting
67. Interviewer: Ok. More interactive and more interesting?
68. Interviewer: Is there anything you think is not adequate or you don't like about the simulations?
70. Student: No. It's a decent way of teaching.
71. Interviewer: Ok. A decent way of teaching. What would you like to see?
72. Student: All subjects taught like that.
73. Interviewer: Ok, all subjects taught like that.
74. Student: Yeah
75. Interviewer: Ok. Would it have made any difference to you if you directly interacted with the simulations rather than the teacher using it to explain things or to show you
78. Student: No.
79. Interviewer: Ok, so it's fine the way it was used.
80. Student: Yeah
81. Interviewer: Ok. Now we want to compare what it was like I mean your performance before the simulations and after you now did the test. You did a test and then you now did a

cycle test. Ok so what do you say about your performance? Has it helped you in any way?
Student: I think I got better marks with the simulation
Interviewer: Ok and…..
Student: So it did help quite a bit.
Interviewer: Ok. It helped quite a bit. Ok.
Interviewer: Any final comments
Student: No.
Interviewer: Ok, no final comments. Thank you very much.

STUDENT E

Interviewer: Yes you are welcome. Can you please introduce yourself and tell us the subjects you are taking.
Student: My name is Student E, I attend (school name deleted). Em..I take english, science, maths, afrikaans, geography and business studies.
Interviewer: Oh. So let's go to the questions. Do you have access to computers at home?
Student: I do.
Interviewer: Ok. How long have you been using computers?
Student: About say 6 years
Interviewer: About 6 years so do you say you are ok at using computers or very good?
Student: I'm not amazing but I know all like the basic things you need to know when you want to do your work.
Interviewer: Ok, great. Now let's look at the subjects you do. When you look at science how do you compare it in terms of the level of difficulty with all the other subjects?
Student: It's much harder. I mean most of the subjects you compare like the maths theory and science to real maths is actually easier but applying it and you know working out stuff in science because of theory and the maths makes it a lot more and harder to understand but I think if you do start understanding science it becomes easy
Interviewer: Ok.
Interviewer: Now learning science in other ways apart from the normal teaching ways that the teacher comes to class and teaches you. Have you ever learnt science using technology like the Internet or DVD or whatever kind of technology?
Student: No
Interviewer: If you use computers at home then what do you do with computers at home?
Student: Listen to music on them, play computer games sometimes. I use the Internet for projects. In class they

		give us a science project I go on to the Internet, research it and do my science projects from there.
36.	Interviewer:	So on the average maybe in terms of percentage now. How many percent of your time on the Internet do you spend doing science project or school research?
39.	Student:	Very little with like facebook and all of that you get distracted easily. About 5%
41.	Interviewer:	What kind of software do you use?
42.	Student:	Software as in Microsoft
43.	Interviewer:	No those application software like microsoft word, excel
44.	Student:	Yeah I use Microsoft word..pretty much word all the time. Excel I know how to use.
46.	Interviewer:	Basically ok, in the school here do you go to computer lab for any science lesson or any othe lessons?
48.	Student:	No sometimes I go to the science lab to do researches I can't do at home but not really anything that is science related.
50.	Interviewer:	In your class you did not use the simulation in teaching. I mean your teacher did not use the simulation that we are talking about because this research is on the use the simulation so your teacher did not use it because the essence of the research is to use the simulation in one class and not use it in the other class and then we compare the results. Do you understand that?
56.	Student:	Yeah.
57.	Interviewer:	Ok your teacher did not use the simulation but you know what technology in teaching is all about
59.	Student:	I have a faint idea about it.
60.	Interviewer:	Faint idea about it. Can you tell me what idea you have?
61.	Student:	Em..like using modern stuff like smartboard, like computers in class to broaden our ideas of knowledge in science so that you can get a better perspective about it.
64.	Interviewer:	Ok.
65.	Interviewer:	So then would you like to see technology in use in your class?
66.	Student:	Excuse me!
67.	Interviewer:	Would you like to see technology, those things you just mentioned would you like to see it in your class?
68.	Student:	I would like it because I mean a few times we have used it maybe once or twice and it really just gives you a much better idea of what you're doing. Sometimes more basic but more understanding. It helps a lot in class.
72.	Interviewer:	Ok…. So in terms of your performance in physical science can you just give me a rough idea? Maybe in the test, in the exam you did when you resumed in third term and the subsequent tests, the cycle test because you did the same test with the other class 11C. Just give me a

		rough idea not the exact mark but just your performance, the average.
78.	Student:	I got a D for the average it was a pass on the average 47% somewhere around there. Em.. Cycle tests I do better because there is a lot less stress I think. I get 5o's sometimes 60's in cycle tests. Other times you know my marks drop badly I have some tests that really just pulls my average down and those often seem to count more than those ones I get good marks for.
84.	Interviewer:	Ok, great. Thank you very much for your time. Cheers

STUDENT F

85.	Interviewer:	Ok. You are welcome .What's your name and can you please introduce yourself
87.	Student:	My name is Student F. I do science, biology, geography, english, afrikaans and math literacy
89.	Interviewer:	As maths literacy with science, afrikaans, with biology. How many subjects all together?
91.	Student:	seven
92.	Interviewer:	Seven. Now do you have access to computers at home?
93.	Student:	Excuse me.
94.	Interviewer:	Do you have access to computers at home?
95.	Student:	Yes, I do have it.
96.	Interviewer:	You do have.
97.	Interviewer:	For how long have you been using computers?
98.	Student:	I have been using computers probably since Grade 6
99.	Interviewer:	Ok, since Grade 6 so on the average can you tell me the number of years?
101.	Student:	That is now 5 years.
102.	Interviewer:	Ok, approximately five years. That means you must be conversant with computers.
104.	Student:	Yeah
105.	Interviewer:	How do you rate yourself? Good, very good…
106.	Student:	I'm pretty moderate at computers. I don't do computers studies so I'm not that good at the computers
107.	Interviewer:	Now when you compare physical science with all the other subjects that you do, that you mentioned. How do you see science in terms of the level of difficulty.
110.	Student:	I think I will put science on a level of 9 out of 10 because it is quite a hard subject for me. I think chemistry is the hardest for me. All the chemical equations and stuffs like that. I understand physics much better because it involves putting values into a formula

115.	Interviewer:	Ok, thank you. So apart from the lessons we did with the simulations, was there any other time that you have used technology to learn science?
118.	Student:	I just use computers at home and I use the Internet
119.	Interviewer:	Ok, when you use the Internet what site..maybe educational site do you visit?
121.	Student:	Wikipedia I use that website the most
122.	Interviewer:	Ok, Wikipedia. So in terms of science with technology in school you never done that.
124.	Student:	No I've never done that.
125.	Interviewer:	Ok, great. When you use computers at home especially when you go to the Internet how many hours in percentage terms do you think you spend using the Internet for educational purposes?
129.	Student:	I probably use the Internet about 20% of my time at home
130.	Interviewer:	Ok, so other times what are you doing on the Internet to do?
131.	Student:	I'm looking for new music to download or on facebook.
132.	Interviewer:	Ok, thank you. Alright. Tell me..Can you please tell me the software that you have been using or the ones you are used to?
134.	Student:	I usually use microsoft windows
135.	Interviewer:	Windows. What windows?
136.	Student:	Windows Xp.
137.	Interviewer:	What about the applications like microsoft word…
138.	Student:	Microsoft word, microsoft powerpoint and excel yeah.
139.	Interviewer:	Now let us look at the simulation lessons. You attended the lessons, what good thing do you see, what do you enjoy about the simulation lessons?
142.	Student:	The simulation lessons they are quite interesting because you can give proper example of something and you can demonstrate it with program on the computer.
145.	Interviewer:	Ok, great. If you see it as interesting and it shows you more understanding what bad thing would you say about it that you don't like?
148.	Student:	The thing that I don't like is that there is not always someone talking and communicating with you. They just use it just explain it off the board and not properly like explaining what is happening in the computer is doing what.
152.	Interviewer:	Ok., you would love to see maybe some kind of sound coming from the simulation. Ok, great
154.	Interviewer:	Now the lesson…the test before the simulation lesson and the test after the simulation lessons, how do they compare, I mean your performance?
157.	Student:	My marks have definitely increased. I've seen an increase in my marks since we've been using the simulations

159.	Interviewer:	Ok, thank you very much I'm really grateful for your time and I'm grateful for you participating in this research. I wish you good luck in whatever you do.
162.	Student:	Thank you.

STUDENT G

1.	Interviewer:	You are welcome. Please can you introduce yourself, your class and the subjects you do.
3.	Student:	I'm Student G, I'm in 11D and I take science, biology, and geography as well as zulu, maths, life orientation and english
5.	Interviewer:	Ok. 7 subjects. Now this research is all about using technology in teaching and then trying to assess the impact. So you saw the note…I mean the letter that was sent and you know what the research is about.
9.	Interviewer:	Now, do you have access to computers at home?
10.	Student:	Yes, I do.
11.	Interviewer:	Ok, how long have you been using computers now?
12.	Student:	Since I was about two, since a very young age I've always had computers
13.	Interviewer:	So then it means that your computers skills must be ok or very good.
15.	Student:	I'm computer literate I can use the computer pretty well
16.	Interviewer:	ok, that's great. Now let's look at the science you do…physical science compared to all your other subjects what do you….how would you rate the level of difficulty?
19.	Student:	In science?
20.	Interviewer:	Yes compared to the other subjects
21.	Student:	Em..I would say it's relatively a little bit more difficult to understand but it all depends on your teacher at the end of the day.
24.	Interviewer:	Ok. So compared to maths, compared to maybe geography, physical science ehh…life science and the other subjects you see it as something more difficult.
27.	Student:	Yeah, slightly more difficult.
28.	Interviewer:	Ok. Have you ever used or has your teacher ever used technology in teaching you?
30.	Student:	Yes, we have smart board equipped in our classroom now and those are very effective. It's easier to learn off them
32.	Interviewer:	Ok. So then the smart board. Any other kind of technology that…..
34.	Student:	Emm..Nothing in particular that I can think of.
35.	Interviewer:	Ok, thank you.
36.	Student:	Maybe a projector or like overhead projector. That's about it.

37.	Interviewer:	Ok, thank you. You use computers at home can you tell me what you use computers to do at home?
39.	Student:	Emm..I use computers to go on facebook, to search the web, to do homework definitely for projects you use the Internet a lot, even for music because my dad is into music software and stuff so often like programme in songs and do my own drum beats and stuff
44.	Interviewer:	Ok, good. The Internet which you use at home you use it for research at times so can you me on the average how many in terms of percentage now how many percent would you say you spend on looking for academic stuff on the Internet
48.	Student:	I would probably say about 20%
49.	Interviewer:	About 20%, ok.
50.	Interviewer:	Ok, now can you tell me the kind of software you are conversant with using? Maybe word, excel. What type of software are you conversant with using?
53.	Student:	Emm..I mainly use word, the Internet, I use outlook sometimes and sometimes excel.
55.	Interviewer:	ok, great. Now the other class 11C they used simulations in their teaching. They used the simulation to learn science> Your class didn't use the simulation.
58.	Student:	Ok.
59.	Interviewer:	Now I want you to tell me just give me a rough idea of your performance in the exam that you did when you came in for third term and the cycle test you did and the other test you did in physical science.
63.	Student:	I think they were relatively the same. Both of the marks were about the same
65.	Interviewer:	On the average you say they are basically…
66.	Student:	I would say basically the same.
67.	Interviewer:	Thank you very much for your time, good luck in whatever you do
69.	Student:	Yes.

STUDENT H

1.	Interviewer:	Can you please introduce yourself?
2.	Student:	I'm Student H from (school name deleted). I'm currently in Grade 11.
4.	Interviewer:	What Grade 11?
5.	Student:	Grade 11 D
6.	Interviewer:	Grade 11D, ok. Can you please tell me your subjects..The subjects you take.

8.	Student:	I'm currently taking mathematics, english, science, geography, history, zulu and life orientation as well as business studies. 8 subjects.
11.	Interviewer:	Ok, physical science is one of the subjects you take?
12.	Student:	Yes
13.	Interviewer:	Now do you have computers at home?
14.	Student:	Yes, I do have a computer at home.
15.	Interviewer:	How long have you been using computers?
16.	Student:	Since I was in Grade 8
17.	Interviewer:	Ok, since Grade 8
18.	Interviewer:	So how many years?
19.	Student:	plus or minus 4 years
20.	Interviewer:	Ok, plus or minus 4 years. Thank you. Now the science that you do, the physical science and the other subjects, can you give me an idea of how you view physical science in terms of the level of difficulty
24.	Student:	Definitely without a doubt physical science is one of the harder subjects to partake in and like it really needs like a lot of commitment and like time and like you got to be dedicated to the subject if you want to achieve in it so you really have to pay a lot of attention if you compare it to other subjects you need to put in the effort you know.
30.	Interviewer:	A lot more effort than you put in the other subjects
31.	Interviewer:	Now you know what technology is?
32.	Student:	Yes
33.	Interviewer:	I mean technology…computers generally. Now in teaching have you ever learnt or has your teacher ever used technology in teaching you science?
36.	Student:	Yeah, definitely in (school name deleted) we use the latest technology. We've got these new flat screens, we got these computerised like dashboards in which teachers work from their computers on to the screens where we therefore take the work in which they have given out to us..Yeah they use technology.
42.	Interviewer:	Good. Now if you use computers at home, what do you use computers for at home?
44.	Student:	Well, I'm a border so I seldom use computers because I'm always in the boarding house but when I do go home on weekends I use the computers for projects, going on the Internet to get my projects done and yeah, listen to music
48.	Interviewer:	Ok, ok, good. So here in school do you do any lessons in the computer lab?
50.	Student:	Emm.. Well no because of our science lessons are done in class the only time we do go is when we need to do experiments or something like that.
53.	Interviewer:	Ok, good. If you use the Internet at home, what do you do on the Internet?

55.	Student:	Well, mainly on the Internet like when you go there I don't really go on the Internet because I don't have the Internet so I use Encarta to find out information
58.	Interviewer:	School related or academic related?
59.	Student:	Oh.. Academic related. Mostly we found we are given these topics to research on at school so therefore so just quickly just type it in. The Internet is an easy access of information so you just type it and you get whatever you need to get.
63.	Interviewer:	Ok, thank you. So using computer software like word, excel..which one would you say you are very good at.
65.	Student:	Definitely I would say being at a school like (school name deleted) they have equipped us to access the formats of PowerPoint, word, excel. We know how to use all those formats to present our presentation.
69.	Interviewer:	Now because in your class you did not use the simulation so you don't knowl what the simulation is all about.
71.	Student:	Yes
72.	Interviewer:	compare your performance in the exam you did you know when you came in third term you did an exam an your performance in the tests. The tests you did, the cycle test and the other one how do you...how do they compare?
76.	Student:	Well definitely like when we're preparing for the test like it's always obviously to test your ability to see how far you have come like how much your knowledge is expanded throughout the term that you've been learning so physical science being one of the hardest subject obviously there is different level of questions and the manner in which they ask you. So definitely it differentiates when it comes to tests so obviously the tests you'll be expecting to get an 80 average. Sometimes you get a 70 or 60 average but that only means that you can only get better. So it's much harder when you get to the test situation
86.	Interviewer:	So in the test situation what or how do you see the test, the exam score and the test
88.	Student:	Definitely like the normal cycle tests are much better as compared to exams because the exams are very hard.
90.	Interviewer:	What's your average mark
91.	Student:	For science? 65%
92.	Interviewer:	Thank you very much.

STUDENT I

1.	Interviewer:	Hello. How're u?
2.	Student:	I'm good.

3.	Interviewer:	Good. Thank you for agreeing to participate in this research. I will just ask you a few questions for about 5 minutes or so. Can you please introduce yourself?
6.	Student:	Student I, yeah.
7.	Interviewer:	Your class?
8.	Student:	11 C
9.	Interviewer:	Ok, what subjects do you do?
10.	Student:	Em… english, maths, science, guidance, accounting, IT and afrikaans.
12.	Interviewer:	Oh! You do IT as a subject? Ok, so what are the things you do in IT?
14.	Student:	Em..computer programming. We use Delphi to create programs that will help in everyday life. We also do databases, excel and most of microsoft office tools and pretty much it.
17.	Interviewer:	As an IT student it means that my next question will probably be a yes. Do you have computers at home? Do you have access to computers at home?
20.	Student:	My house?
21.	Interviewer:	Yes.
22.	Student:	Yes.
23.	Interviewer:	Ok, and then how long have you been using computers?
24.	Student:	Since I was very, very small I've always had interest in computers and technology especially the gaming side of it that's actually where my field will go into. It's a big influence in my life.
28.	Interviewer:	Ok. So approximately you would say that is about how many years now?
30.	Student:	12, 11
31.	Interviewer:	Ok, ok so this means that you must be a very good computer person. Ok, now from all the subjects you have mentioned how do you see physical science compared those subjects maybe in terms of the level of difficulty?
35.	Student:	Honestly the only reason I do science is to guarantee my place in the university. I don't have a passion for it, I don't have a knack for it. I'm not doing too well in it. I'm average with it. So like I said the only reason I am doing it now is to try and guarantee my place in the university.
40.	Interviewer:	Ok, but I think as an IT person and someone looking forward to go into the IT field, it's very necessary, isn't it.
42.	Student:	Yeah, yes it's very necessary. It's a necessity in that it teaches you logic as well and behind it gives you more fact about everyday life so it's definitely a necessity.
45.	Interviewer:	Ok, thank you. Em..Have you ever learnt science using ICT maybe in your previous years or now?
47.	Student:	In my research?

48.	Interviewer:	No. Like em..maybe the teacher using it to teach you a science topic, ICT technology basically.
50.	Student:	Yeah, yeah. With the new computers they've given us presentations and such. We've been allowed to use computers before for research or project of course. So yeah there is a lot of technology involved in it
54.	Interviewer:	Ok, ok, it means that though the teacher has not really been using the simulations that we used during the lessons
56.	Student:	Before we were taught chalkboard and the likes but since we've got this new smart board. Yes he's been using technology a lot in the presentation so it's a lot easier to teach as well with videos that we've had on the computer itself because now we can see the experiment and it's been already done so there is no time being wasted
62.	Interviewer:	Ok, thank you very much for that response. Now if you use computers at home. What do you do on the computers basically?
65.	Student:	Myself? My work of course and gaming a lot I use the Internet for research for tasks to keep in contact with everyone to keep up current affairs. Computers is everything actually even computers on your cellphone you can use that.

Appendix N: Teacher Interview Transcript

Mr. C

1.	Interviewer:	This is in continuation of our research which started with you about 2 months ago. Would you please introduce yourself?
3.	Teacher:	My name is Mr. C. I'm a teacher at (school name deleted). I teach Physical Science to the Grades 10, 11 and 12's and I was helping with the research.
6.	Interviewer:	Ok, thank you very much for that introduction. Now we want to look at some of the factors that you think might prevent people from using technology. This research is all about the incorporation or integration of technology into teaching so we want to look at those factors that prevent people using technology. So one of the things here, I'll ask you the questions and you'll just respond to the questions
13.	Interviewer:	have you ever used any ICT in your science teaching before this research?
15.	Teacher:	I haven't used ICT as such. I've just used PowerPoint presentation and this other slide but not interactive software just as a PowerPoint and I've used slides that I produced on word as well so just the normal Microsoft but not interactive software, yeah.
20.	Interviewer:	So this would be the first time then that you are using the interactive software in teaching
22.	Teacher:	I have got a white board…I mean a smart board but it's not really interactive software but it's just an interactive board but not necessarily software but this is the first time I've used this interactive software.
26.	Interviewer:	Apart from that any other teaching aid that you use in your teaching?
28.	Teacher:	No. I just use the normal practical work and whiteboard or chalkboard not different to any other educators
30.	Interviewer:	Ok, thank you. Now do you have access to computers after school?
32.	Teacher:	Yes our boys do have access. They have got three computer rooms and we have a 120 computers so all our learners have access to the computers.
35.	Interviewer:	And you do you have access as a teacher?
36.	Teacher:	Yes, I do. I do have access.
37.	Interviewer:	Now do you have access to the internet at home?
38.	Teacher:	Yes, we do. All the computers have access to the Internet
39.	Interviewer:	At home?
40.	Teacher:	I have

41.	Interviewer:	Now what software are you conversant with…Are you comfortable with
43.	Teacher:	I'm comfortable with any Microsoft software. We set our tests in Microsoft. I haven't like I said I haven't used any of the interactive stuff before. At university we got introduced to maths graph drawing but I haven't used it since university so I haven't used it since. So I'm comfortable with any microsoft stuff.
49.	Interviewer:	Ok, thank you very much. One of the other reason available in literature is that teachers say they don't have enough time. Maybe there is too much work so they cannot incorporate that into the teaching but now from your view or from your side how many teaching periods do you have?
54.	Teacher:	Do I have in total?
55.	Interviewer:	Yes
56.	Teacher:	I used to teach 38 out of 50 but it's come down now with the matric leaving obviously but I also can I add in something not only time wise, but I think that educators are quite nervous to try out new things as well as time wise I think it's difficult for them to have the confidence to go out to the Internet and look for new software. I don't think teachers are comfortable in researching that stuff. I think if they were introduced to it as I've been introduced to it I think they would be more comfortable and willing to do more research more...look for more software to use.
66.	Interviewer:	Ok, now if you teach 38 out of 50 that's quite a lot of work so on your part if you want to use technology you may not have the time to actually get all that information to use for your teaching.
70.	Teacher:	Yeah it's true eh..I think that's why teachers stick to what they know and they don't have the time to go and look out stuff but as well as that I think we could make the time because I think that time must not be used as an excuse but you're right it is a heavy timetable but also we could do a research properly and you could save the time at the end of the day.
76.	Interviewer:	Ok, that's taken thank you very much…em any other duties in school?
78.	Teacher:	A lot of duties in school. Now I'm in charge of two sports, I'm fully involved in extramural activities. I'm studying also so but at school I'm fully involved in extra-mural activities and sports. I'm in charge of two sports…That's about it yeah.
82.	Interviewer:	Ok, so you are very loaded with a lot of work. Ok, how do you think computers can be used in…teaching to aid students' conceptual understanding?

85.	Teacher:	I think that students nowadays they've grown up in a technology age so I think students are a lot more comfortable with computers than we are in our generation so if you have to tell a kid or show a kid how to use a computer they'll probably show you ten times more how to use a computer so I think they can be used because I think they enjoy to get out of the normal chalk and talk method and to get in front of the computer and do some new stuff so I think it could be used to em...build the interest in your subject because the kid would I think focus more on doing something different.
95.	Interviewer:	Thank you for that explanation because I can see that you know a lot about technology and you know what technology can do in eh in eh teaching. Ok now what would be your concerns about an ICT learning environment? Would there be any concerns about....if they say ok we are making this place...yeah what would be your concern?
101.	Teacher:	I think my major concern would be that teachers would become too relaxed. They wouldn't do as much prep as they needed to do. I mean for teachers to teach properly they have to know more than the syllabus and I think that teachers all done for me and they can relax and let computers do the work and I just think that teachers would lose focus on where they were aiming, yeah.
108.	Interviewer:	Ok.
109.	Teacher:	Another one of my concern is that the learners wouldn't learn the full content so they would be working on the computers but I just would be nervous that when I get to exams time that they would have enough content less so as well as using computers I think you have to like you have to use the normal textbook. They have to also use more knowledge
115.	Interviewer:	Ok, for content?
116.	Teacher:	For content, yeah.
117.	Interviewer:	Ok, alright now you know about the government's effort about e-learning and things like that. Now what are your opinions about this e-learning programme because I've heard and read in the white paper that the government signed about some 4 to 5 years ago. Now what are your opinions about this e-learning and do you see it as a success or...yeah?
123.	Teacher:	I don't know if it's going to work, I think in bigger…in town schools it could work that have got more money maybe but I think in rural school where kids are rarely maybe seen a television I think it's going to be impossible for them to use computers so it's like an idealist approach

		that will definitely work but you've got to also remember where you are, who's got money and who's not got money. Are the governments going to supply the computers? It can work but I think you've got to have the right training, learners have got to be exposed to the computers at a much earlier age in all areas. So yeah, it could work but I think it's gonna take a lot of time. I don't think they can just say it's a 1 or 2 years programme. I think they've got to put a lot of time and effort and money into this programme
136.	Interviewer:	Ok, thank you very much for that. If I understand you very well you are trying to say that it requires a lot of planning.
138.	Teacher:	A lot more planning than they are doing now. I think they've just focused on in town schools and they've taken it for granted that everyone knows what a computer looks like and it's not the reality. But the reality is that maybe 60% of population never used a computer. Yeah they got to think about all learners not just in town learners.
144.	Interviewer:	Ok, thank you very much. Now this second part is trying to see the kind of pre-service training that was given to you as a teacher in terms of technology because you have said earlier that many teachers don't know or may not know how to use this or may not have the time or the will to look for technology and further information that they could use. Now I just want to know your level of training in terms of technology and ICT in your pre-service days.
152.	Teacher:	Ok, mine is quite big because I actually did a computer course at university so one of the years at varsity I actually did a computer course but when I think about the guys in my course even in my honours course out of about 19 people this is the first year that about 6 people have even submitted an assignment that have been word processed. So even at honours level people haven't used computers. Even though I have proper training in computers and I have used them for a long time, other people my age in this same job as me they haven't even used word before. So yeah...
162.	Interviewer:	So can you just mention some of the software and ICT tools that you were trained to use or you learnt to use.
164.	Teacher:	Not ICT as I think but I did programming in Visual Basic so I do program so I also used Access when I was at varsity we used a tool it was called graphmathematical at varsity. That's about all I can recall right now on top of my head, yeah.
168.	Interviewer:	So which of these do you know how to use? Data projector, digital camera, data em…simulations, Internet

		and email and online learning and assessment. I would just take them one by one again. Data projector?
172.	Teacher:	I know how to use a data projector.
173.	Interviewer:	Digital camera?
174.	Teacher:	I definitely know how to use a digital camera and I use one quite often.
176.	Interviewer:	Simulations?
177.	Teacher:	I can learn how to use them. I don't know how to use them but I get very familiar with them very quickly.
179.	Interviewer:	What about Internet research?
180.	Teacher:	Yeah, I'm becoming an expert in Internet research.
181.	Interviewer:	Ok. I think I was quite impressed with the way you grasped the simulations and the way you incorporated it into your teaching even though you had not used it before
184.	Teacher:	Yeah I enjoyed it so I spent a little bit of time because I saw that the learners were enjoying it so that's why I spent a bit of time going through it. It was good to use
187.	Interviewer:	Some of the things I got from the learners were that that was a very good thing because they were able to see some things really in action rather than the normal method of being told how it works and things like that.
191.	Teacher:	The one that we are talking about I think is the Newton 2 practical or the Newton 2 simulation that we did. Yeah, it was very good because the guys even came out with the Newton's second law in words by themselves. They've never been introduced to it. Yeah, I think they enjoyed it, it was very good.
196.	Interviewer:	Ok. So we are moving on to the last part of the questions. This part we just want to know in the past year how well did you use technology? Not simulations this time around but you using technology maybe typing things or whatever how often or how well do you use technology?
201.	Teacher:	I use technology every single day. I type their worksheet, I prepare assignments, I use the smart board. Every single day I'm using technology.
204.	Interviewer:	Alright, thank you very much.
205.	Interviewer:	What are you views about..How do you view the learners perception about the simulation lessons?
207.	Teacher:	I think they really enjoyed it. There was a lot of interaction me and them. Em..It also got me to explain things very very quickly because like you said all the content was already....context was already done so could see straight away. It allowed me to explain things very quickly and also they enjoyed seeing something different in the class because they are so used to me standing up in the class and just talking. I think they enjoyed seeing something different. Also I was able to do a few different

		thing that like the simulation wasn't designed for like making a skateboard fly and then they enjoyed that kind of stuff.
218.	Interviewer:	Yeah, thank you for that beautiful response. Now if you look at the simulations. Maybe there are some things you would have loved to see. Maybe…can you tell me some of these things?
221.	Teacher:	I think the simulation was designed for other curriculum. I think if we have to do this in South Africa we have to get South African educators to design the simulation. For example, em..not everything was in the unit that we use, it could have been in miles when it should be in kilometers..things like that. They are useful part of it but you can't use to teach wholly because it's not really towards our syllabus. I had to like adapt and change the simulations.
229.	Interviewer:	Ok, that's adaptation of the simulation into your lesson. Ok, thank you very much. Now if you have the opportunity would you like to use simulations or technology quite often than this?
232.	Teacher:	I think I would like to use it but I'm still hesitant to use it often in class but I think it's very good especially for the weaker learners I think they can see it so they can grasp the basic concepts a lot quicker. For the stronger learners, I'm still a kind of educator that think you must rather give them more and more things to solve. I think that's the way they learn better. So for the weaker learners I will be encouraged to use it more often but for the stronger learners I will be hesitant. I will still use it but not as often for them.
241.	Interviewer:	Mr. C I'm really grateful for your time. Thank you for being so supportive in this research.

Mr. D INTERVIEW TRANSCRIPT

1.	Interviewer:	Good morning. Please can you introduce yourself?
2.	Teacher:	My name is Mr. D. I am a science teacher at (name deleted for confidentiality) from Grade 8 to matric
4.	Interviewer:	Now in this research what class do you teach? What class of Grade 11 do you teach?
6.	Teacher:	The second class 11B
7.	Interviewer:	What about the other class 11 D?
8.	Teacher:	I was teaching 11 D until a couple of weeks ago because we got a new teacher who took that class

10.	Interviewer:	Ok. Basically what this research is about is to see the impact of ICT i.e technology in teaching. So we want to know how far do you use technology in your teaching?
13.	Teacher:	How frequently?
14.	Interviewer:	Yes
15.	Teacher:	Ok, it depends on the topic. I think that according to my experience some topics are very suitable to be taught using for example animation or computer graphs because it helped the learners to visualise what is going on. But not every topic perhaps just some of them and to some extent. And this is one part. I know the part is that for the teacher it saves a lot of time perhaps we just spent time writing on the board and we just give our back to the learners. So also to keep the discipline it better to have some things prepared on the computer so you project what you have on to the screen and then you keep your eye contact with the learners, yes.
26.	Interviewer:	Ok, thank you very much for that comment and response. Now what…can I know the kind of technology you as teacher have used in your science teaching?
29.	Teacher:	Ok, what we have basically here is a computer and on my computer with two very useful say accessories. One of them is a projector which allows you to put on to a screen what you have in the computer. And of course it's very useful for the learners and the second thing is a camera which allows you to project also using a projector things that you don't necessarily have in the computer but you have like a piece of paper or textbook and you can put it just underneath the camera and the camera allows you to project those things perhaps from textbook, from notebooks, from personal notes that you have and that saves a lot of time and it's very practical.
40.	Interviewer:	Ok, thank you. Now apart from using computers what other teaching aids or teaching methods do you adopt?
42.	Teacher:	Em…not technological things you mean?
43.	Interviewer:	Yeah…yeah not technology things. Like tools, apparatus and whatever..
45.	Teacher:	Right. Evidently for chemistry for instance, fortunately we do have a complete set of apparatus for chemistry experiments and our practicals from because delivery tubes, stoves and of course all the chemistry compounds or elements that that we need or so in that sense it allows us to do some demostrations in front of the class, that is one thing or we can also work with the learners in groups. Groups of three, four, five students and they do the practical so of course for chemistry for example it's quite useful to have all those things.

54.	Interviewer:	Alright, thank you very much. Em..you are actually throwing more light into the research from your responses to these questions. Now this aspect is going to look at those factors that would prevent or hamper the use of technology in teaching. Now so from your experience even though the technology is there, there are some factors that you think or that have prevented you from actually using this technology in your teaching. Can you throw more light on those factors?
62.	Teacher:	Factors that prevent me from using that technology?
63.	Interviewer:	Yes, something that will not make you to use technology.
64.	Teacher:	Negative?
65.	Interviewer:	Maybe negative, yeah.
66.	Teacher:	As I said before maybe perhaps there are some topics that we have to teach that perhaps better to go to the classical methods. Em..because you can have more flexibility in the board and you would take a lot of time in the computer let's say especially if you think of something like in an impromptu way like suddendly you thought about one example or one idea that you had to explain something, to do it in the computer will take a lot of time and rather to just take marker and do it in the whiteboard quicker and you have more flexibility to do it the way you thought that example say.
76.	Interviewer:	So, so basically the issue of time would be a factor and also the issue of the topic that is at hand would also be a factor.
78.	Teacher:	Right.
79.	Interviewer:	Now, how many periods do you teach in school right now?
80.	Teacher:	Right now? Let me think. Like 25 periods a week.
81.	Interviewer:	Ok, thank you. 25 periods a week. Now are there any other duties that you are assigned in the school?
83.	Teacher:	Yeah. In the school every teacher is involved in extra-mural activities of course My case I am the master in charge of chess and also the philosophy society which is very interesting. Some of our teachers do some sport for instance.
87.	Interviewer:	So you have other duties that you do in school. Now considering the kinds of application you use on the computer which ones are you conversant, very conversant with or which ones are you comfortable using?
91.	Teacher:	This is very interesting. We have been given some software prepared by some companies they have developed specific software for example for science and biology as well. In Grade 9 for example I teach some biology. There are quite a number of nice software to

show the human body or how things work in a cell or in the lungs etc. The different system of the human body to show that through the computer is very good and that's one thing but the next step we are thinking of implementing in the school is the connection to the Internet from the classrooms because at home I have found in several websites fantastic things done around the world and some universities in America or in Europe and if we had the possibility of surfing those websites we could find very, very good things and huge amounts of materials there that is not precisely the way it's shown if it's shown in the software we have got.

106. Interviewer: You see the question you answered now has actually somehow gone to answer my next question. The next question is to ask you if you have access to computers and Internet after school at home and the way you have answered the question has shown that you have access to computers at home and you also have access to the Internet at home. Now how often do you go searching for academic resources on the Internet?

113. Teacher: Hmmm…Perhaps once a month or something I use to search the Internet for topics or examples. I think it's a very important source of information and problems and examples that are very, very useful.

117. Interviewer: Ok, alright. Now taking you back a bit. You said that when you use computers to teach, students can actually visualise easily. Now apart from this any other thing that you think computers can do for the learners?

121. Teacher: Any other task?

122. Interviewer: Or any advantage or any other good way that you think.

123. Teacher: I would say that the most important advantage is the visualisation as I was telling you of theoretical things they could actually see in animation for instance like really it's actually difficult to do it in normal life. For example you can simulate say the movement of a rocket going to space. Of course we don't have a rocket or a real rocket to do..to show the learners how works and perhaps you could find some movies actually in the Internet that I think but simulation in the computer they can see it very nicely.

132. Interviewer: Ok, I understand what . Now your…the introduction of ICT (computers) into the learning environment. What would you think your concern would be? Maybe in a way would there be any concern or thing that would bother you about the full implementation or full introduction of IT in the learning environment?

138.	Teacher:	Of course, em..it's like in every other field it could happen for some teachers for example that they rely too much in the technology or in animation or what they can show graphically through the computer and perhaps people could lose sight of the real teaching or concern for the understanding of the learning so it's easy to just spend time showing animation or showing things through the computer but perhaps I'm mean it shouldn't stop there you have to make sure that the learning process is taking place and you have to also evaluate how what you have been doing is useful or for the learners also and so yeah it's like a medical doctor who has the machine to I don't know to that helps to know what is going on with a patient but of course they have to look further and they have to apply what they think in their knowledge for it to really work properly.
152.	Interviewer:	Yeah, thank you. It basically means that what we can get from your answer here is that the technology should not replace the teacher.
155.	Teacher:	Absolutely.
156.	Interviewer:	Ok, now you know about the government's effort at making computers available in schools and things like that. They call it like for this province they said its Gauteng online. They do a lot of em..trying to put technology into teaching. What do you feel about that?
161.	Teacher:	I think it's not the essential problem. I think it helps, the thing is nice and useful but I see one mentioning there government and that level I would say that there are much more urgent things solve. For example, they make sure that the level of the teacher is good. Ok, the salaries of the teachers must be something like proper, right. And because as you were saying computers cannot replace the teacher so basically the teacher is important, the teacher himself. So I think the first priority is to make sure that we have proper teachers, well trained with the capacity to do the job properly and to manage this technology properly.
171.	Interviewer:	Alright. Now we are finishing the interview now. The next thing is to see if the undergraduate training that is the pre-service training really gives enough teachers as regards the preparation in ICT usage.
175.	Teacher:	I have no idea.
176.	Interviewer:	No, I'm talking about your experience. From your undergraduate training….
178.	Teacher:	Yeah. The thing is that my case is a little different especially because I am an engineer. I didn't study to be a teacher really in an undergraduate degree programme. I

		studied engineering and in engineering of course you do have plenty of possibilities to manage ...to use high level technology so it makes it very easy to implement that technology in the classroom. I don't know what's going on with the teachers really.
185.	Interviewer:	Yeah, you have the advantage with engineering you definitely learn to do a lot of things with technology.
187.	Teacher:	Yeah
188.	Interviewer:	So in this past year what are the things you have really done with technology? The things you have really done, maybe 1 or 2 topics that you have used technology for.
191.	Teacher:	Especially it was very good for me to use technology in biology which is very nice to show the systems in the human body and functioning of some systems within the different organs within the human body. That was fantastic really.
195.	Interviewer:	Ok, nice. What about Grade 10 and 11?
196.	Teacher:	Ok, in Grade 11 and 12, it was very interesting to use electromagnetism animation and simulation especially concerning generators and motors because it's very difficult to show the learners really in the white board or to…I mean you need to have a lot of materials really, lab materials to show it. And actually it's difficult to show it even if you have it but the simulation in the computer, the way current produces the magnetic field and the way the coils rotate was really, really good and you can show actually the direction of the magnetic field and the direction of the current. How it changes with the commutator and that in the computer was fantastic.
207.	Interviewer:	Ok, now whenever you want to do a lesson with the simulation or anytime you introduce it how do you perceive the response of the learners?
210.	Teacher:	It's good because it's actually much better than to do it in the whiteboard or…because it's very difficult you have to have a lot of drawing skills to do something appropriate to show what is going on there but of course in the Internet I actually found there very nice drawing and graphs showing how it works very well explained and then of course the learners saw it by themselves and it's very much easier for them to internalise what was going on in the theory to visualise to see how it is expressed in reality
219.	Interviewer:	That's great. When you compare this method the simulation and technology method with the traditional method how do you compare them? Your own opinion
222.	Teacher:	The thing is that both are different. I would say that they complement each other, right. As I was telling you for

		some topics you can use very much simulations and animations and it's very useful but for some other topics it's very important to go to the traditional methods. They are also very useful so I think it's a matter of combining both in a proper way to achieve the best possible teaching for the learners.
229.	Interviewer:	Ok. Now coming to our last question, how often would you like to use technology in your classroom? How often would you want to?
232.	Teacher:	As I was telling you it depends on the topic. If we are going through electromagnetism or free falling etc of bodies falling to the earth perhaps I would use much more than I don't know we could be teaching em..some chemistry balancing equations and things like that. You could also do it through technology but perhaps in the whiteboard you have more flexibility, change things and to change numbers quickly and to erase and to do it again that it would take a lot of time in the computer.
240.	Interviewer:	I am really very grateful for your time. Thank you very much.

Appendix O: Pretest and posttest marks

11 C **Experimental group**

	Cycle test Pre-test	class test Post-test	percentage
Student 1	31	47	37
Student 2	17	20	18
Student 3	49	19	37
Student 4	32	39	35
Student 5	29	23	27
Student 6	31	21	27
Student 7	63	31	50
Student 8	62	41	53
Student 9	29	51	38
Student 10	54	26	43
Student 11	23	30	26
Student 12	17	47	29
Student 13	34	33	33
Student 14	63	83	71
Student 15	14	7.1	11
Student 16	54	46	51
Student 17	31	29	30
Student 18	35	41	38
Student 19	42	57	48
Student 20	45	30	39
Student 21	34	44	38
Student 22	40	44	42
Student 23	43	67	53
Student 24	34	46	39
Student 25	17	21	19
Student 26	32	30	31
Student 27	38	49	43
Student 28	28	31	29
Student 29	32	53	41
Student 30	18	40	27

11 D **Control group**

	cycle test Pre-test	class test Post-test	percentage
Student 1	40	47	43
Student 2	45	51	47
Student 3	52	33	45
Student 4	65	56	61
Student 5	40	50	44
Student 6	45	29	38
Student 7	15	36	24
Student 8	57	69	62
Student 9	23	27	25
Student 10	57	47	53
Student 11	22	36	27
Student 12	20	46	30
Student 13	29	21	26
Student 14	15	51	30
Student 15	38	53	44
Student 16	51	69	58
Student 17	48	26	39
Student 18	31	49	38
Student 19	23	34	28
Student 20	46	74	57
Student 21	23	29	25
Student 22	25	47	34
Student 23	17	43	27
Student 24	34	44	38
Student 25	17	49	30
Student 26	25	34	28

Appendix P: Achievement tests

PRETEST

SECTION A

Answer this section on the attached ANSWER SHEET.

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 Rate of change of distance. (1)

1.2 Rate of change of displacement. (1)

1.3 The product of mass and acceleration due to gravity. (1)

1.4 The gradient of a velocity time graph. (1)

1.5 The amount an object resists change in motion. (1)

[5]

QUESTION 2: MULTIPLE-CHOICE QUESTIONS

Four possible options are provided as answers to the following questions. Each question has only ONE correct answer. Choose the answer and make a cross (X) in the block (A –D) next to the question number (4.1 -4.5) on the ANSWER SHEET.

2.1 A car accelerates from an initial velocity $\mathbf{v_i}$ to reach a final velocity $\mathbf{v_f}$ after travelling a displacement **x** in time **t**. Which combination of these physical quantities **cannot** be used to determine the acceleration, if only **one** equation is used?

A x, v_i and t

B $v_{i,}$ x and v_f

C $v_{i,}$ v_f and t

D x, v_f and t (3)

2.2 Which of the following statements is true for a body moving with uniform velocity?

A The displacement of the body is constant.

B The speed of the body is constant.

C The body accelerates with constant acceleration.

D A resultant force acts on the body. (3)

2.3 A car P accelerates from rest at **y** $m.s^{-2}$. A car Q also accelerates from rest, but at **2y** $m.s^{-2}$. After the same time t, Q will have travelled a distance of…

(Where x stands for displacement)

A ½ x.

B x.

C 2 x.

D 4 x. (3)

2.4 The unit for the expression ½ at^2 is…

A $m.s^3$.

B m.s.

C m.

D $m.s^{-1}$. (3)

2.5 Which one of the following quantities has the same SI units as the quantity represented by ”average velocity x time”?

A Momentum

B Power

C Acceleration

D Displacement (3)

[15]

SECTION B

INSTRUCTIONS AND INFORMATION

1. Answer SECTION B on your own folio paper

2. The formula and substitution must be shown in ALL calculations.

3. Round off your answer to TWO decimal places.

QUESTION 3

During the last Olympic Games Usain Bolt became the hero of the track because of his three world records from three events (100 m, 200 m and 4 x 100 m relay). He achieved a feat that no other athlete has been able to achieve in the history of the games.

As technology has improved over the years sports scientists are able to measure every step of Bolt's 100 m race. Study the table below and answer the questions that follow.

The following data was collected by Bolt's coach to analyse his acceleration to improve his time.

Time (s)	Total Distance (m)
1	3.25
2	6,5
3	14,625
4	26
5	39
6	52
7	65
8	78
9	91
9,69	100

Bolt is accelerating for the first 4 seconds with a constant acceleration; he then travels with a constant velocity for the remainder of the time.

3.1 Calculate Bolt's acceleration for the first 4 seconds. (3)

3.2 Calculate his velocity after 3 seconds. (3)

3.3 Calculate his velocity after 4 seconds. (2)

3.4 Bolt took 42 steps when becoming the new Olympic champion in the 100 m race. Calculate the average displacement of Usain Bolt's step during the race. (2)

3.5 The next best athlete in the race could only manage to accelerate at 3,1 $m.s^{-2}$ for the first

four seconds. By what distance did Usain Bolt beat the second placed athlete? (6)

3.6 What would Bolt's time have been if he could keep accelerating for the first 4,5 seconds of the race? (5)

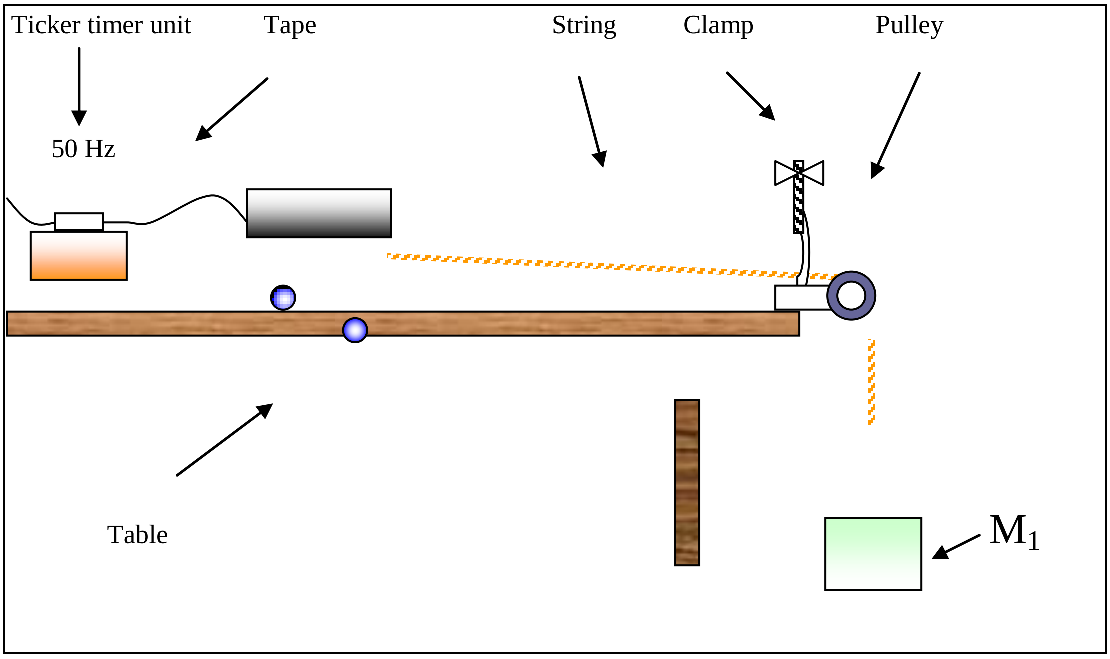
[21]

QUESTION 4

Newton, Sir Isaac (1642-1727), mathematician and physicist, one of the foremost scientific intellects of all time. Born at Woolsthorpe, near Grantham in Lincolnshire, where he attended school, he entered Cambridge University in 1661; he was elected a Fellow of Trinity College in 1667, and Lucasian Professor of Mathematics in 1669. He remained at the university, lecturing in most years, until 1696. Of these Cambridge years, in which Newton was at the height of his creative power, he singled out 1665-1666 (spent largely in Lincolnshire because of plague in Cambridge) as "the prime of my age for invention". During two to three years of intense mental effort he prepared Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy) commonly known as the Principia, although this was not published until 1687. (*Microsoft ® Encarta ® Premium Suite 2005. © 1993-2004 Microsoft Corporation. All rights reserved*.)

In the school laboratory we try and replicate Isaac Newton's work with the following practical investigation.

The apparatus below is set up and the following results are achieved when changing the mass (M_1) and therefore changing the applied force on the trolley ($F_g = mg$ where $g = 9,8$ $m.s^{-2}$). When doing calculations for this question **round off to one decimal place**.



Mass of M_1 (kg)	Acceleration of trolley ($m.s^{-2}$)
0,276	1,4
0,368	1,8
0,459	2,3
0,551	2,72

4.1 What do you think a possible hypothesis (educated guess about the outcome) for this practical will be? (2)

4.2 What is the independent variable (variable that you change) for this investigation? (2)

4.3 What is the dependent variable (variable that changes due to the independent variable) for this investigation? (2)

4.4 Calculate the **force applied** by all four masses M_1. (8)

4.5 Draw a Force (x - axis) VS Acceleration (y – axis) graph on the graph paper provided. (8)

4.6 What is the relationship between force and acceleration? (2)

[24]

TOTAL SECTION B: 45

GRAND TOTAL: 65

POSTTEST

PHYSICS – Newton's Laws

DATE: 19/09/2008 **MARKS: 70 ✓** **TIME: 1 HOUR**

QUESTION #1: MULTIPLE CHOICE – Indicate the correct answer by making a cross on one letter on the special answer sheet provided **(10 x 4 = 40 MARKS).**

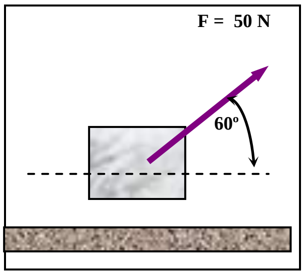
1.1 THE FOLOWING DEFINITION: "THE ACCELERATION OF A BODY IS DIRECTLY PROPORTIONAL TO THE RESULTANT FORCE APPLIED UPON IT AND INVERSELY PROPORTIONAL TO ITS MASS", CORRESPONDS TO:

a) Newton's First Law.
b) Law of proportionality.
c) Newton's Second Law
d) Law of Inertia.

1.2 IF A CONSTANT, RESULTANT FORCE IS ACTING ON AN OBJECT, THE OBJECT IS…

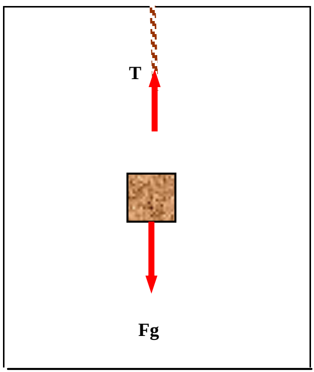
a) Moving with constant velocity.
b) Remaining stationary.
c) Moving with constant acceleration.
d) Moving with increasing acceleration.

1.3 THE MAGNITUDE OF THE **RESUTANT FORCE** ACTING THE BLOCK OF MASS 10 kg IS:



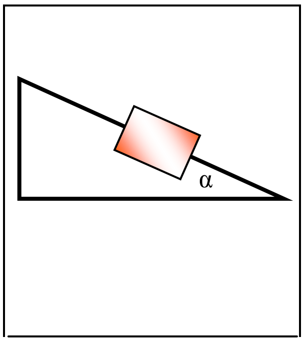
a) 50 N
b) 50 x 9,8 N
c) 50 cos 60º N
d) 50 sin 60º N

1.4 TWO FORCES ARE ACTING ON THIS BLOCK: A TENSION (UPWARD) BY THE ROPE OF 12 N AND THE BLOCK'S WEIGHT. IF THE BLOCK IS ACCELERATING AT 2 $m \cdot s^{-2}$ (UPWARD), ITS **MASS** WILL BE …



a) 1 kg
b) 10 kg
c) 3/4 kg
d) 2/3 kg

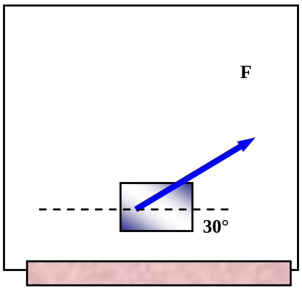
1.5 A BLOCK OF MASS "**M**" IS SHOWN ON A FRICTIONLESS, INCLINED PLANE AT AN ANGLE α. WHICH OF THE FOLLOWING STATEMENTS IS CORRECT?



I. Resultant Force on the block: **M·g·sin (α)**
II. The acceleration of the block is: **g·sin (α)**
III. The greater the mass of the block, the faster the block will reach the end of the plane.

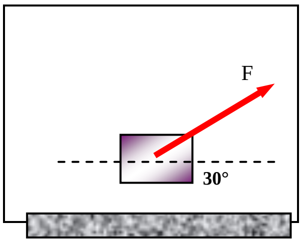
a) Only I b) I and II c) II and III d) I, II and III

1.6 A BLOCK OF MASS 5 kg IS STATIONARY ON THE SURFACE AS SHOWN. SUDDENLY A FORCE F IS APPLIED AT AN ANGLE OF 30°. HOW LARGE MUST **F** BE IN ORDER TO LIFT THE BLOCK FROM THE GROUND?



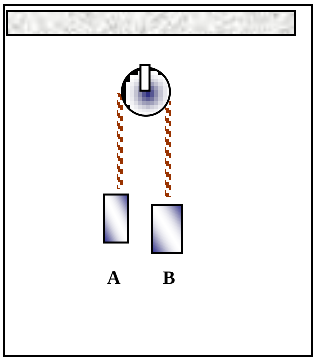
a) 50 N
b) 100 N
c) $50\sqrt{3}$ N
d) $100/\sqrt{3}$ N

1.7 IN THIS CASE, F=100 N, WHILE THE MASS OF THE BLOCK IS M=15 kg. THE **NORMAL** FORCE EXERTED ON THE BLOCK BY THE GROUND IS…



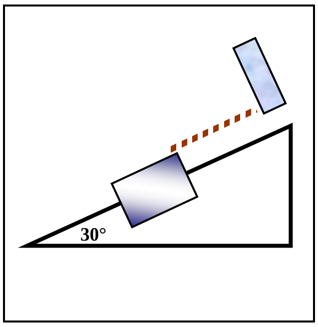
a) 150 N
b) 50 N
c) 100 N
d) $50\sqrt{3}$ N

1.8 IN THIS SYSTEM TWO MASSES ARE HANGING AS SHOWN. M_A=10 kg, M_B=8 kg. IF WE IGNORE THE FRICTION IN THE PULLEY, THE **TENSION** IN THE ROPE IS...



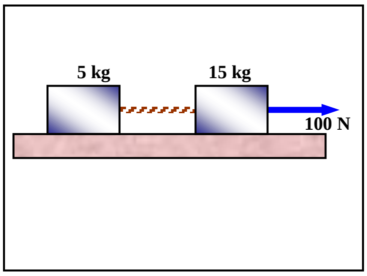
a) 800 / 9 N
b) 100 N
c) 80 N
d) 20 N

1.9 THE BLOCK OF MASS M=10 kg IS STATIONARY. THE FRICTION PRODUCED BY THE SURFACE ON THE BLOCK HAS A MAGNITUDE OF 50 N. THE **TENSION** IN THE ROPE IS…



a) 0 N
b) 50 N
c) 100 N
d) $50\sqrt{3}$ N

1.10 FOR THE FOLLOWING SYSTEM YOU MAY IGNORE THE FRICTION BETWEEN THE BLOCKS AND THE HORIZONTAL SURFACE. THE **ACCELERATION** OF THE SYSTEM IS…



b) 5 $m \cdot s^{-2}$
c) 10 $m \cdot s^{-2}$
d) 100 $m \cdot s^{-2}$
e) 75 $m \cdot s^{-2}$

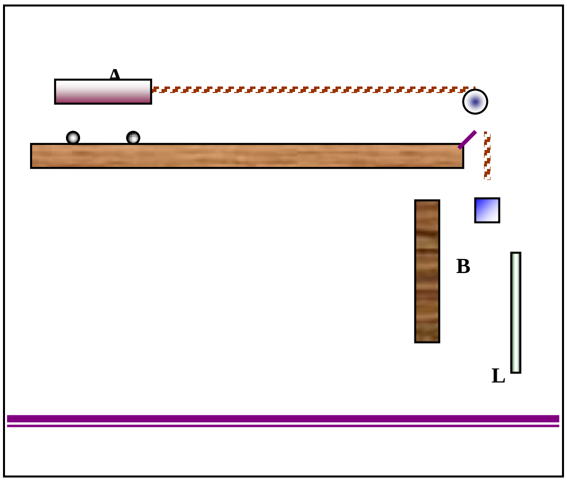
[40]

BASIC INSTRUCTIONS FOR THE FOLLOWING QUESTIONS

- *Answer questions 2 and 3 in a folio paper.*
- *Work in an orderly way so that all your calculations and the equations used are very clear. Marks will be deducted for untidy work.*
- *Do not forget to give your results in the correct units.*
- *Do not forget to show the reference points and/or the correct directions for vectors.*
- *When sketching figures, show all the important vectors and label them correctly.*
- *Do not forget to draw the arrow of each vector.*

QUESTION #2: (18 MARKS)

AN ENTERPRISING PUPIL INTENDS TO USE THE FOLLOWING SETUP TO DETERMINE THE ACCELERATION DUE TO GRAVITY (g):



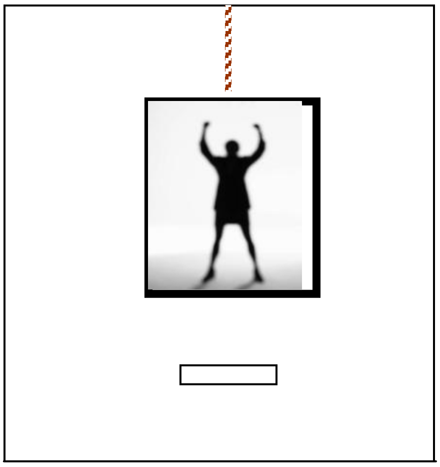
A TROLLEY (A, OF MASS M_A=900 g) ON A SMOOTH HORIZONTAL TABLE IS CONNECTED BY A LIGHT THREAD OVER A PULLEY TO AN OBJECT B OF MASS M_B=100 g. "L" IS A 1 METRE RULER OF WHICH THE TOP IS IN LINE WITH THE BOTTOM OF OBJECT B. B IS THEN RELEASED TO START MOVING. A STOP WATCH IS USED TO MEASURE THE TIME FROM THIS MOMENT UNTIL B STRIKES THE FLOOR. THIS PROCESS IS REPEATED 5 TIMES, TO ARRIVE AT AN AVERAGE TIME OF 1,5 s.

a) Draw two separate **diagrams** to show ALL the forces that act on A and B. (5)
b) Use the average time and the length L to determine the average **Acceleration** of B. (3)
c) Apply Newton's second law to each object to **calculate "g"**. (5)
d) **Explain** a possible reason for the difference between this result (in c) and the well-known value of "g". (2)
e) State Newton's second law **in words**. (3)

[18]

QUESTION #3: (12 MARKS)

A man has a mass of 30 KG. He stands on a bathroom scale, calibrated in Newtons, in a lift (see figure).



What is the **reading on the scale** when the lift

a) IS STATIONARY. (2)
b) IS ACCELERATING UPWARDS AT 2 $m \cdot s^{-2}$ (4)
c) IS MOVING AT CONSTANT VELOCITY OF 8 $m \cdot s^{-2}$ (2)
d) IS MOVING DOWNWARDS AND RETARDING AT 2 $m \cdot s^{-2}$ (4)

[12]

Appendix Q: Ethics clearance

Wits School of Education

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

27 St Andrews Road, Parktown, Johannesburg, 2193 • Private Bag 3, Wits 2050, South Africa
Tel: +27 11 717-3007 • Fax: +27 11 717-3009 • E-mail: enquiries@educ.wits.ac.za • Website: www.wits.ac.za

STUDENT NUMBER: 0310546K
Protocol: 2008ECE51

02 February 2009

Mr. K. Arowolo
Marang Centre

Dear Mr. K Arowolo

Application for Ethics Clearance

I have a pleasure in advising you that the Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate has agreed to approve your application for ethics clearance submitted for your proposal entitled:

The Impact of Information and Communication Technology in the Teaching and Learning of Kinematics in Grade 11 Physical Science

Recommendation:

Ethics clearance is granted

Yours sincerely

Matsie Mabeta
Wits School of Education

Cc Supervisor: Dr F Mundalamo (via email)

Appendix R: Gauteng Department of Education approval

9. Jun. 2008 13:17 No. 9673 P. 2/3

UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Enquiries: Nomvula Ubisi (011)3550488

Date:	**23 May 2008**
Name of Researcher:	**Arowolo Kayode**
Address of Researcher:	**P.O. Box 543**
	Wits
	2050
Telephone Number:	**N/A**
Fax Number:	**N/A**
Research Topic:	**The impact of information and communication technology (ICT) in the teaching and learning of kinematics in grade 10 physics**
Number and type of schools:	**1 Secondary School**
District/s/HO	**Johannesburg East**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. ***The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.***
2. ***The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.***
3. ***A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.***

Office of the Chief Director: Information and Knowledge Management
Room 501, 111 Commissioner Street, Johannesburg, 2000 P.O.Box 7710, Johannesburg, 2000
Tel: (011) 355-0809 Fax: (011) 355-0734

9. Jun. 2003 13:17 No. 9673 P. 3/3

4. *A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher must supply the Director: Knowledge Management & Research with one Hard Cover bound and one Ring bound copy of the final, approved research report. The researcher would also provide the said manager with an electronic copy of the research abstract/summary and/or annotation.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

CHIEF DIRECTOR: INFORMATION & KNOWLEDGE MANAGEMENT

The contents of this letter has been read and understood by the researcher.	
Signature of Researcher:	
Date:	