EFFECTIVENESS OF THE 'PHYSICSCLASSROOM' COMPUTER SOFTWARE IN THE LEARNING OF KINEMATICS AT MUNALI BOYS HIGH SCHOOL IN LUSAKA.

BY

GOODWELL KAULU

A dissertation submitted to the University of Zambia in fulfilment of the requirements for the degree of master of education in science education.

THE UNIVERSITY OF ZAMBIA

LUSAKA.

2008

DECLARATION

I ....Goodwell Kaulu......................, hereby declare that this dissertation is my own work and that it has not been previously submitted for a degree at this or any other University.

SIGNED...DATE..16-01-09..........

CERTIFICATE OF APPROVAL

This dissertation by Goodwell Kaulu has been approved as fulfilling the requirements for the award of the Master of Education in Science Education by the University of Zambia.

SIGNED.................................INTERNAL EXAMINER, DATE.................

SIGNED.................................INTERNAL EXAMINER, DATE 21st January 2009

SIGNED.................................EXTERNAL EXAMINER, DATE 21/01/2009

ABSTRACT

This study investigated the effectiveness of the 'Physicsclassroom' computer software in the learning of kinematics in high school physics at Munali Boys High School in Lusaka. The main objective was to find out if this software could enhance pupil performance in kinematics in physics at Munali Boys High School when it was used as a supplement to traditional learning methods.

An experimental design of the pre-test post-test type was used. The main sources of data were: pre- and post-tests, an attitude questionnaire, an observation schedule, participant reports and an interview with physics teachers.

The sample for the study consisted of 40 grade 12 boys of Munali Boys High School. Half the number of boys were in the experimental group and the other half in the control group. The experimental group learnt kinematics from the Zambian High School Pure Physics Syllabus using the 'Physicsclassroom' computer software and traditional learning methods for six weeks. At the same time the control group learnt the same work with the same teacher but using traditional learning methods only. The groups were pre-tested and post-tested using the same test. The scores obtained by the participants in the tests were analysed quantitatively and qualitatively. This also applied to the data collected from the attitude questionnaire. The data from other sources were analysed by qualitative means. All statistical tests were evaluated at the $p < 0.05$ level of confidence.

The results revealed a significantly higher performance of 10.5 % in the post-tests for the experimental group than the control group. All the pupils interviewed agreed that the 'Physicsclassroom' computer software be used for kinematics and other topics in high school physics at Munali.

From the results it was concluded that the 'Physicsclassroom' computer software can enhance the performance of pupils in kinematics in high school physics at Munali Boys High School. Furthermore, pupils showed a positive attitude towards the 'Physicsclassroom' learning approach.

The following recommendations were made:

(i) While the 'Physicsclassroom' learning approach enhanced pupil performance in kinematics to the extent above and showed a high degree of acceptability with the study group, it should not be used as the only learning method on this topic but as a supplement to the traditional learning methods which have been in use.

(ii) Research with a larger and more representative sample should be done to verify the preliminary findings above in order to arrive at a more definite decision regarding the implementation of the 'Physicsclassroom' learning technique.

DEDICATION

This dissertation is dedicated to my dear wife Maureen Kaulu , my children: Byrne, Janet, Einstein, Paul and my niece Regina for the hardships they bore during the time I pursued my post graduate studies.

ACKNOWLEDGEMENTS

I wish to acknowledge my indebtedness to the loving God for allowing me to complete the Master's programme. Being a self sponsored student, life was never easy but the Lord made the resources available, even where I had no hope.

Thanks go to Prof. V.S Kostyuk, who supervised my work for some time. Special thanks are due to my Supervisor, Mr. C. Haambokoma, for the splendid advice, encouragement and academic support he rendered. His advice was always very helpful to me.

I am indebted to Mr. Mbewe of the University of Zambia, School of Education , Department of Mathematics and Science Education for the help he gave me on computer software. I also wish to express my appreciation to Mr. Daka and Mr. Kangwa for the valued help and encouragement they rendered to me regarding this work.

Lastly but not the least, I wish to thank the Kaulu family for the patience and support during my studies, despite the difficulties we all went through.

TABLE OF CONTENTS

TITLE **PAGE**

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ALT.............Academic Learning Time

CBI..............Computer Based Instruction

COSM ....Centre for the study of the Origin and the Structure of Matter.

ECZ..............Examinations Council of Zambia

MOE............Ministry of Education

P..................Participant

PCR..............'Physicsclassroom' computer software

TI ....Traditional Instruction/Learning method

ZASE............Zambia Association for Science Education

CHAPTER 1

INTRODUCTION

1.1 Preamble

This chapter is an introduction to the study. It presents the following: background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitations of the study and the operational definitions of key terms.

1.2 Background

Science subjects form a very important component of the secondary school curriculum (MOE, 1996). Therefore, all pupils in high schools are expected to take at least a science subject. One of these subjects is physics and it is taken either as a pure science or as a component of science.

According to Shakuba (2007), since the year 2002, the mean performance of candidates in high school physics in Zambia has not been good. It has always been lower than half of the whole paper total mark as shown in table 1 below.

Table 1. Mean performance of candidates in pure physics from 2002 to 2006

Year	Whole paper total mark	Mean mark
2002	165	72.0
2003	165	67.0
2004	165	76.6
2005	165	47.1
2006	165	81.5

The situation has been the same for Grade 12 Science Paper 2 (Physics). For example, in 2004 and 2005, out of the total mark of 65, the candidates' mean marks in this paper were 23.2 and 12.2 respectively (ibid, 2007:1) showing that the performance of pupils was below average.

Prior to 1996, the Ministry of Education made similar observations about the low achievement of pupils in mathematics and science, as indicated below:

> achievement is far from satisfactory, especially in the key areas of mathematics and science. This comes out strongly in examination results. On average, less than two-thirds of the candidates obtain a full pass in school certificate each year. This is not a good return for the many years of investiment made by the nation and students themselves in their education (MOE,1996:56).

Furthermore, the Ministry attributed the overall poor performance of the pupils in school certificate mainly to mathematics and science as shown in the following extract:

> The overall unsatisfactory performance in school certificate is attributable in large measure to poor performance in mathematics and science. Cumulatively, one-third of boys and girls have registered total failure in mathematics in the years since 1987. In the sciences, a massive proportion of candidates obtain failing or only mediocre passing grades each, with girls' performance always lagging far behind that of boys (ibid :53).

As a result the Ministry had no choice but to suggest for interventions as follows:

> Clearly, there is a situation here which requires urgent attention and major interventions. The pupils themselves and the country as a whole cannot sustain a continuation of this unsatisfactory performance in mathematics and science leading to equally unsatisfactory performance in the certificate as a whole and subsequent impairment of the national potential for technological development (ibid: 54).

For this reason, studies have been undertaken to establish topics in physics which pupils find difficult to learn. One of the topics that has been identified as very difficult is kinematics (Haambokoma et al., 2002; ZASE, 2004; COSM-Zambia, 2005). Kepler (1960) defines kinematics as the study of motion of bodies without regard to the forces that cause it. In other words it is a branch of science which deals with motion without looking at the causes of motion (Woodbridge, 1963). It emerged as a special branch of mechanics in the first half of the 19^{th} Century due to pressure from the growing machine building industry (Kepler,1960:1). Today kinematics is very important in several ways. For example, it is used by police officers in accident investigations to determine if speed was a contributing factor to the accident. In such cases, the officers are only interested in the minimum speed for legal purposes (Borges: 2008).

Kinematics is also used in the designing of automobiles. As we all know, the immediate cause of injury or death in traffic accidents are numerous. Some are: broken glass, fires, the crushing of the vehicle and hurling the passenger against the car itself. But the main one is the acceleration a passenger experiences (ibid:1). In a collision there is a very large change in velocity in a very short period of time, hence there is an enormous acceleration (or deceleration) that produces a large force on the object. Using the test dummies in recorded crashes, automobile designers are able to get an idea of what values of acceleration are survivable and so, they can design the automobiles accordingly.

But as already stated, kinematics has been problematic to the pupils in various ways. With regard to this topic, the Examinations Council of Zambia (2000) report that pupils are confused with the terms, "uniform and constant," "speed, velocity and acceleration". Worse more, they have difficulties with kinematic graphs (ibid:3).

A point to strengthen the foregoing has been made by Redish and Risley (1988:471) as follows:

> The most common problem on kinematics is that students confuse position and velocity. Given a position verses time graph students often draw a velocity verses time graph that is indistinguishable from the position verses time graph even after

> having completed an introductory college physics course. In addition they have a difficult translating a written description of a motion and vice- versa.

But why do the pupils face all these difficulties in kinematics? The causes of the *difficulties are several. The main ones are the mathematical aspect (Brassel,* 1987a), the traditional instructional methods of teaching that are used in schools (Sinyangwe et al., 1995; Mulemwa, 1999; Haambokoma et al., 2002; ZASE, 2004) and the under qualified teachers who teach physics (MOE, 1996; Sewel and Burger, 1998). Therefore, there is a need for an intervention that should address the causes above and consequently help eradicate or minimise the difficulties faced by pupils in kinematics so as to improve their performance.

Some physics teachers now think that the difficulties pupils face in learning kinematics in high schools can be eradicated or minimised by supplementing traditional teaching methods with the 'Physicsclassroom' computer software (COSM-Zambia, 2005). This is because when a suitable computer based instruction is used as a supplement to traditional teaching approaches, it provides greater access to learning for pupils with special educational needs, models and simulates a range of scientific phenomena, motivates students, develops problem solving capabilities and aids deeper understanding of the subject matter (Sibiya, 2003; Edwards et al., 1975).

However, although many scholars (Vinsonhaler and Bass, 1972; Edwards et al., 1975; Redish and Risley, 1988; Kulik and Kulik, 1991; Woerner et al., 1993; Scaife and Wellington, 1993) show that CBI is effective in teaching and learning, there are others who indicate a different finding. For example, Kerry (1996) asserted that students' use of CBI for various tasks such as drawing or graphing did not radically transform what they would do without computers. Liu et al. (1998) reported that there was no significant effect of computer integration on achievement or in student attitude towards computers after computer integration. Choi and Gennaro (1987) argued that students who were given the opportunity for computer based learning of science gained no advantage in computer-simulated experiments over students who conducted the same experiments hands-on, when the students were of average ability. Clark (1994) also argued that media (including computers) do not influence learning and achievement under any conditions. Clark states:

> The best current evidence is that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition. Basically, the choice of vehicle might influence the cost or extent of distributing instruction, but only the content of the vehicle can influence achievement'(ibid:445)

The implication of these contradictory findings is that in a given context, CBI may or may not help enhance learner performance depending upon a number of factors such as: the guidelines followed by the designers, the conceptual framework for creating it, the learners' interests and their preferred learning styles (Thomas and Emereole, 2002). It is therefore important that before a new software, in this case the 'Physicsclassroom' computer software is used to aid learning in any of the schools in the country, its effectiveness is known.

1.3 Statement of the Problem.

It is not clear how effective the 'Physicsclassroom' computer software would be on pupils' learning achievement in kinematics at Munali Boys High School if it was used to supplement traditional teaching approaches.

1.4 Purpose of the study

The purpose of the study was to find out the effectiveness (if any) of the 'Physicsclassroom' computer software on the performance of pupils in kinematics at Munali Boys High School when used as a supplement to traditional teaching approaches.

1.5 Objectives of the study

The objectives of the study were to:

(i) find out if the PCR software can enhance pupil performance in kinematics in physics at Munali Boys High School when it is used as a supplement to traditional learning methods.

(ii) determine the extent to which the PCR software can enhance pupil performance in kinematics.

(iii) find out the effects (if any) which the PCR has on the attitudes of pupils to kinematics and the learning methods.

1.6 Research questions

In the study, three research questions were addressed:

(i) Does the PCR software enhance pupil performance in kinematics in physics at Munali Boys High School when it is used as a supplement to traditional learning methods?

(ii) To what extent (if any) does the PCR software enhance pupil performance in kinematics?

(iii) What effects (if any) does the PCR have on the attitudes of pupils to kinematics and the learning methods?

1.7 Significance of the study

The researcher has been a teacher of physics in Zambia and an Examiner in this subject for many years. Currently, he is a member of the COSM-Zambia education programme. In 2004, 2005 and 2006, COSM-Zambia identified and discussed topics from the Zambian High School Physics Syllabus which pupils perceived to be very difficult. Among these topics was kinematics. Traditional practical teaching methods of presenting kinematics were demonstrated to help the teachers recall how to teach the topic. However, it was felt by many teachers of physics (60%) in COSM-Zambia who were interviewed that use of CBI such as the PCR software as a supplement to traditional learning methods would be more helpful to the pupils in kinematics than the traditional instructional methods only that have been in use for a long time. Unfortunately, no study has been done in Zambia to determine the effectiveness of the PCR software on the performance of pupils in kinematics. Hence, this research, the findings of which could be useful particularly to the Ministry of Education that has endorsed the e-learning programme in Zambia and so is in search of effective educational software to help enhance learner performance in various subjects. Secondly, the study might stimulate further research by the academicians especially in the field of mathematics and science education on the use of the latest software packages in high school physics and other subjects. This in turn could help the educationists to appreciate the use of computer based learning more and utilise it effectively. In addition, since the use of CBI is new to Zambia, the study might not only help bridge the knowledge gap in computer based instruction in our society but also supplement the existing literature on the Constructivist learning methods.

1.8 Limitations of the study

A number of factors restricted the scope and breadth of this study. Firstly, only one urban school, Munali Boys High, was used as many other schools in Lusaka did not have the required number of computers and the internet connectivity. Secondly, the researcher had limited time and so could not involve participants from other schools. Lastly, conclusive studies needed a larger sample size but that was not achieveable due to financial difficulties.

1.9 Operational definitions of key terms

In this study the key terms had the following meanings:

Attitude Attitude is the predisposition or tendency to react specifically towards an object, situation, or value; usually accompanied by feelings and emotions (Good, 1973). In this study the term attitude referred to the way the participants thought or felt about kinematics, the TI and the PCR software.

The attitude was either positive or negative.

Effective This means working well and producing the intended result (Collins, 2002). Here, the PCR was effective if it enhanced pupil performance in kinematics and made the pupils develop a positive attitude towards kinematics and the PCR learning approach.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This Literature review is organised around the following headings: The Physics Curriculum – some old and new challenges, pupils' learning difficulties in kinematics, the theoretical framework of the study, effectiveness of Computer Based Instruction on learning, the main gap in the literature review and the summary of the chapter.

2.2 The Physics curriculum - some old and new challenges.

According to Brassel (1987a), science (physics) was introduced long before the 20th Century. The main reasons for this were the industralisation of societies and the development of science as a social activity. Early methods of teaching the subject in schools were based on lecturing and the text book. Practical work and laboratory as an intergral part were only introduced in the early 20th Century. Mathematics was an important aspect in the physics courses (ibid:145). At that time no one thought that mathematics would make it difficult to learn physics.

After some time scientists and teachers realised that due to the mathematical aspect, it was not easy to learn physics (ibid: 145). For this reason, there was need to reduce mathematical content in order to broaden the appeal to students with less mathematical skills. According to Brassel (ibid: 145):

> Between 1960s and 1970s, the physics curriculum suffered significant changes. Teams of scientists and teachers joined efforts to develop new texts and new approaches to teaching. *In 1964 the United States initiated a type of science called* Project Physics. This was under the direction of experienced physics educators, philosophers and historians of science and it had international impact. The course intended to increase the appeal of physics to a broader range of high school students by emphasing the humanistic roots and consequences of physics integrating history, culture, technology, and people

> in the development of physical ideas. Physics was seen as a human intellectual endeavour. Mathematical skills were reduced in order to broaden the appeal to students with academic abilities.

However, the reduction of mathematical skills did not last. A new wave of innovations in the physics curriculum started in the 1990s and was inspired by the standards movement (mainly in the US) and by professional societies, such as the Institute of Physics in the (UK) and the American Association for the Advancement of Science. The Associations came up with the new curricula called Active Physics (Eisenkraft, 1998) in the US and the Advancing Physics in the UK, which presented physics as a much more practical subject, linked to every day phenomena, technology, and engineering. These new curricula tried to broaden the appeal of physics, not only for those interested in it, but also for students that would pursue careers in other sciences and engineering, or even in other subjects outside science and technology. Because of the change in the appeal, mathematics was again seen as fundamental to the pleasure and power that physics had to offer (Cokroft, 1982; Ogborn, 1999). Algebraic expressions, equations and graphs were approached as a way of representing ideas in physics symbolically and this has continued up to now (Berger, 2007; Govender, 2007). The difficulties which students had with the mathematical side of Physics were ignored by the professionals. What mattered most was for more people to have a feel of physics, regardless of how they found it.

As a result of such innovations, a lot of learning difficulties still exist in physics. Among their many causes are not only the insufficient experimental activity, common sense knowledge and teachers' inadequacies, but also the mathematics used in this subject (Sassi, 1996). Commenting on physics, Kingsbury (2004:1) said:

> Physics – a science that deals with matter and energy and their interactions is one of the most, if not the most difficult science in existence. It tries to understand the world from the motion of galaxies hurtling through space and time, to the inner working of the atom . It is difficult and frustrating....

The perception of physics as a difficult subject has not spared the developed countries in the world (Intuitor, 2002). For example, out of the three major sciences taught in the high schools of the United States, physics is the most neglected because it has more misconceptions associated with its principles than any of the other sciences, not to mention an undeserved reputation for difficult (ibid:1).

2.3 Pupils' learning difficulties in kinematics

African countries, including Zambia, have not been spared by the same physics problems above particularly in kinematics (Haambokoma et al., 2002; ZASE, 2004; COSM-Zambia, 2005; Kanyongo et al., 2007). No matter how the teachers teach the topic using traditional instructional methods, the pupils' perception of kinematics has remained the same. They complain that kinematics has too many formulae and calculations, and either no explanation is given to certain concepts by the teachers, or the explanation given is not clear (Haambokoma et al., 2002). Indeed the mathematical side of physics has been a stumbling block even to intelligent pupils. This is because although mathematics is said to be the language of physics, many pupils find it to be the most unfavourable of all the subjects (MOE, 1996; Haambokoma et al., 2002).

According to the Examinations Council of Zambia (2000), another problem pupils face in kinematics is that they are confused with the terms "uniform and constant," "speed, velocity and acceleration." The terms to them fit any description of motion. They also have problems with graphs (ibid:3). Commenting on the performance of candidates in the 1999 Physics Examination, number 5054/2, the Examinations Council of Zambia (2000:2) said:

> If educators of the candidates followed their syllabus, they would be aware of topics that require knowledge of graph work of all types involved. As at now it appears, pupils know graphs and construction from the mathematics point of view with no connections with science requirements of the skills.

Mc Dermott et al (1987:55) asserted that " graphs and cartesian representation of data have many associated misconceptions. Typical misconceptions include the *confusion between trajectory and shapes of position verses time graphs." This was* also reflected by Redish and Risley (1988:471), in the following extract:

> The most common problem in kinematics is that students confuse position and velocity. Given a position verses time graph students often draw a velocity verses time graph that is indistinguishable from the position verses time graph even after having completed an introductory college physics course. In addition they have a difficult translating a written description of a motion and vice-versa.

Apart from the mathematical aspect indicated by Brassel (1987a) the other reason why pupils in high school physics have difficulties in kinematics is the TI teaching approach which is commonly used by the teachers to teach the topic (Sinyangwe et al., 1995). Although there are many traditional teaching/ learning methods in schools such as: demonstrations, lecture method, group discussions, question and answer, whole class discussion, individualised work, small group practical work, field trips, home work, role play, team teaching, pair work, project work, book method, problem solving investigation and education games, the most common one in class in kinematics is the lecture method (Mulemwa, 1999; Haambokoma et al., 2002; ZASE, 2004). Teacher demonstrations are only done in rare cases. In Zambia teachers give a number of reasons for using the lecture method.

Firstly, about 80% of the staff who teach physics in high schools in Zambia were not trained to teach physics and so did not have the competence to use active learning methods (Haambokoma et al, 2002). Secondly, the physics syllabus is long and the only way to finish it before the final examinations is to use the lecture method where one covers a lot of content in a short period of time (ibid:133). Another reason is that some schools have no laboratories, while others have but with no required materials and pieces of apparatus for practical activities (ibid:134). Futhermore, some teachers have heavy teaching loads and it is difficult for them to prepare learner centered lessons (ibid:134).

But Banda (2004) argues that practical laboratory activities are better than the lecture method because they help pupils to see or visualise what is being taught. Lawrence et al (1996) contend that visualizing of physical phenomena through techniques such as experiments, demonstrations, and models contribute much to students' understanding of physics concepts. This is because such techniques allow students to observe how objects behave and interact. Furthermore, they provide students with visual associations which capture and preserve the essence of physical phenomena more effectively than do verbal descriptions.

Therefore, there is need for a more reliable intervention (practical teaching approach) that may help eradicate or minimise pupil difficulties in physics (particularly in kinematics) and enhance their performance in this subject as per appeal from the Ministry of Education (MOE, 1996).

Some physics teachers now think that one way to deal with the problems of kinematics and help the learners achieve higher on this topic is to use CBI, in particular the 'Physicsclassroom' educational software, as a supplement to traditional instruction (COSM-Zambia, 2005). This is because CBI can serve as, a personal tutor by providing reliable tutorials, a science laboratory by providing demonstrations and animations, a model by showing pictures of real objects and as a tireless servant, as it is always at a command of the user (Peter et al., 1982).

Rushby (1987:17), brings out a number of reasons why CBI constitutes such a powerful educational tool as follows:

- The most important reason is that the CBI is interactive. Unlike books, tapes, films, radio and television, the user's response determines what happens next. This gives children a sense of control. It also elicits active, motor involvement.

- Computers are fun. Human beings love to respond to challenges and love to make things happen. The computer games industry has grown rich on that basic axiom. By coupling education to games of challenge, computer-assisted learning becomes fun.
- Computers have infinite patience. A computer programme does not care how slowly the user responds or how often a user makes mistakes. Among the earliest uses of computer-assisted learning on a wide scale was the use of computers in Ontario in the late 1960s designed to help innumerate teenagers to fulfil the mathematics requirement for college courses. The programme was successful from a number of points of view, not the least of them the attitude expressed by one girl who stated that the computer was the first mathematics teacher who had never yelled at her.
- Good education programmes never put a child down. Instead they provide effective positive reinforcement.
- CBI can provide privacy. Children, or for that matter teachers, can make embarrasing mistakes without any one seeing them. Ignorance, lack of skill, slowness to comprehend, poor co-ordination, can be overcome in the privacy of one's home. The computer will not tell any one.
- Conversely the CBI can be used in a variety of social situations. These include class room activities involving groups, or a teacher and single pupil only, or two neighbourhood children, or party games, or a grand parent and grand child, etc. Many education programmes are designed to allow for either individual practice, or for two or more children to play games.
- A computer programme can explain concepts in a more interesting and understandable manner by means of animated material. No amount of talking, writing or providing diagrams, can compare with making things come alive on the screen.

- Whereas it is very difficult to hide things in a book, it becomes possible to hide things in a programme, which become apparent only occasionally. A book, on reading, holds few surprises (although the reader may have missed points the first time). In contrast, a computer programme can be full of surprises. Good programmes contain an element of mystery and uncertainty which keeps the user interested. It means that the learning experience provides new situations not only for the students, but also for the teacher or parent as well.
- The ability to simulate complex situations, such as chemical reactions, ecosystems, demographic or economic changes, is a particularly powerful reason for using CBI in education. Training pilots, managers, doctors, chemical engineers, or any professions or activities where a mistake in the real world could be very costly, are best served by learning on a computer which simulates real situations. In addition, simulating real events often makes it possible to train students to think 'literally' across traditional subject boundaries.

2.4 The theoretical framework of the study

The study was informed by the constructivism theory of learning. Two approaches of learning involving this theory were considered, namely: the cognitive and the social constructivist theories of learning. The rationale for the use of cognitive and social constructivism here is based on the psychological principles of the social as well as the cognitive benefits of peer/peer relationships (Shanyinde, 1998). Through interaction individuals learn to view situations and problems from perspectives other than their own. Structuring learner/learner interaction co-operatively leads to high achievement, use of high level reasoning, higher levels of achievement motivation, positive motivation , positive inter personal relations and the attainment of higher self- esteem (ibid:56).

According to Piaget (1955) cognitive constructivism asserts that learners create their own knowledge through personal experiences that enable them to create mental images in their minds. This argument is reflected in the work of Epstein (2002:1), Adeyinka and Mayor (2005:76) when they say "Learning is constructed through mental and physical activities whereby the learner gets direct sense impressions like touching, seeing and/ or smelling." According to Wellington (1994), learning involves construction of knowledge through experience with the physical environment. In such a process, learners are able to discover knowledge themselves. Therefore, the use of computer based instruction in this study puts across the premise that knowledge could be actively constructed by the thinking of the learner and not passively received from the teacher. It also puts across the notion of learner-centeredness where learners could build confidence and create an anxiety–free atmosphere for learning (Pulist, 2005). Furthermore, through this approach learners are provided with greater autonomy and control over the choice of subject matter, learning methods and pace (Gibbs, 1992). In the learning process, the pupils are given the opportunity to process information, solve problems and make decisions of their own using computer based instruction.

On the other hand "social constructivism encourages students' active involvement based on their own constructions, questions and motivation (Patronis, Potari and Spiliotopoulou, 1999:746). It emphasises the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding (McMahon, 1997). Learning is viewed as not only being confined to the individual mind, but as also involving social and cultural processes (Newton, Driver and Osborn, 1999). Social constructivists believe that reality is constructed through human activity and that members of a society together invent the properties of the world (Kukla, 2000). For a social constructivist, reality cannot be discovered; it does not exist prior to its social invention (Kaino, 2007). Also to social constructivists, knowledge is a human product, and is socially and culturally constructed (Ernest, 1999; Gredler, 1997). Social constructivists argue that individuals create meaning through their interactions with each other and with the environment they live in. They view learning as a social process that does not take place only within an individual or as a passive development of behaviours that are shaped by external forces (McMahon, 1997). It is argued that meaningful learning occurs when individuals are engaged in social activities. Therefore, use of computer based instruction in this study puts across another premise that interaction and cooperation among pupils has an influence on their learning.

Hawkins et al (1982) examined the type of and amount of social interaction that took place during regular classroom activities and while using computers. The investigators observed the type and frequency of peer interactions that occurred in classroom work before and after computers were placed in the classroom. The findings were that more task-related interaction occurred among children when they were working with computers than when they were engaged in other non-teacher-directed classroom activities (e.g mathematics activities). These results suggest that the computer based instruction can provide a context in classrooms where children recognise each other as additional resources.

According to Kuhn (1993), science is a social activity which is advanced through the thought processes that occur between people, not just within them. Learning is intimately related to discourse and talking. Rather than just hearing about scientific concepts, students should be able to talk about them (De Vries, Lund and Baker, 2002). An enabling learning environment is created when learners are able to participate actively in the discourse of lessons (Newton, Driver and Osborne, 1999). Ideas which arise, can be articulated, questioned, clarified, defended and elaborated in the social setting (Kuhn, 1993). This is reflected by Wellington (1994) who asserts that no man is an Island, entire of itself; every man is a piece of the continent, a part of the main. We are social species, the more so by virtue of our possession of language. Interpersonal processes influence how and what we learn (Maturana, 1991). Wellington, 1994:55) states:

> Therefore, whatever we scientists do as we do science has validity and meaning as any other human activity does, only in the context of human coexistence in which it arises; central to this coexistence is language. We exist in language, experience takes

> place in language and we know what we know through its constitution in language.

Maturana's underlying point, that knowledge is constructed by individuals through interpersonal processes, is now shared by many people. Bruner (1964) stressed the importance of language in cognitive development nearly thirty years earlier. Edwards and Mercer (1987), regard knowledge and thought as fundamentally cultural, deriving their distinctive properties from the nature of social activity, language, discourse and other cultural forms. This implies that meaning is constructed not only through processes operating on individuals, such as the stimulation of senses or the mediation of prior knowledge, but also through processes of social communication.

There are more studies which show a positive relationship between giving and / or receiving explanations and learning (Chi et al., 1994). De Vries, Lund and Baker (2002) assert that through being involved in the discussion/ explanation, the person learning or explaining may detect and repair gaps in his or her own knowledge. The corollary to this is that the learner listening to the explanation or participating in the discussion is exposed to new ideas, and possibly can assimilate these to develop new or extend his / her understanding (ibid: : 68).

According to Green (2007), dialogical or argumentation interactions are very helpful in learning. Argumentation may be thought of as the process of engaging in an argument. Kuhn (1993:322) defines an argument (in its social sense) as :

> ..a dialogue between two or more people who hold opposing views. Each offers justification for his or her own view, and at least in a skilled argument, each attempts to rebut the other's view by means of counter argument.

De Vries, Lund and Baker (2002:68), describe ways in which argumentation may contribute to understanding. They suggest the following :

- Engaging in argumentation allows learners to make their ideas explicity, open to scrutiny, consideration, challenge and possible revision
- Engaging in argumentation may cause learners to actively search for 'new' knowledge, and multiple ways of presenting it in order to convince them.
- Arguments shown and accepted to be flawed may be rejected in favour of the opposite view.
- In order to convince, participants need to be precise about the proposals and counter proposals that are made. This allows participants to make fine conceptual distinctions in the subject domain.

These ideas are informative in several respects. They are an elaboration of how learning is augmented socially and point to the characteristics that are essential for achieving education outcomes in a positive way. They embody concepts that help to explain the process of knowledge transfer socially (interpersonal to interpersonal). They show that engaging in social activities has reciprocal value and this may explain how learning is socially augmented (Shanyinde, 1998). Further, they seem to suggest that using computer based instruction, learners could acquire knowledge not only through working independently to discover and create their own knowledge, but also through interaction with colleagues and cooperation among themselves in computer classes. The interactive nature of using computer based instruction tends to provide the opportunity for learners to work independently as well as in cooperate atmosphere. The section that follows discusses the effectiveness of computer based instruction on learning.

2.5 Effectiveness of Computer Based Instruction on learning

This section starts with a brief history of the types of studies which researchers have designed and used from the 1960s to date to study the effectiveness of computer based instruction in teaching and learning. Where possible specific examples have been given including some limitations if any.

2.5.1 History of the types of studies designed by researchers from the 1960s to date in an attempt to determine the effectiveness of CBI in teaching/ learning.

Soon after the introduction of computer based instruction, researchers began to design studies that attempted to determine the effectiveness of computer based instruction when compared to traditional instruction. One of the researchers who did this was Arkinson (1968). He conducted a study where 100 first – graders received daily 20 minutes of computer based instruction in mathematics. The pupils in the control group only depended on traditional instruction for the same lessons without CBI. The findings from the study showed that computer based instruction was superior to the traditional instruction in enhancing pupil performance in mathematics.

But according to Hasselbring (1986), while the early evaluation studies produced some valuable information on the effectiveness of CBI on learning, the results from the studies were inconsistent and the conclusions drawn by the investigations were often unclear. Therefore, in order to try and gain a better understanding of the effectiveness of CBI on achievement a different approach was needed. Several reviews were written to bring the separately published studies together to reveal the common findings. These early reviews used a ' box-score' technique for integrating the results. The box score reviews generally reported the proportion of studies that were favourable and unfavourable toward CBI, as well as narrative comments on the studies. An example of the box-score reviews , was the study done by Vinsonhaler and Bass (1972). They summarised the results of 10 major studies that were conducted from 1967 to 1970 involving CBI drill and practice with more than 10,000 elementary school children from different sections of the United States of America. The investigators concluded that children who received computerised drill and practice generally showed performance gains of 1 to 8 months over control children who received only traditional instruction. These findings were reflected in a later review by Edwards et al. (1975) who evaluated the effects of drill and practice, problem-solving, simulation and tutorial computer instruction programs for producing achievement gains in school children. Based upon results from six studies, they concluded that CBI as a substitute for TI produced positive effects.

Again, although the 'box–score' reviews provided additional insight into the fundamental questions regarding the effectiveness of CBI, this type of review has certain limitations. For example, the 'box-score' reviews do not say how much better one method is than the other. They simply report how often the method comes out on top (Hasselbring, 1986). Further, they do not use statistics to find the characteristics that distinguish studies with positive results from those with negative findings. Therefore, in an effort to overcome the limitations of box-score reviews, researchers have been employing a more sophisticated method called 'meta-analysis'. This is simply an analysis of a large collection of results from individual studies for the purpose of integrating the findings. Here the effects are expressed in two ways:

(a) the number of standard deviations separating experimental and control groups, and

(b) as improvements in percentile scores on a final examination.

The first researcher to apply meta-analysis to findings on CBI was Hartely (1977). She focused her analysis on mathematics education in elementary and secondary schools. Hartely reported that the average effect of computer based instruction was to raise student achievement from the 50th to the 66th percentile (ibid:1)

Other researchers who used meta-analysis were Burns and Bozeman (1981). These integrated the research findings on CBI in mathematics teaching in elementary and secondary schools also. They found that computer based tutorials raised achievement test results by 0.45 standard deviations and that computer based drill and practice raised test scores by 0.34 standard deviations.

Kulik, Bangert and Williams (1983) also analysed 51 independent experimental studies that used computer based instruction in grades six through twelve. They found that when CBI was used in instruction, student scores on final examinations were raised from the 50th percentile to the 63rd percentile which represented a 0.32 standard deviation increase. In addition Kulik and colleagues reported that students' attitudes toward the subject being learned and student ratings of the quality of instruction are slightly more favourable with CBI. Further, students' attitudes toward computers are significantly more positive as a result of CBI.

But one problem with many of the studies above is that they are not conducted for a long time and so the participants do not have enough encounters with the computers. Wise and Okey (1983) report that in three of the studies they reviewed, the students had only one encounter with a computer and the greatest number of encounters for any study was only eleven. Thus, many of the findings being reported are based on brief encounters with computer based instruction by the students.

A well known study which was done for a long time and in which the participants had enough encounters with CBI was that by the Educational Testing Service (ETS), in conjuction with the Los Angeles Unified School District (Ragosta, Holland and Jamison, 1982). This was a four year longitudinal study on the effectiveness of CBI for compensatory education students. The study was designed to answer questions about the effectiveness of CBI on three curricular, one of which was mathematics, when used for one year and over several years. Four elementary schools were each equipped with CBI labs using computer terminals and printers operated by a mini computer. Half of the students in each school attended the CBI lab for 10 to 20 minutes a day over four years. Each of the curricular was designed to reinforce skills that students had already been taught in the classroom. The computer programme adapted its delivery of each skill strand of the CBI curriculum to the performance level of each student and moved the student along at his/her own rate of progress. The learning outcomes were translated into equivalent percentile scores that allowed comparison between CBI and traditional instruction, the 50^{th} percentile being the average for the control students. On the curriculum – specific tests designed for this study, the CBI mathematics students showed significant progress. They performed at the 79^{th} percentile by the end of one year, at the 82^{nd} percentile by the end of two years and at the 89^{th} percentile at the end of three years.

2.5.2 Additional findings on the effectiveness of CBI from the 1960s to date.

Research findings in section 2.5.1 show that when computer based instruction is used, thoughtfully as a supplement to traditional instruction (TI), it enhances pupil performance in a subject. This view is supported by several other researchers (Edwards et al, 1975; Zalpha, 1986; Chapman, 1986; Brassel, 1987b; Wynn and Wynn, 1988; Garvison and Shale, 1990).

Edwards et al. (1975), reviewed studies published between 1966 and 1973. The researchers distinguished between studies in which computer based instruction was used as a supplement to traditional instruction and those studies in which computer based instruction served as a substitute for traditional instruction . In all their studies, the findings were that when computer based instruction was used to supplement traditional instruction, this approach was more effective than when traditional instruction alone was used; but substituting computer based instruction for traditional instruction produced inconsistent results. These findings seem to suggest that computer based instruction enhances pupil performance in various subject areas but mainly when it is used as a supplement to traditional instruction and not as a replacement for traditional instructional methods .

Zalpha (1986), carried out a study on the effectiveness of microcomputer assisted instruction on achievement in high school chemistry. The purpose of the study was to investigate the effect of the use of microcomputers as instructional tools on achievement in chemistry in selected urban high schools. An experimental design was used in the research. The study found that frequent computer users made better achievement gains than those who rarely used computers; medium ability students achieved significantly higher when they spent more time on the computer and students felt that the computer programmes were helpful as instructional tools. Therefore, the research concluded that students who use computer aided instruction achieve significantly higher gains than those who do not.

Zalpha's study is important in several aspects. It is one of the few studies the researcher came across in chemistry, where the purpose and design were very clear. Furthermore, it was done in chemistry which is another science subject that gives pupils a lot of difficulties. However, one problem that was identified has to do with the conclusion made about computer aided instruction. Since the study related the performance of pupils to the amount of time the participants spent on computers, the time aspect should have been included in the conclusion, this was not the case.

In the area of physics, Brassel (1987b) studied the impact of computer based learning in kinematics. He used a 'Kinematics unit' to find out the high school physics pupils' ability to translate between a physical event and the graphical representation of it, and the effect of real time graphing (i.e graphing done in the shortest possible time using a computer) as opposed to delayed graphing of data on paper. Overall post-test scores from the experimental group in which the graphs were displayed in real-time were significantly higher than scores from the control group where the graphing of data took longer on the board. He concluded that a single class period was sufficient for high school physics students to improve their comprehension of distance and velocity-time graphs on kinematics, when compared with a paper and pencil control treatment. Most of the improvement (90%) was attributed to real-time graphing so that students got immediate feedback and saw data in a comprehensible form. These findings were consistent with those of other researchers who believed that used as a supplement to traditional instruction, computer based instruction can not only enhance pupil performance in various subjects but also enable pupils to complete their high school courses in a shorter period of time. Chapman (1986) asserted that computer based instruction can increase efficiency in teaching and learning, there by decreasing the number of years required to complete an undergraduate course. This view is shared by Nizar and Chum (1999) who claim that computer based instruction makes it possible for gifted and talented middle school and high school students to complete advanced courses in mathematics and physics several years before than they would normally do.

The study by Brassel (1987b) was also important in a number of ways. Firstly, it was in physics, particularly in kinematics , which is my area of study. It has shown that use of computer based instruction may help the pupils to learn the content in a shorter period of time and to perform better than when they use traditional instruction only. It attributes pupil achievement to real-time graphing and so indirectly brings about the importance of immediate feedback in motivating the pupils. This motivation due to CBI results in pupils' better performance than when they use the traditional learning methods only.

Other studies support the use of computer based instruction in science education because of the simulations and /or animations that may be embedded in CBI (Dence, 1980; Gershman and Sakamoto,1981; Wynn and Wynn, 1988; O'Shea et al, 1993; Gokhale, 1996). A simulation is an operating representation of central features of reality (Ellington et al., 1981:15). It represents a real situation of some sort on a computer and it must be operational. In other words it must constitute an ongoing process. Animations are actions that happen on a computer to move the viewer's focus from one object on a single slide to another object on the same slide (Brian, 2000:302).

Wynn and Wynn (1988) asserted that computer based instruction provides better aids (such as simulations and animations) as compared to abstract. These aids help users master concepts and apply abstract thought to reality. O'Shea et al., (1993) talks of a study of 29 secondary pupils which was done using five computers over three years, involving the use of simulations in mechanics lessons. The findings showed that within a short time a significant amount of conceptual change was detected in the pupils, which showed up on various measures that the researchers used. The study also found that the number of correct responses and explanations based on correct Newtonian theories increased significantly between the pre-test and post-test and delayed post-test.

Gokhale (1996) asserted that students who use computer simulations in lecture-lab activities perform better on academic problems than students who are taught with traditional lecture lab instruction only. When simulations are used, even the reluctant learners become more active and interested in what is being taught (Dence,1980; Gershman and Sakamoto,1981) Therefore, computer simulations embedded in CBI can solve a lot of problems for the teachers and pupils in science education and help enhance pupil performance as described in the following literature.

Wellington (1994:198) outlines the main advantages of computer simulations as follows:

- **Cost**

  Money can be saved in directly copying some laboratory experiments, either by reducing outlay on consumables, such as chemicals and test-tubes, or by removing the need to buy increasingly costly equipment in the first place.
- **Time**

  Using a computer simulation instead of a genuine practical activity *may save time, although some teachers are finding that a good* computer simulation in which pupils fully explore all the possibilities may take a great deal longer.

- **Safety**

  Some activities simply cannot be carried out in a school setting because they are unsafe. An example of these activities may be the effect of corrosive acids on a human skin. This can not be done using the actual acid and skin. The teacher can demonstrate such an effect using a computer simulation.

- **Motivation**

  There is a feeling, though with little evidence to support it, that computer simulations motivate pupils in science education more than traditional practical work.

- **Control**

  The use of a simulation allows ease of control of variables, which traditional school practical work does not. This may lead to unguided discovery learning by pupils who are encouraged to explore and hypothesise for themselves.

- **Management**

  Lastly, Computer simulations offer far fewer management problems to teachers than do many traditional activities. Problems of handing out equipment, collecting it back again and guarding against damage and theft are removed at a stroke. Problems of supervision, timing and clearing up virtually disappear.

But although computer simulations are advantageous, there are several dangers in using them in science education. According to Wellington (1994:199) the main dangers of using simulations lie in the hidden messages they convey, which are classified as follows:

- **Variables**

  Simulations give pupils the impression that variables in a physical process can be easily, equally, and independently controlled. This message is conveyed by simulations of industrial processes, ecological systems, and laboratory experiments. In reality not all variables in a physical situation can be as easily, equally, and independently controlled as certain simulations suggest.

- **Unquestioned models, facts and assumptions**

  Every simulation is based on a certain model of reality. Users are only able to manipulate factors and variables within that model; they cannot tamper with that model itself. Moreover, they are neither encouraged nor able to question its validity. The model is hidden from the user. All simulations are based on certain assumptions but the assumptions are not revealed to the user.

- **Caricatures of reality**

  Any model is an idealisation of reality, i.e, it ignores certain features in order to concentrate on others. Some idealisations are worse than others. In some cases, a model may be used of a process not fully understood. Other models may be deceptive, misleading or downright inaccurate; they provide caricatures of reality, rather than representations of it.

- **Confusion with reality**

  Pupils are almost certain to confound the programmer's model or reality with reality itself. Students may then be fooled into thinking that because they can use and understand a model of reality they can also understand the more complex real phenomena it represents or idealises which may not be the case.

The literature above brings about important points which show that in order for computer simulations to serve their intended purpose certain safeguards need to be put in place. Firstly, all teachers, and in turn pupils, must be fully conscious that the models they use in a computer simulation are simplified. Since the models are made by humans, pupils should examine and question the models. Unless, the developers of the programmes ensure that all the facts, assumptions, and even the models themselves which are used by the programmer are made clear and available to the pupils through the teacher's guidance or in the documentation with the programme, the simulations may not serve the intended purpose. Therefore, all sources of data about computer simulations need to be stated and clearly referenced. Any pupil using a model can then be taught to examine and question the facts, assumptions and models underlying it rather than just accepting the simulation as an absolute truth which may not be so.

Use of computer based instruction as a supplement to TI has been studied in South Africa by Sewel and Buirski-Burger (1998). These scholars did a research to find out if CBI can serve science education in that country. They established that in South Africa they had a problem with science education. The essence of the problem was that very few people with appropriate science qualifications became teachers and thus the teaching of science was left to people who themselves were struggling with science ideas. They recommended that the possible way out of that problem was to use computers to supplement traditional instructional methods of learning. Computers would facilitate the learners' acquistion of knowledge and insight, which may ultimately be greater than their own.

In Botswana, Thomas and Emeriole (2002) carried out a study on the effects of CBI on performance (on electricity and electronics) in physics. The purpose was to determine how effective the CBI or the use of the computer as an instructional technology would be in enhancing academic achievement and attitude towards the classroom integration of computer technology. Sixty six students of Naledi Senior Secondary School in Botswana participated in the study. Results showed that use of combined computer based instruction and traditional instruction methods enhanced academic performance in physics and was viewed as a positive experience by the majority of the students.

The two studies above depict a similarity and some differences worth taking note of. Although they were carried out in different countries, for different purposes and using different methodologies, both found that use of computer based instruction as a supplement to traditional instruction enhances pupil performance in science (Sewel and Buirski-Burger,1998; Thomas and Emeriole, 2002). In my opinion the study by

Thomas and Emeriole (2002) is more focused than the other in structure, methodology and the conclusions. It shows a marked difference from the other, as it has provided empirical evidence of CBI's effectiveness in the affective and cognitive gains of students in physics.

In South Africa, Green (2007) did a study on the effectiveness of microcomputer based learning in addressing learner difficulties and misconceptions related to kinematics and kinematic graphs. In the study a group of learners were required to work through a series of learning activities designed to provide opportunity for the learners to interact with common difficulties related to kinematics and kinematic graphs. Twenty pupils participated in the week-long study. All the pupils applied to participate in the study in response to a flyer distributed by the researcher at local schools. Pupils were selected on a first-come, first serve basis. They were all in Grade 12 (the final year of formal schooling in South Africa) at the time and were studying physical science on the higher grade. Pupils studying science at a higher level covered more concepts, as well as studied certain concepts at deeper levels of complexity, compared to learners who studied science on the standard grade. Thus higher grade pupils were generally considered to be higher ability pupils. All the teachers had worked through the section of dealing with kinematics and kinematic graphs in the course of their normal physical science lessons in school. Pupils were drawn from a variety of school types. Male and female pupils participated in the study. Pupils worked in four small groups, each consisting of five learners. Changes in learner understanding of particular concepts and skills related to kinematic graphs were tracked through inspection of responses in pre- and post-tests. Multiple choice test items were used for pre- and post-tests.

Table 2 that follows illustrates learning successes of the participating pupils, as measured by their performance on the pre- and post-test.

Table 2 Pre – and Post-test scores. Learners arranged in order of number allocated to each at the beginning of the programme.

Pupil ID	Pre-test (32)	Post-test (32)	Change in mark between pre-test and post-test
1	10	15	5
2	8	22	14
3	8	9	1
4	6	18	12
5	7	6	-1
6	6	11	5
7	6	17	11
8	10	18	8
9	12	24	12
10	5	19	14
11	7	11	4
12	11	14	3
13	17	24	7
14	18	23	5
15	23	32	9
16	13	29	16
17	4	11	7
18	14	22	8
19	12	15	3
20	14	25	11
Mean	10.6	18.3	7.7
Mean %	32.9	57	24.1
Standard deviation	4.79	6.89	4.65

The analysis showed that overall , participation on the microcomputer based learning programme contributed to pupil understanding of kinematics and kinematics graphs.

This study is similar to that of Thomas and Emeriole(2002) in three ways i.e both used computer based instruction as an intervention to address pupil difficulties; they both used an experimental design of the pre-test post-test type, and the conclusions made about CBI were more or less the same. The differences were on the content that was studied and the software which were used. Green's study is informative because it shows that CBI is more helpful to the pupils than traditional instruction only. These findings were reflected by Musker (2000) in the editorial page of Education in science in the following extract:

> I have carried out several studies comparing test results of year 10 student groups. These showed that students using an enriched ICT science curriculum improved their performance. It is very difficult to pinpoint exactly how ICT could improve the performance of students in tests. I believe that ICT can often put scientific information across in a different, in a more visually stimulating manner. ICT also allows students to obtain results quicker and more easily and therefore, allows them more time to interprete them........(ibid: 4).

An interesting explanation for the reported positive effects of computer based instruction was given by Bright (1983). His explanation was based on academic learning time(ALT), which he defined as the amount of time in which the student is engaged in a task and is highly successful in completing the task. He argued that when academic learning time is increased there is a concomitant gain in student achievement. Therefore, the more academic learning time a student accumulates the more the student learns. He suggested that the many CBI activities lead to an increase in academic learning time. For example, the amount of ALT is often increased by providing the student with an exciting computer-based learning environment through games or adventures while at the same time providing the student with a learning task in which he is highly successful. Hence, the very nature of CBI activities leads to an increase in ALT and achievement.

Zambia has already learnt about many of these encouraging findings on computer based instruction from studies done in other countries and so has now endorsed an e-learning programme in all the schools. E-learning is basically the use of the internet for learning using computers or educational materials like the PCR software and sending of such learning materials to schools via the internet. The intention is to supplement traditional instruction methods. According to Lungwangwa (2007) e-learning will compliment traditional forms of educational delivery as emphasized in the country's Fifth National Development Plan. The Zambian government's adoption of e-learning will greatly enhance the education system since for a long time the education sector has depended on blackboard and chalk classes (ibid:1).

Already some schools like Munali Boys High in Lusaka, have used the 'Physicsclassroom' computer software as a supplement to traditional instruction in kinematics. According to COSM-Zambia (2005), the PCR is an excellent all-round tutorial with a lot of information on kinematics which is in line with the Zambian Ordinary level Physics syllabi (ibid:1); The PCR has animations to help demonstrate difficult concepts like free fall and a lot of exercises for the learners to practice. The mathematical steps on the equations of motion are arranged in such a way that more pupils easily follow than they do with the TI. However, it seems no research has been done in Zambia to determine the effectiveness of the PCR in the learning of kinematics.

Much of the literature reviewed so far indicates a good picture about the use of computer based instruction in education. However, it should be mentioned here that not every form of CBI is effective in teaching and learning. In fact, 55% of the computer educational software fall into the "Not Recommended" category; Only 40% are in the "Recommended" category and 5% in the "Highly Recommended" category (Wynn and Wynn, 1988).

In Nigeria a study was done by Olugbemiro et al. (1991) on "computers and the learning of biological concepts: attitudes and achievement of Nigerian students". The purpose was to find out how the attitudes of the students would be affected by the use of computers and the distinction, if any, in their achievement due to computer based learning. The study found that there was no significant difference between the groups which used computers and the one which did not. In fact the students with the best results were those working in cooperative teams without computer aided instruction. According to Kerry (1996:113) "students' use of computers for various tasks – writing, drawing or graphing usually did not radically transform what they would do without computers."

Liu et al (1998) argued that there is no significant effect of computer aided learning on achievement or in student attitude toward computers after computer integration. Sani (2001:17) reports:

> The new information and communication technologies, whose role was considered by most speakers as crucial to the quality of science teaching at the present time, were nevertheless called in to question by some. In one speakers's view, those technologies were not essential to the learning process, which could take place with out them and they neither could, nor should replace learning in and through the real world and practical experiments.

It is clear from the literature reviewed that the findings about the effectiveness of CBI are quite conflicting. Some are positive while others are negative. Therefore, before using any latest educational software, in this case the PCR, we need to investigate its effectiveness in our context so that we get to know whether or not it will serve the intended purpose.

2.6 The main gap in the literature reviewed

This study is not comparative in nature, but rather focuses on the effectiveness of the Physicsclassroom computer software, in the learning of kinematics by pupils in high school physics at Munali Boys High School in Lusaka. From the literature review it is clear that no study has been done to find out the effectiveness of the 'Physicsclassroom' computer software in the learning of kinematics in high school physics in Zambia. Hence, the need to investigate the software.

2.7 Summary of the chapter

This chapter reviewed literature about some of the challenges in the physics curriculum which have contributed to the difficulties the pupils face in this subject. The main ones are : the use of mathematics in physics which is unavoidable, perpetual use of the TI teaching methods especially the lecture method, due to lack of teaching/learning aids and the use of unqualified teachers to teach physics. The literature reviewed suggests that such difficulties may be minimised by using CBI as a supplement to TI. The chapter that follows presents the methodology of the study.

CHAPTER 3

METHODOLOGY

3.1 Research design

Kerlinger (1986) defines a research design as a plan and strategy of investigation so conceived as to obtain answers to research questions or problems. The plan is the complete scheme or programme of the research. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data. But Kumar (1996:74) defines a research design as "a procedural plan that is adopted by the researcher to answer questions validly, objectively, accurately, and economically."

From the definitions above, we can see that a research design has two main functions. The first relates to the identification and/or development of procedures and logistical arrangements required to undertake a study, and the second emphasises the importance of quality in these procedures to ensure their validity, objectivity and accuracy (Kumar, 1996). Hence, through a research design you conceptualise an operational plan to *undertake the various procedures and tasks required to complete your study and ensure that these procedures are adequate to obtain valid, objective and accurate* answers to the research questions (ibid:74).

In this study an experimental design of the type pre-test, post-test control group was used (Cohen and Manion,1990). This was as illustrated below.

R	O1	X	O2	(Experimental group)
R	O3	X	O4	(Control group)

R implied that the participants were randomly assigned to the groups. Randomisation ensured the greater likelihood of equivalence, that is, the apportioning of the experimental and control groups of any factors or characteristics of the subjects which might have conceivably affected the experimental variables in which the researcher was interested (Cohen and Manion, 1990). When the groups are made equivalent, then any 'clouding' effects should be present in both groups. For example, 'if the mental ages of the children in the experimental group increase, so should the mental ages of the children of the control group. If something happens to affect the experimental subjects between the pre-test and post-test, this samething should also affect the subjects of the control groups' (Campbell and Stanley, 1963).

The O s in the design referred to the pre-test and post-test in sequential order for each group. X represented the treatment, which for the experimental group was the PCR computer software. The control group used only the traditional instructional methods, particularly the lecture method, simple demonstrations and physics books. The design was used because though simple and elegant, it is so strong that it controls many of the common threats to internal validity such as : history, maturation, statistical regression, testing, instrumentation, selection, and experimental mortality (Campbell and Stanley, 1963).

According to Cohen and Manion(1990), one problem that has been identified with this particular experimental design is the interaction effect of testing, as reflected in the following extract:

> Whereas the various threats to the validity of the experiment that we have listed can be thought of as main effects, manipulating themselves in mean differences independently of the presence of variables, other interaction effects, as their name implies, are joint effects and may occur even when no main effects are present. For example, an interaction effect may occur as a result of the pre-test measure sensitising the subjects to the experimental variable (ibid: 198).

If chance had allowed, interaction effects could have been controlled for by adding to the pre-test post-test control group design two more groups that did not experience the pre-test measures. Then, the researcher could have taken into account the possibility of pre-test sensitisation.

Both the qualitative and the quantitative research methodologies were utilised. According to Baxter and Tight (1996), quantitative research consists of those studies in which the data concerned can be analysed in terms of numbers while qualitative research is that which describes events, persons and so forth scientifically, without the use of numerical data. The former is based more directly on its original plans and its results are more readily analysed and interpreted. Qualitative research is more open and responsive to its subjects. The two kinds of research are not mutually exclusive. It is possible for a single investigation to use both methods (Charles, 1988) so that variations in a phenomenon, situation or attitude are not only described but also quantified (Kumar, 1996).

3.2 Study area

The target area was Munali Boys High School in Lusaka. This school was chosen because it had most of the facilities which were required for the study like a computer laboratory, lap top computers, Internet connectivity and the PCR software. Furthermore, there were a good number of respondents who were not only computer literate but also followed the pure physics syllabus number, 5054. They were all willing to participate in the study.

3.3 Study population

The subjects were all grade 12 pupils from Munali Boys High School. At the time of the study, the number of grade 12 boys at the school who were computer literate, followed the pure physics syllabus and were willing to participate was 120. Grade 12 boys were picked because they were at the same level in physics, knew how to use computers better than the pupils in other grades and showed no excitement with computers as they had used these for too long.

3.4 Sample size

The sample was made up of 40 randomly picked grade 12 students. The sample size was larger than what could be expected from a population of 120 because findings based upon larger samples have more certainty than those based on smaller ones; 'As a rule the larger the sample size the more accurate are the findings (Kumar :1996:152).'

3.5 Sampling

Kumar(1996) defines sampling as the process of selecting a few (a sample) from a bigger group (the population) to become the basis for estimating or predicting a fact, situation or outcome regarding the bigger group. A sample is a sub-group of the population you are interested in.

This process of selecting a sample from the total population has advantages and disadvantages. The advantages are that it saves time as well as financial and human resourses. However, the disadvantage is that you do not find out the facts about the population's characteristics of interest to you but only estimate them. Hence an error in your estimates exists (ibid:148).

A stratified sampling was used to select the participants on the basis of the physics syllabus they followed at O-Level. Stratified random sampling is a type of sampling which is based upon the logic that the accuracy of one's estimate largely depends on the extent of variability or heterogeneity of the study population with respect to the characteristics that have a strong correlation with what you are trying to ascertain (Kumar, 1996). The greater the variation in the study population with respect to the characteristics under study, for a given sample size, the greater will be the uncertainty (ibid:152). For a population which is homogeneous with respect to the characteristics under study, even a small sample can provide a reasonably good estimate, but for that which is heterogeneous, to obtain the same level of accuracy, you need to select a larger sample. Therefore, if by some means the heterogeneity in the group can be reduced, for a given sample, the researcher can achieve better results.

The participants were stratified in such a way that the population within a stratum was homogeneous with respect to the physics syllabus the pupils followed. Those who followed the 5054 pure physics syllabus and were competent enough in computers were lined up and only the odd numbered ones were picked until the number came to 60. Each of the 60 subjects was then numbered using a separate slip of paper. All the papers were put in a box. They were picked out one by one without looking until the number of slips selected equalled 50. This is called the fishbowl draw method of selecting a random sample (Kumar, 1996).

A judgemental or purposive sampling was then employed to select the study subjects (40) who had gone through all the basic computer lessons at Munali Boys High School including the Internet use and so could use the PCR software on a computer with no difficulties. The primary consideration in purposive sampling was the judgement of the researcher as to who can provide the best information in order to achieve the objectives of the study. The researcher only goes to those who in her/his opinion are likely to have the required information and be willing to share it (ibid:162).

3.6 Research instruments

The following research instruments were used:

(i) Tests

Multiple choice tests were used (both for the pre-tests and post-tests) as they were the most appropriate ways to get enough quantitative data, in form of raw scores, which were to help answer the first and second research questions. Tests were developed by carefully selecting standard questions from past Cambridge Examinations and Examinations Council of Zambia's past examination papers. They contained 60 items at different levels of cognitive domain to test what was learnt.

(ii) Attitude questionnaire

According to Kumar (1996:110) 'A questionnaire is a written list of questions, the answers to which are recorded by respondents.' The questionnaire consisted of 13 items which dealt with the pupils' attitude towards the learning of kinematics with the PCR software. This modified questionnaire was originally developed for investigating the impact on the attitudes of undergraduate pre-service teachers towards hypermedia by a team of experts in test development at the Delaware State University, in the USA

(Thomas and Emereole, 2002). Thomas and Emereole modified this questionnaire and used it in their study on the effectiveness of computer based instruction on performance in physics, to find out whether or not the male and female respondents would develop positive attitudes to using the computer based instruction. I modified the questionnaire further so that it could suit this study.

(iii) Observations

'Observation is a purposeful, systematic and selective way of watching and listening to an interaction or phenomenon as it takes place' (Kumar,1999:105). This was used to see how the participants would interact with each other in the group, interact with the given intervention, handle the PCR exercises and any other kind of behaviour.

(iv) Participant Reports

Each participant in the experimental group was asked to write a short report about the kinematics lessons they learnt using the PCR software. This helped me to confirm the information that was obtained using other instruments.

(v) Interview schedule for teachers of physics

There was a group interview about the effectiveness of the PCR computer software with 10 physics teachers in COSM-Zambia who had used the software before. COSM-Zambia is the collaboration between American Physics teachers organised by the Hampton University and Zambian physics and mathematics teachers under the auspices of ZASE. Working together, these groups have established a series of annual workshops in Zambia to identify student learning problems and provide or suggest solutions to these. The goal is to improve physics education in Zambia (COSM-Zambia, 2005). Among the problem topics the physics teachers have already identified is kinematics. Findings from the interview also helped me to confirm the information that was obtained from the instruments above.

3.7 Data collection

Data was collected over a period of six weeks . The Physicsclassroom computer software contained six lessons on kinematics, under the following headings:

(i) Describing motion with words,

(ii) Describing motion with diagrams,

(iii) Describing motion with position versus time graphs

(iv) Describing motion with velocity versus time graphs,

(v) Describing motion with equations

(vi) Free fall and acceleration of due to gravity.

A lesson was done per week to collect and record the data. There were two groups of pupils, the experimental group and the control group. At first both groups learnt kinematics from the Zambian High School Physics Syllabus (ZHPS) using traditional learning approaches, in particular, the lecture method, simple demonstrations and books. After this they were pre-tested. Then, the experimental group learnt more about kinematics using the Physicsclassroom computer software. Each pupil had his own laptop computer and progressed at his own pace. The lessons were short enough and except for the first one, other lessons took less than an hour for the pupils to finish.

At the same time, the control group learnt more about kinematics using the same traditional instructional methods named above. In case of any difficulties, both groups had the same amount of time in which to ask the teacher for help.

At the end of the lesson both groups were tested using the same questions as before. Due to the limited number of objectives on the syllabus, each test contained ten multiple choice questions. These were to be done in 15 minutes. The period of time was based on the past examination papers where these questions came from. 40 multiple choice questions were expected to be done in 60 minutes, implying that on average 10 questions could be done in fifteen minutes (Examinations Council of Zambia, 2007).

The results were not given to the respondents immediately but at the end of the study. This was done to prevent the participants from worrying about the results but instead concentrate on the work that was given. Enough effort was made to ensure that the pupils did not have the impression that they were treated differently. Those in the control group were assured that they would be given a chance to use the PCR software package and this was later done.

Throughout the process, the researcher maintained the position of being a non-participant observer. This was neither easy nor good, especially when pupils failed to find a right answer on a computer and so got frustrated. Probably the researcher could have played a better role in effecting the process of conceptual change if the position of the non-participant observer had not been decided upon earlier.

3.8 Data analysis

The data collected were grouped according to strata of research questions and analysed both quantitatively and qualitatively. The quantitative data were presented using tables of numbers (Tables 4.2a - 4.3b), percentages (Appendix F) and line graphs (Appendix G). The group Means, standard deviation, percentages and line graphs were compared to see which of the two groups performed better than the other. The qualitative data collected from the Attitude questionnaire, Observation schedule, participant reports and the interview schedule were carefully organised and verified by triangulation. That is, the responses from the pupils and teachers were compared and also related to previous researchers' findings. Themes that were most common from the statements made by the respondents formed the basis of the findings and conclusions of the study. A 't-value' was computed for each of the six tests to see whether or not there was a significant difference between the pre-test and the post-test scores for each group. Since no prediction was made about the direction of the differences between the pre-test and post-test, a two-tailed test was appropriate and so the table was prepared to deal with a difference in favour of either group. All statistical tests were evaluated at the $p < 0.05$ level of confidence.

3.9 Ethical considerations

The term ethics or ethical means ' in accordance with principles of conduct that are considered correct, especially those of a given profession or group' (Kumar, 1999:190). Certain behaviours in research such as causing harm to individuals, breaching confidentiality, using information improperly, and introducing bias are unethical. Therefore, participation in this research was voluntary. Anonymity was respected by not exposing the participants. The information given by each participant was treated with confidentiality. All the questionnaires were issued and collected by the researcher.

3.10 Validity and Reliability of the instruments used

'Validity is an attempt to check out whether the meaning and interpretation of an event is sound or whether a particular measure is an accurate reflection of what you intend to find out, while reliability refers to the consistency of a measure, score or rating' (Renuka and Jansen 1997:1).' In this study the content validity of the tests was confirmed by matching the test questions to specific objectives as required by the Zambian High School Physics Syllabus, number 5054. An Experimental design was used to obtain data , and though simple, this method is so strong that when it is used, many common threats to internal validity are controlled (Cohen and Manion, 1990). For example, the time span between the pre-test and post-test did not exceed an hour. During this time, no other events were allowed except the experimental treatment. Because of this and the fact that there were negligible developmental changes within the subjects, threats to internal validity such as history and maturation produced little or no effect in addition to the experimental variable which could mistakenly be attributed to differences in treatment.

Secondly, it could be true that since the same questions were used for pre and post-tests, students showed an improvement as an effect of their experience with the pretest. However, the testing effect, if any, affected all the subjects equally, and so any significant improvement above that of the control group could not be attributed to this but to the use of the PCR.

Thirdly, during the study, both the PRC as well as the researcher's manner of data collecting and recording did not change. This helped to eliminate the effect of instrumentation. Furthermore, only one observer took note of the results and observations and this helped to eliminate the effect of instrument delay.

In studies of this nature, there are cases were subjects scoring highest on a pre-test may score relatively lower on a post-test and those scoring lowest on a pre-test scoring relatively higher on a post-test. In other words, there could be a regression to the mean. In order to avoid this, the researcher avoided the selection of extreme scorers to the exclusion of average scorers.

In order to avoid the problem of differential selection, the random assignment was used. Any person in the subject pool had an equal probability of being assigned to either the experimental or the control group. Hence, the outcome of this study was a function of the treatment being evaluated and not the initial differences between the groups.

If in a study, some participants are lost from the experimental or the control group because they drop out of the study, miss pre-testing or post-testing , or are absent during some sessions the experiment's internal validity may be threatened. This is called experimental mortality or attrition. In this study the effect was minimised by randomly assigning students to treatment groups and assuring them that they would have equal chances to benefit from the two treatments, as both were equally desirable. Following this, nearly all the participants were present when they were required. This also helped to minimise the other threats to internal validity such as compensatory rivalry and the resentful demoralisation of the control group. The subjects were randomly assigned and they were of about the same age (18years). This minimised the effect of the selection-maturation interaction.

Another threat to internal validity is experimental treatment diffusion. It can happen if the experimental and control groups are very close to each other during the experiment. The treatment may diffuse to the control group and so the effect of treatment on the post-test would be confounded. In this study diffusion was avoided by arranging conditions in such a way that there was no contact between the experimental and control groups when the intervention was given.

One problem with the design which was used is the interaction effect, already mentioned. This effect could have been controlled by adding to the pre-test post-test control group design two more groups that did not experience the pre-test measures. The result could have been a four-group design as suggested by Solomon (Thomas and Emereole, 2002). Due to time factor, this was not done and it probably affected the internal validity i.e, the extent to which extraneous variables had been controlled by the researcher.

In order to maximise the external validity, the subjects picked were to a good extent a representative of the population to which the researcher chose to generalise his findings.

The reliability of the multiple choice tests was determined by using the External consistence procedure of the type, test/retest (Kumar,1999:141). The test was administered once, and again, under the same or similar conditions. The ratio between the test and retest scores indicated the reliability of the instrument used. The greater the value of the ratio, the higher the reliability of an instrument. As an equation:

$$\frac{\text{Test score}}{\text{Re-test score}} = 1$$

A ratio of 1 showed 100% reliability and any deviation from it indicated less reliabilty. The data obtained for all the tests was as shown in table 3.

Table 3 Table of the Test/Retest ratio.

Test no.	No. of cases for which the ratio was 1 (or about 1) (%)
1	89
2	87.5
3	80
4	89
5	79
6	95

The information in table 3 indicated that the six tests were generally reliable though not 100% so, most likely due to extraneous variables.

At the end of the study, the Attitude questionnaire was administered to the experimental group for the second time, and the test/retest ratio gave the value 0.88 (88%) showing that the questionnaire used was highly reliable. This procedure of determining reliability was used in both cases because it has an advantage of permitting the instrument to be compared with itself, thus avoiding the sort of problems that could arise with the use of another instrument (Kumar,1996).

3.11 Summary of the chapter

This chapter presented the methodology of the study. The next chapter presents the results obtained from the participants.

CHAPTER 4

FINDINGS

4.1 Introduction

This chapter is in three parts. The first one presents the performance of the experimental and control groups in pre- and post-tests. The information is shown in tables 4.2a to 4.2f and this was used to answer question one of the study. The second part shows the change in performance for the two groups between the pre- and post-tests. The information is shown in tables 4.3a and 4.3b. This information was used to answer question two. Part three has findings from: the attitude questionnaire, observations made by the researcher, participant reports and the physics teachers. The information was used to answer the third question of the study.

4.2 Research Question 1: Does the PCR software enhance pupil performance in kinematics in physics at Munali Boys High School when it is used as a supplement to traditional learning methods?

The performance of the participants from both groups in pre- and post-tests are in tables 4.2a to 4.2f.

Table 4.2a. Experimental and control groups' performance on test 1

Pre-test 1

Group	N	Mean	SD
Experimental	20	50	14
Control	19	54	14.9

Post-test 1

Group	N	Mean	SD
Experimental	20	64	12
Control	19	55	13.9

The information in table 4.2a shows that in pre-test 1, the mean mark of the experimental group was 50% while in post-test 1, it was 64%. This showed a difference in performance of 14% for the experimental group after using the Physicsclassroom software. In the same pre-and post-tests, the mean marks of the control group were 54% and 55% respectively, showing a difference in performance of only 1%.

Table 4.2b. Experimental and control groups' performance on test 2

Pre-test 2

Group	N	Mean	SD
Experimental	20	57	15.2
Control	16	51	17.9

Post-test 2

Group	N	Mean	SD
Experimental	20	70	15.6
Control	16	53	17.2

In pre-test 2, the mean mark of the experimental group was 57%, while in post-test 2, it was 70%. This showed an increase in performance of 13% after using the Physics classroom software. In the same pre- and post-tests, the mean marks of the control group were 51% and 53%, showing a difference in performance of 2%.

Table 4.2c. Experimental and control groups' performance on test 3

Pre-test 3

Group	N	Mean	SD
Experimental	17	41	18.4
Control	20	50	18.2

Post-test 3

Group	N	Mean	SD
Experimental	17	55	14.9
Control	20	50	16.3

In pre-test 3, the mean mark of the experimental group was 41% while in post-test 3 it was 55%. This showed an increase in performance of 14% after using the Physicsclassroom software. In the same pre- and post tests, the mean marks of the control group were 50 and 50 respectively, showing no change in performance.

Table 4.2d. Experimental and control groups' performance on test 4

Pre-test 4

Group	N	Mean	SD
Experimental	17	42	13.1
Control	18	54	13

Post-test 4

Group	N	Mean	SD
Experimental	17	46	14.2
Control	18	50	16.5

In pre-test 4, the mean mark of the experimental group was 42% while in post-test 4 it was 46%. This showed an increase in performance of 4% after using the Physicsclassroom software. In the same pre-and post-tests, the mean marks of the control group were 54% and 50% respectively, showing a decrease in performance of 4% for the control group.

Table 4.2e. Experimental and control groups' performance on test 5

Pre-test 5

Group	**N**	**Mean**	**SD**
Experimental	18	42	10.7
Control	17	47	17.8

Post-test 5

Group	**N**	**Mean**	**SD**
Experimental	18	51	14.3
Control	17	47	17.1

In pre-test 5, the mean mark of the experimental group was 42% while in post-test 5 it was 51%. This showed an increase in performance of 9% after using the PCR. In the same pre- and post test 5, the mean marks of the control group were 47% and 47% respectively, showing no change in performance.

Table 4.2f. Experimental and control groups' performance on test 6

Pre-test 6

Group	N	Mean	SD
Experimental	17	61	19.5
Control	19	60	16.6

Post-test 6

Group	N	Mean	SD
Experimental	17	69	22.5
Control	19	60	15.5

In pre-test 6, the mean mark of the experimental group was 61%, but in post-test 6 it was 69%. This showed an increase in performance of 8% after using the Physics classroom software. In the same pre- and post tests, the mean scores of the control group were 60 % and 60% respectively, showing no change in performance.

In many cases (67%) the standard deviation of the post-test scores for the control group was bigger than the standard deviation of the post-test scores for the experimental group. Except for test 4, all the t-values for the experimental group were bigger than the table values. As for the control group, all the t-values were smaller than the table values.

Table 4.2f. Experimental and control groups' performance on test 6

Pre-test 6

Group	N	Mean	SD
Experimental	17	61	19.5
Control	19	60	16.6

Post-test 6

Group	N	Mean	SD
Experimental	17	69	22.5
Control	19	60	15.5

In pre-test 6, the mean mark of the experimental group was 61%, but in post-test 6 it was 69%. This showed an increase in performance of 8% after using the Physics classroom software. In the same pre- and post tests, the mean scores of the control group were 60 % and 60% respectively, showing no change in performance.

In many cases (67%) the standard deviation of the post-test scores for the control group was bigger than the standard deviation of the post-test scores for the experimental group. Except for test 4, all the t-values for the experimental group were bigger than the table values. As for the control group, all the t-values were smaller than the table values.

4.3 Research question 2: To what extent does the PCR software enhance pupil performance in kinematics?

The information in tables 4.3a and 4.3b shows the change in performance of the experimental and control groups between pre- and post-tests. This information helped to answer question 2.

Table 4.3a. Change in performance of the experimental group between the pre- and post-tests.

Experimental group			
Test	Pre-test Mean %	Post-test Mean %	Change in the Mean %
1	50	64	14
2	57	70	13
3	41	55	14
4	42	46	4
5	42	51	9
6	61	69	8

It can be seen in table 4.3a that the experimental group performed better in all the post-tests than in pre-tests, suggesting that the PCR improved the performance of the pupils. The average increase in the Mean for the 6 tests was 10.3%. In general, the t-values for this group showed that the change in the Mean was significant.

Table 4.3b. Change in performance of the control group between the pre- and post-tests.

Control group			
Test	**Pre-test Mean %**	**Post-test Mean %**	**Change in the mean %**
1	54	55	1
2	51	53	2
3	50	50	0
4	54	50	-4
5	47	47	0
6	60	60	0

The average change in the mean score for the control group was -0.2%. This meant that on average there was literaly no change in performance for the control group which was taught using traditional methods only, between the pre-tests and post-tests.

The pre-test mean score difference between the experimental and control groups was -3.5%. This confirmed that before the PCR was introduced, the performance of the two groups in the pre-tests was more or less the same.

4.4 Research question 3: What effects (if any) does the PCR have on the attitudes of pupils to kinematics and the learning methods?

4.4.1 Findings from the Attitude Questionnaire.

Table 4.4 lists the descriptive statistics of the experimental group's responses to the 13 items on the attitude questionnaire, which was given to the participants. The Likert scale was used and responses were recorded in frequencies and then computed into percentages.

Table 4.4 Responses given by participants to items one to thirteen of the attitude questionnaire.

No.	Item	Responses							
		Strongly agree N (%) 7	Moderately Agree N (%) 6	Slightly agree N (%) 5	Neutral N (%) 4	Slightly disagree N (%) 3	Moderately disagree N (%) 2	Strongl disagre N (%)	
1	The use of the PC software for learning Kinematics was an exciting experience.	15 (88.2%)	2 (11.8%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%	
2	In understanding the concepts of a lesson the PC method of presenting Kinematics is better than the traditional classroom presentations.	5 (29.4%)	7 (41.1%)	2 (11.8%)	2(11.8%)	1(5.9%)	0	0	
3	The PC approach allows one to discuss Kinematics with others much more than the traditional methods of learning Physics.	10 (58.8%)	5 (29.4%)	1 (5.9%)	0	1(5.9%)	0	0	
4	My level of motivation on Kinematics has increased with the use of the PC software.	9 (52.9%)	4 (23.5%)	2 (11.8%)	0	1(5.9%)	1(5.9%)	0	
5	The information on all the lessons on Kinematics was clear	8 (47.0%)	5 (29.4%)	2 (11.8%)	1(5.9%)	0	0	1(5.9%)	
6	The amount and quality of materials in the PC were just about right compared with what would normally be covered *in a traditional* classroom.	6 (35.3%)	6 (35.3%)	0	3(17.6 %)	2(11.8%)	0	0	1
7	The use of the PC software has increased my degree of interest in	13 (76.5%)	3 (17.6%)	0	1(5.9%)	0	0	0	10

	Kinematics and Physics in general.							
8	The PC learning method allowed me to work at my own pace (which the traditional classroom methods do not do).	4 (23.5%)	7 (41.1%)	2 (11.8%)	1(5.9%)	2(11.8%)	0	1(5.9%
9	The PC software offered me greater flexebility in the sequence of various ideas / concepts on each lesson than traditional classroom methods	10 (58.8%)	3 (17.6%)	3 (17.6%)	1(5.9%)	0	0	0
10	The use of the PC in learning Kinematics in Physics made me more creative.	9 (52.9%)	3 (17.6%)	4 (23.5%)	0	1(5.9%)	0	0
11	I learned more things about Kinematics through the use of the PC software than I learned using Traditional methods.	13 (76.5%)	3 (17.6%)	0	1(5.9%)	0	0	0
12	I recommend the use of the PC software in the learning of Kinematics and other topics in Physics.	17 (100%)	0	0	0	0	0	0
13	I would like the Traditional method of learning Kinematics be replaced completely with the PC learning approach rather than only supplement it.	5 (29.4%)	2(11.8%)	3(17.6%)	1(5.9%)	1(5.9%)	1(5.9%)	4(23.5%)
Total 221		124 (56 %)	50 (23 %)	19 (9 %)	11 (5%)	9 (4%)	2 (1 %)	6 (3 %)

As can be seen in table 4.4, the majority of respondents (56 %) strongly agreed with items one to thirteen of the attitude questionnaire. The most highly rated item was recommending the use of the PCR software in the learning of kinematics and other topics in physics. All the respondents (100%) agreed to use the PCR for kinematics and other topics in physics. Many participants (88.2%) found the PCR learning method a very exciting experience. A good number of pupils (76.5%) indicated that the PCR learning method had increased their degree of interest in kinematics and physics in general. The same number of pupils (76.5%) strongly agreed that using the PCR made it possible for them to learn more things in kinematics than they did with TI methods of learning. Many pupils (58.8%) strongly agreed with the statement that the PCR enabled them to discuss kinematics with each other more than they did in traditional learning approaches. Some pupils (58.8%) wanted the traditional instructional methods to be completely replaced with the PCR learning approach. However, the rest did not want this to happen, but just to use the PCR as a supplement to TI.

4.4.2 Findings from the observations

A number of things were observed about the experimental group. Firstly, participants were always punctual for lessons and the class attendance was 80% or more as shown in appendix C. Once in the Laboratory, they started their computers and immediately went to the 'Physicsclassroom ' software to explore the new information. Their behaviour was very good. They interacted with the 'Physicsclassroom' software well. In problem solving situations they shared ideas with each other very well and at the end, each of them solved at least 75% of the problems on kinematics as an exercise. No participant appeared to be reluctant to do work. After using the software the pupils did not complain about the mathematical part of kinematics. Their performance in the post-tests was generally better than that of their counterparts in the control group as shown in tables 4.3a and 4.3b on pages 54 and 55 respectively. They appeared to be happy with the PCR software and expressed a desire to continue learning physics with the PCR learning approach. After the study, they frequented the Computer lab for more 'Physics classroom' lessons.

Participants in the control group were also punctual for work and the class attendance was equally good (80% or more). As their friends in the experimental group learnt physics with the Physicsclassroom software, those in the control group learnt the same content using conventional learning methods in particular: lectures , simple demonstrations and books. Discipline was slightly less than those in the experimental group and the teacher always needed to be around for the pupils to maintain order. Like their friends in the experimental group, at the end of every lesson, they did a physics exercise which was given by the teacher. But unlike the participants in the experimental group, in problem solving situations participants in the control group rarely shared ideas. Their general performance in the exercises and post-tests was lower than those in the experimental group (below 75%).

4.4.3 Pupils' views

With the exception of two participants 9 and 33 who were out of the station at the time of research, all other participants in the experimental group (18) wrote a report each about how they found the PCR software in the learning of kinematics in high school physics. The main statements made by the participants were grouped into three themes, understanding of kinematics, calculations using the equations of motion and interest in the Physics classroom teaching approach as follows:

4.4.3a Understanding of kinematics

Some respondents indicated that through the use of the PCR they understood kinematics better. For example, Participant 1, said :

> "For the few days I attended kinematics lessons through the use of the PCR, I must admit that the animations were excellent because they showed the practical part of kinematics more clearly than the traditional methods. The notes were thoroughly explained, the diagrams were clear and the examples were straight to the point. Besides, several steps on how to approach kinematics questions were explained which is not the case in the traditional methods. Therefore, I recommend that this software, the PCR, must be made available in all high schools so as to help pupils in this area."

Participant 3 had the following to say:

> "although some tests were hard before, they became slightly simple after going through the PCR."

Participant 19 indicated that using the PCR, he understood kinematics clearly, as follows:

> "I now understand the topic clearly. There is surely and honestly greater understanding in the PCR than the traditional classroom presentation. It keeps one wanting to find out how a topic goes to the end."

Participant 29 also confessed as follows:

> "I personally used to have problems in kinematics due to the poor foundation but due to the use of the Physics classroom computer software, I have really gotten more understanding of the topic. I would suggest that this be the beginning and not the first and last."

Participant 37 made a special request in the following statement:

> "The pre-test was a bit hard but after the research on the computer it was easy. I would like to ask you if you can mind to conduct the same thing on other topics because on the computer I found it easy to understand than in traditional teaching."

The comments from Participant 39 were also worth mentioning. He wrote:

> "I appreciate what the PCR has done towards my understanding in physics. Everything is clear than learning things in the traditional classroom. I just wish this programme would go on and on. Apart from learning kinematics, we should include other topics as well which are approved quite complicated. I think with the PCR, a pupil can do with or without a teacher because understanding is simplified."

All these statements showed that pupils understood kinematics better when they used the PCR learning approach as a supplement to traditional instructional learning approaches than when they used the latter methods of learning only.

4.4.3b Calculations using the equations of motion

Participant 23 felt that the PCR had a negative effect. He wrote:

> "I think it can help in many ways. But in one where I found difficulties and this was in questions in which we were required to use either of the four equations. The equations were a bit complicated and it was difficult to plug in the value. With the animations they were terrific and very helpful."

But other pupils had a different feeling from that of Participant 23. For example, Participant 21 wrote,

> "In the PCR software, I could find new and simple methods for calculating tricky questions in a very simplified way. If at all I were to give the computer a percentage, then it would deserve a 75% with no reduction. I therefore conclude by saying that during the whole process of examination, I could find answers in a very simple way after using a computer."

Therefore, equations of motion were appreciated by the majority of pupils.

4.4.3c Interest in the Physicsclassroom teaching approach

A number of participants had a lot of interest in the PCR learning approach. For example Participant 5 had the following to say:

> " In the PCR, I was free to discuss the lessons with others much more than in conventional methods of learning. I hope the use of the PCR will be compulsory and every pupil doing physics will have access to the PCR, in future."

Another pupil, Participant 7, wrote:

> "I would say I enjoyed myself and it was exciting. This method taught me some of the concepts in kinematics that I didn't learn in class e.g slope. The animations give the pupil a picture of what he is reading, making it difficult or even impossible to forget. This way of learning should even be included on the time-table of the school. It should be done for some other subjects like: chemistry, biology, maths and english."

Participant 33 made the following statements:

> "From the use of PCR, I had gained a strong interest in knowing more about kinematics. I think the use of PCR should be introduced in schools for certain physics topics. Because our traditional physics classroom does not offer us with all the required information, for example diagrams. Diagrams are not clearly explained in our own traditional physics l earning systems. This method also allowed us to discuss with friends while dealing with a topic on the computer."

These statements indicated that the participants had developed more interest in the Physicsclassroom learning approach as a supplement to TI than the TI only.

4.4.4 Findings from the Physics teachers

When asked for comments by the researcher about the effects of the Physicsclassroom software, a group of 10 physics teachers from COSM-Zambia made positive remarks. They said that the software was good for high school physics, particulary on kinematics and wave motion. Some of the reasons they gave included: " it makes the invisible visible", "has a lot of self explanatory diagrams" , " has a lot of exercises for practice", and " more content in kinematics than many of the books used in high school physics."

The teachers of physics at Munali Boys High School who have used the Physicsclassroom software in their kinematics lessons also informed the researcher that the software in question was good. Their reasons included: " not as boring as the chalk and talk method", "makes certain abstract concepts appear concrete e.g on free fall", "motivates pupils more than many TI learning methods", has a lot of information in kinematics and exercises for the learner", "enhances learner performance in physics" and "is liked by nearly all the learners who use it".

4.5 Summary of the Chapter

This chapter presented the findings of the study. In the pre-tests the performance of the experimental and control groups was not significantly different. But after using the PCR software as a supplement to TI, the experimental group performed better than the control group which only depended on TI to learn kinematics. Furthermore, the findings revealed that the attitude of the experimental group to the PCR software and kinematics was positive. The chapter that follows discusses these findings.

CHAPTER 5

DISCUSSION OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter has two main sections. The first one discusses the findings in Chapter 4. The second one presents the conclusions and recommendations of the study.

5.2 Discussion of findings

The first issue the study sought to establish was whether the Physicsclassroom computer software could enhance pupils' performance in kinematics in high school physics at Munali Boys High School when it was used as a supplement to traditional instructional methods of learning. Secondly, if so, to determine the extent to which the PCR could enhance pupil performance in Kinematics.

By comparing the pre- and post-test Mean scores (Tables 4.2a - 4.3b) and the line graphs (Appendix G), this study found that the experimental group gained more than their counterparts in the control group. For example, the average change in the Mean scores for the experimental group between the pre- and post-tests was 10.3% (Table 4.3a) while that for the control group was -0.2% (Table 4.3b), showing a difference in performance of 10.5 % between the two groups. This indicated that on average, use of the PCR as a supplement to TI had enhanced the performance of the pupils by 10.5%. These results collaborate those of other researchers such as (Kulik and Kulik,1991 ; Thomas and Emereole, 2002; Vinsonhaler and Bass, 1972) who found that approppriate use of computer based instruction as a supplement to traditional instruction enhances the performance of learners.

However, this part of the discussion may not be complete without a comment on the result of test 4. From the difference in the scores obtained by the two groups, one may be tempted to think that the Physicsclassroom software did not enhance learner performance on test 4 and may support Clark (1994) who argued that media (including computers) do not influence learning and achievement under any conditions. Here, it was very difficult to support Clark because although the initial difference between the two groups in pre-test 4 showed a better performance for the control group of 12%, in post-test 4 the performance of the experimental group went up by 4% (Table 4.3a) while that of the control group went down by the same percentage (Table 4.3b).

Therefore, there should be no doubt that media influences learning because the form in which information is presented might determine how it is processed in the mind, and how it might be learned (Cobb, 1977). Papert (1980:131) argues, "I too see the computer presence as a potent influence on the human mind." In this regard, Clarks theory was refuted. The situation in post-test 4 could have been because of other reasons such as experimental mortality, which is the phenomenon of losing research participants during the course of an experiment. At the time of post-test 4, three participants from the experimental group had problems with the school and so missed the test. This differential loss of three participants might have resulted in confounding the effect of the experimental variable, for whereas initially the groups were randomly selected, the residue that stayed for the test was likely to be slightly different from the unbiased sample that began it. The other reason could be the variable commonly known as compensatory rivalry by the control group. According to Saretsky (1972:579), "compensatory rivalry involves a situation in which control group participants perform beyond their usual level because they perceive that they are in competition with the experimental group". Therefore, the observed difference between the experimental and control groups on pre-test 4 can also be attributed to the control group's unusual motivation rather than to treatment effects.

In many cases (67%) the standard deviation of the post-test scores for the control group was bigger than the standard deviation of the post-test scores for the experimental group. This, however, did not mean that the control group performed better than the experimental group in any of the post-tests. It only indicated that the post-test scores for the control group were more dispersed (had a wider spread from the mean) than those of the experimental group.

Lastly, the study tried to find out if the PCR had any effects on the attitudes of pupils to kinematics and the learning methods. The "strongly agree", "moderately agree" and "slightly agree" responses in table 4.4 of the Attitude questionnaire revealed pupils' positive attitudes to kinematics and the PCR but not the TI.

Firstly, many participants (76.5%) strongly agreed that by using the PCR , they learned more things about kinematics than they did with the TI only. The main goal of pupils in schools is to do well in their final examinations so that in future they get into good training and/ or find good jobs. But better performance in the final examinations depends on how much they know in a subject. Therefore, a learning approach which helps them to cover more content on a topic is more beneficial to them because consequently, it enables them to perform better in their final examinations and achieve their goal. Their attitudes to such learning approaches should be positive and this was the case with the Physicsclassroom learning method.

A good number of pupils (59%) strongly agreed that in the PCR learning environment, they discussed kinematics more than they did in the TI learning environments. Research shows that the more the pupils participate in a lesson e.g; through classroom discussions, the more they understand the content covered (Monk and Osborn, 2000:51). "Scientific reasoning is learned, by talking to other members of the community; we practice it by talking to others, and we use it in talking to them, in talking to ourselves...and in other forms of more complex activity"(ibid:51). In a science class, pupils need teaching/learning approaches which enable them to spend time talking science, identifying problems, framing questions, and working with the teacher mainly as a consultant to talk through, and to help develop possible solutions (ibid:122).When this happens their interest in the subject and the teaching/learning approach goes up. In short, pupils enjoy teaching/learning methods which accord them the chance to participate in the lessons fully. In this study the participants' responses gave an impression that in the PCR learning environment, they were free to discuss the kinematics lessons and so they developed interest in this learning approach.

In this study many participants (52.9%) indicated that due to the PCR software, their level of motivation in kinematics had increased. But pupils can only be more motivated on a topic if they enjoy learning it and this enjoyment is dependent on the manner in which a lesson is presented. The implication of this is that the participants in the experimental group were happy with the way in which the kinematics lessons were presented in the PCR learning environment.

A number of participants (23.5%) strongly agreed that with the PCR they were able to work at their own pace, which was not the case when they used the TI. Some pupils in learning institutions are fast learners while others are slow learners. However, certain learning methods like the lecture method, demonstrations and books do not take into consideration the different abilities of these pupils. As a result when these methods are used, they do not benefit all the learners equally. In this study it was clear that with the PCR, the fast learners went through the lesson faster while the slow learners covered exactly the same content but in a longer period of time. Therefore, both the fast and the slow leaners benefited equally, in terms of the content, from the learning approach. Hence, the pupils' positive attitude towards the PCR learning method.

Many pupils (59%) strongly agreed that using the PCR enabled them experience greater flexibility in the sequence of various ideas/concepts on each lesson than the TI. A learning approach which is rigid will present material in a particular way without any consideration for different types of learners. In this study what came out from the participants was that there was logical presentation of content in various and simpler ways in the PCR than in the TI and the pupils had no difficulties in grasping the content. Therefore, the participants developed a positive attitude to the PCR learning approach.

Many participants (52.9%) strongly agreed that after using the PCR they had become more creative. It was always interesting to see how the majority of the pupils were handling both the PCR Physics exercises and those from the teacher. Indeed, there was an element of creativity in them because given a problem, the participants did not remain stuck but used various ways until a solution was found.

The majority of pupils (76.5%) strongly agreed that the PCR software had increased their degree of interest in kinematics and physics. According to Schofield et al. (1993), computers enhance enjoyment and interest in the learning of pupils. This is because the pupils easily follow the lessons and so develop positive attitudes to what is taught and the learning approach which is used.

Although some pupils (about 41%) did not want the TI to be replaced completely with the PCR learning approach rather than only supplement the TI, it was interesting to note that the rest of the participants (59%) wanted the TI to be replaced completely with the PCR learning approach. Furthermore, all the pupils strongly agreed that the PCR be used in the learning of kinematics and other topics in physics. It seemed from this view that the software benefited all the participants in the experimental group. Hence, their attitude towards the PCR learning approach was positive.

Some of the written comments from the experimental group reflected on their enthusiasm in the use of the Physicsclassroom learning approach. Others were related to the motivational value, improved interest in kinematics and physics in general, and the amount of content covered under the Physicsclassroom learning approach. The statements included: "...enjoyed my self and it was very exciting...", made me develop interest in kinematics...", and "...learnt new concepts on graphs which were not covered before..."

These statements indicated that some participants (P1, P3, P19, P29, P37 and P39) understood kinematics better with the PCR as a supplement to TI than when they used the TI only and develped more interest(P5, P7 and P33) in kinematics, physics in general and above all in the PCR learning approach than the TI. The statements confirmed the findings from the attitude questionnaire that the participants had developed positive attitudes to kinematics and the PCR but not the TI.

The observations I made during the study confirmed the findings above. The fact that the participants were always punctual for the PCR lessons and the class attendance was 80% or more, was a clear indication that the participants were happy with the work they did and the PCR learning approach used. Once in the Lab, they never wasted time but straight away got into the PCR lessons. Normally on a computer there are so many things which can disturb the learners like news, games, music e.t.c. The behaviour of pupils of not getting into other programmes indicated that they were more interested in the PCR lessons than other things, and consequently, in the manner in which the lessons were presented. The researcher observed more discipline in the experimental class than the control class. This could have been because the participants in the experimental group were happier with what they were doing, the learning approach that was used and were more involved in the work. They interacted with the 'Physicsclassroom' software well and enjoyed seeing computer displays and animations because these made abstract physics ideas concrete. In problem solving situations they discussed the problems well and worked together most likely because of the nature of the PCR learning approach that was used.

Unlike those in the control group, each of the participants in the experimental group solved at least 75% of the problems on kinematics as an exercise from the teacher and no participant appeared to be reluctant to do work. Their performance in the physics exercises and post-tests was generally better than that of their counterparts in the control group and this made them happier with the PCR learning method than the TI approach. They expressed happiness for the PCR software and a desire to continue learning physics with the PCR learning approach, a sign that they had developed a lot of interest in the PCR lessons. After the study, they frequented the

Computer lab for more Physicsclassroom lessons , a clear indication that they had developed a positive attitude to the PCR learning approach.

Comments from the COSM-ZASE Physics teachers and the two teachers of Munali Boys High School, who were interviewed also reviewed the same things. The comments gave the impression that the PCR learning method: is more child centred than the TI, makes kinematics more concrete and involves the pupils more in problem solving. Therefore, the PCR could help the learners to achieve more in kinematics in physics than the TI methods only.

5.3 Summary of the chapter

Chapter 5 discussed the findings about the effectiveness of the PCR software package, in the learning of kinematics. It was clear that when used as a supplement to TI, the PCR had many positive effects on pupil performance in kinematics. Some of these were: enabling the pupils to understand the topic more, making the pupils develop more interest in the topic, helping the pupils to cover more on the topic, allowing the pupils to discuss the topic with each other and increasing pupil creativity. As a result the PCR enhanced learner performance in kinematics and the pupils developed positive attitudes to kinematics and the PCR learning method.

5.4 Conclusions

The results in this study revealed significantly higher performance of 10.5% for the experimental group than the control group. Quite a good number of participants (76.5%) in the experimental group developed more interest in kinematics and declared that using the PCR they had learnt more things on kinematics than they did with the TI only. All the pupils in the experimental group strongly agreed that the use of the PCR learning approach be used for kinematics and other topics in high school physics. Fifty-nine percent of pupils in the same group wanted the traditional classroom methods to be replaced completely with the PCR and not to supplement the TI but the rest (41%) did not agree. These results are similar to those of other researchers in and outside Africa on computer based instruction (Shanyinde, 1998; Thomas and Emeriole , 2002; Brassel, 1987b).

Therefore, based on the findings of this study, we could say that when used as a supplement to TI, the Physicsclassroom computer software enhances learner performance in kinematics in high school physics. The second conclusion is that pupils who use the PCR develop positive attitudes to kinematics and the PCR learning approach.

5.5 Recommendations

In view of the findings of the study, the following recommendations are made:

1. While the PCR learning approach enhances pupil performance in kinematics and shows a high degree of acceptability with the study group, it should not be used as the only learning method on this topic but as a supplement to the traditional instruction methods which have been in use.
2. Research with a larger and more representative sample could be done to verify the preliminary findings and possibly arrive at a more definite decision regarding the implementation of this PCR teaching /learning technique.

REFERENCES

Adeyinka, A.A., and E.T. Mayor, 2005. "Sample philosophers of the post-renaissance period: implications of their ideas for educational policy and practice in Africa." *Journal of Sociology and education in Africa*, 4 (1), 76-95.

Atkinson, R., 1968. "Computerised Instruction and the Learning Process." *American Psychologist*, 23, 225-239.

Banda, B., 2004. "Enhancing Classroom Activities for Quality Teaching and Learning in Zambia." Paper presented at the NAGEDA, ZAME, ZASE and ZATE Annual General Conference, 1-2 September, 2004, ZAMISE, Lusaka, Zambia. 1-3.

Baxter H.C., and M. Tight, 1996. How to research. University Press, Buckingham.

Berger, M., and P. Cretchley, 2007. " Technology and mathematics learning at university level: A South African perspective." *African Journal of research in Mathematics, Science and Technology Education*, 9(2), 97-108.

Borges, D., 2008. The Physics in car collisions-for Physics 420 demonstrations. Retrieved on 10th January 2008 from http://www.physics.ubc.ca.

Brian, U., 2000. Teach Yourself: Microsoft Office 2000. IDG Books Worldwide, Inc, California, USA.

Burns, P., and W. Bozeman, 1981. "Computer Assisted Instruction and Mathematics Achievement. Is there a relationship?" *Educational Technology*, 2, 32-39.

Brassel, H., 1987a. Modelling and Modellus in the Physics curriculum; Some examples and a framework. Retrieved on 24th January 2008 from http://www.google.co.uk/brassel.

Brassel, H., 1987b. " The effect of real time laboratory graphing on learning graphic representations of distance and velocity." *Journal of research in science teaching*, 31, 323-344.

Bright, G., 1983. "Explaining the efficiency of Computer-Assited Instruction." *Association for Education Data systems Journal*, 3, 144 -152.

Bruner, J., 1964. The course of Cognitive growth, American Psychologist, Cambridge. Cambridge University Press.

Campbell, D.T, and J.C. Stanley, 1963. 'Experimental and quasi experimental designs for Researcher on teaching', *in: Handbook of Research on Teaching, N.L.* Gage, Ed, 1-50, Rand Mc Nally, Chicago.

Chapman, D.T., 1986. Predicting the effects which micro computer technology is likely to have on Undergraduate studies. *Dissertation Abstracts International: The Humanities and Social Sciences,* 47(5), 1701-A.

Charles, C.M., 1988. Introduction to Educational Research. Longman, London.

Chi, M.T.H., N. deLeeuw, M.H. Chiu, and C. La Vancher, 1994. "Eliciting self-explanations improves understanding." *Cognitive Science*, 13, 145-182.

Choi, B. and E. Gennaro, 1987. "The effectiveness of using computer simulated experiments on junior high students, Understanding of the volume displacement concept." *Journal of Research in Science teaching*, 24, 539-50.

Clark , R.E., 1994. "Media will never influnce learning." *Educational Technology Research and development*, 53(4), 445-459

Cobb, T., 1997. "Cognitive efficiency: Toward a revised theory of media." *ET & D*, 45, 21-35.

Cockroft, W.H., 1982. Mathematics counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools. HMSO, London.

Cohen, L., and L. Manion, 1990. Research Methods in Education, 3rd ed. Routledge. London

COSM-Zambia., 2005. The physics classroom and maths soft engineering and education. Retrieved on 20th June 2007 from http://www.jlab.org/~cecire/cosmzambia/cz/Cznews1.doc.

Collins, H., 2002. New school Dictionary. Haper publishers. Great Britain.

Dence, M., 1980. "Toward Defining a Role for CAI: A Review." *Educational Technology*, 20(11), 50-54.

De Vries, E., K. Lund, M. Baker, 2002. "Computer-mediated epistemic dialogue: Explanation and Argumentation as Vehicles for Understanding Scientific Notions." *The Journal of the learning Sciences*, 11, 481-480.

Eisenkraft, (1998). Modellus: Learning Physics with mathematics modelling. Retrieved on 28th January 2008 from .http://www.google.cd.uk/brassel .

Ellington, H.I., E. Addinal, and F. Percival, (1981). Games and Simulations. Kogan Page, Nichols Publishing House, London.

Examinations Council of Zambia, 2000. Physics Chief Examiner's Report. April 2000. Lusaka. Zambia.

Examinations Council of Zambia, 2007. Grade 12 physics Paper 1. November 2007, Lusaka. Zambia.

Edwards, D., and N. Mercer, 1987. Common Knowledge. London, Routledge.

Edwards, J., S. Norton , S. Taylor, M. Wess, and R. Van Dusseldrop, 1975. "How effective is CAI? A review of the research." *Research review*, 33,147-153

Enerst, P., 1999. Social constructivism as a Philosophy of mathematics: Radical Constructivism. The Falmer Press, London.

Epstein, M., 2007). Using information effectively in education. Retrieved on 30th January 2008 from http://tiger.towson .edu/users/mepstel/researchpaper.htm.

Garvison, D.R, and D. Shale., 1990. Education at a Distance. From Issues to practice. Robert E Krieger Publishing Company,London.

Gershman, J. and E. Sakamoto, 1981. "Assisted Remediation and Evaluation: A CAI Project for Ontario Secondary Schools." *Educational Technology*, 3, 40-43

Gibbs, G., 1992. Assessing more students. Oxford Brookes University, London.

Gokhale, A.A., 1996. "Effectiveness of Computer Simulation for enhancing higher order thinking" *Journal of Industrial Teacher Education.Thompkins*, 33, 4, 36-46.

Good ,C.V., 1973. Dictionary of Education. Mc Graw-Hill Book Company. New York.

Govender, N.,2007. "Physics student teachers' mix of understanding of algebraic sign convention in vector-kinematics: A phenomenographic perspective." *African Journal of Research in SMT Education*, 11(1), 61-73.

Gredler, M.E., 1997. Learning and instruction: Theory into practice, 3rd ed. Upper Saddle River, NJ: Prentice-Hall.

Green, W.J 2007. "Learner discourse and science learning in the context of microcomputer-based laboratory (MBL) collaborative learning." *African Journal of Research in SMT Education*, 11(1), 1-16.

Haambokoma, C., B. Nkhata, V.S Kostyuk ,V. Chabalengula , S Mbewe, M. Tabakamulamu, Z.B Ndhlovu ,R. Mushanga and D. Nthani , 2002. Strengthening of Mathematics and Science Education in Zambian Secondary Schools: A Baseline study with Japan Official Development Assistance. Prepared for the Ministry of Education, Zambia and Japan International Co-operation Agency.

Hawkins, J., K. Sheingold, M. Greenhart, and C.Berger, 1982. "Microcomputers in schools: Impact on the social life of Elementary classroom." *Journal of Applied Developmental Psychology*, 3, 361-372.

Hartley, S., 1977. Meta-Analysis of the Effects of individually Paced Instruction in Mathematics. *Dissertation Abstracts International. University of Colorado*, 38, 4003.

Hasselbring, T.S., 1986. "Research on the effectiveness of Computer Based instruction: A Review." *Technical Report, 84 (1)*, 3.

Intuitor (2002), Physics is a neglected science. Retrieved on 14th June 2006 from http:/www.intuitor.com/physics..

Kaino, L.M., 2007. "Computers in learning a Case Study of Students' Gender Attitudes in selected Botswana Junior Secondary Schools." In: Mathematics, Science and Technology Education : Proceedings of the 15th Annual Conference of the Southern African Association for Research, Maputo, Mozambique, 9-12 January 2007. Mozambique : Eduardo Mondlane University press, 129.

Kanyongo, G.Y., J.B. Schreiber, L.L Brown, 2007. "Factors affecting mathematics achievement among 6th graders in three sub-Saharan African countries: The use oof hierarchical linear models (HLM)." *African Journal of Research in SMT Education*, 11(1), 37-46.

Kerlinger, F.N., 1986. Foundations of Behavioral Research, 3rd ed. New York, Holt. Rinchart and Winstone.

Kepler, H.B., 1960. Basic Graphical Kinematics, Mc Graw-Hill Book Company, Inc. NewYork , Toronto , London.

Kerr, S.T., 1996. Technology and the future of school. National Society for the study of Education. Chicago.

Kingsbury,K., 2004. Physics is difficult. Retrieved on 14th June 2006 from http://www.korpenekus.com/physics/index.

Kulik J.A and C.C. Kulik, 1991. "Effectiveness of Computer based instruction: an updated analysis." *Computers in Human Behaviour*, 7, 75 – 94.

Kulik, J., R. Bangert, and G.Williams, 1983. "Effects of Computer based Teaching on Secondary School students." *Journal of Educational Psychology* , 1, 19-26.

Kukla, A., 2000. Social constructivism and the philosophy of Science. New York, Routledge.

Kuhn, D., 1993. "Science as an argument: implications for teaching and learning scientific thinking." *Science Education*, 77, 319-337.

Kumar, R., 1996. Research Methodology: A step by step guide for beginners. Addison Wesley Longman Australia Pty Limited, London.Thousand oaks.New dlhi.

Lawrence, T.E., R. Grabhom and D.A Zollman, 1996. Application of Interactive Digital video in a physics classroom. Kansa state university, Manhattan.

Liu, X., R. Macmillan, and V. Timmons, 1998. "Intergration of Computers into the curriculum: How teachers may hinder students' uses of computers." *McGill Journal of Education*, 33,69.

Lungwangwa, G., 2007. Education and Training. Paper presented at the Conference on ICT for development, 15th –17th March, 2007. Retrieved on 10th July 2007 from http://www.elearning-zambia.com..

Maturana, H., 1991. ' Science & daily life: the ontology of scientific explanations', in F.Steier(ed.), Research and Reflexivity, London: Sage.

Mc Demott, L.C., M.L. Rosenquist, and E.H Van Zee, 1987. "Student difficulties in connecting graphs and Physics: Exmples from Kinematics." *American Journal of Physics*, 55,503-513.

Mc Mahon, M., 1997. Social Constructivism and the World Wide Web- A paradigm for learning. Perth, Australia.

MOE, 1996. Educating our future. National Policy on education. Lusaka. Zambia.

Monk, M. and Osborne, J., 2000. Good Practice in Science Teaching. Open University Press. Buckingam. Philadelphia.

Mulemwa, J., 1999. "Scientific, Technical and Vocational Education of Girls in Africa. Education Sector 1999."*Guidelines for programme planning.UNESCO ; Paris*, 7 , 20-23.

Musker, R., 2000. "Why ICT makes a difference." *Education in Science*, 4, 186.

Newton, P., R. Driver, J. Osborne, 1999. " The place of argumentation in the pedagogy of school science." *International Journal of Science Education*, 21(5), 553-576.

Nizar, A. and J.A Chum , 1999. "Teaching Electro-science using computer based instruction." *Journal of engineering education. San Juan,Puerto Ric*. Retrieved on 31st January 2008 from http//www fie.Enging .pitt.edu/fie99/papers/..

Ogborn, J., 1999. Modellus: Learning Physics with Mathematical Modelling. Retrieved on 28th January, 2007 from http//www.google.co.uk/brassel.

Olugbemiro, J. et al., 1991. Computers and the learning of Biological concepts: attitudes and achievement ofNigerian students. *Charlip*, 75 (6),701-706.

O' Shea, T., E. Scanlon, M. Byard et al., 1993. 'Twenty-nine children, five computers and a teacher', in: D.Edwards, E. Scanion and D.West (eds). Teaching, Learning and Assessment in Science Education. Buckingham: Open University Press.

Parpert, S., 1993. Mindstorms: Children, Computers and powerful ideas. New York: Basic books, Inc.

Patronis, T.; D. Potari, Spiliotopoulou, V., 1999. " Students' argumentation in decision-making on a socio-scientific issue: implications for teaching." *International Journal of Science education* ,21(5),745-754.

Peter, C., K . Peter , R. Nancy, F. Thomas, F. Synder, H.W. Daniel and W. Cheryl , 1982. Practical guide to computers in Education. Addison-Wesley Publishing Company, London.

Piaget, J., 1955. The child's construction of reality. NY: Harcout, Brace Jovanovich.

Pulist, S.K., 2005. "Affective variables and mathematics education." *Elementary School Journal*, 18(2), 207-218.

Ragosta, M., P. Holland and D.Jamison, 1983. Computer-Assisted Instruction and compensatory Education: The ETS / LAUSD study. The Excutive summary and Policy Implications, Princeton, N.J Educational Testing Service.

Redish, E . F, and J.S Risley, 1988. Computers in Physics Instruction. Addisson-Wesley Publishing Company. Raleigh, North Carolina.

Renuka, V. and J. Jansen, 1997. Designing your first proposal. Juta and co. Ltd , South Africa.

Rushby, N., 1987. Technology Based Learning. Kogan Page, London/ Nicholas Publishing Company. Newyork.

Sani, M.J., 2001. "Scientific Progress and Science education: basic Knowledge, Interdisciplinarity and ethical issues". In: UNESCO Hand book: Proceedings of the 46th International Conference on Education, 5th–8th September 2001. Geneva, 17.

Saretsky, G., 1972. "The OEO P.C. experiment and the John Henry effect." Phi Delta Kappan, 53, 579-581.

Sassi, E., 1996. New ways of teaching Physics._Retrieved on 31st January 2008 from _http:// www. Pef.uni.lj.si/-girep/nwt pabst. htm#gt11 ljubljana/ slovenia.

Schofield, J.W., R. Eurich-Fulcer, and C.L Britt, 1993. " Teachers, Computer tutors and teaching: the artificial intelligent tutor as an agent for change", *Journal of Educational Technology*, 31(3): 579-607.

Scaife, J. and J.J. Wellingtone, 1993. Information technology in science and technology education. Philadelphia: Open University Press.

Shakuba B.M., 2007. Examinations Council of Zambia: Mark distribution sheet, no. 93 of 27th January 2008. Lusaka. Zambia.

Shanyinde, P.D., 1998. An investigation of Learner/Learner Scafforlding Using Microcomputer-Based Labs. Ed.D Thesis.University of Bristol. U.K.

Sewel ,B.T.and B. Burger, 1998. "Can Computer Based Education save science education in South Africa?" In: SAARMSTE: Proceedings of the 6th Annual Meeting of the SAARMSTE conference, UNISA, 14-17 January 1998. South Africa, 8.

Sibiya, G.T, 2003. "Information and Communication Technology and Education." In: SAARMSTE: Proceedings of the 11th Annual SAARMSTE conference. Waterford Kambiaba UWC, 11th -15th January 2003. Swaziland : Webster Print(PTY)Ltd, 26-32.

Sinyangwe, M.M., A.L Sikwebele, S.M.K. Ng'andu, O. Chakulimba, R. Simukoko, S.M. Kunkhuli, C. Namafe, R. Siaciwena, M. Milimo, and A. Mwanza, 1995.

Increasing Access to Secondary Education. Zambia Education Rehabilitation Project. Education Policy studies. Lusaka, Zambia.

Thomas, P.Y. and H.U Emereole, 2002. "Effect of computer-based instruction on performance in physics." *African Journal of Research in Mathematics, Science and Technology Education*, 6, 97-112.

Vinsonhaler J.F. and R.K Bass, 1972. "A summary of ten major studies on CAI drill and practice." *Educational Technology*, 12, 29-32.

Wellington, J., 1994. Secondary Science.Contemporaly Issues and Practical Approaches. Routledge. London and Newyork.

Wise, K. and J. Okey, 1983. The Impact of Microcomputer Based Instruction on student Achievement. Dalles, Texas.

Woodbridge,F., 1963. Fundamental laws of Physics. Addison-Wesley Publishing Company, inc. USA.

Woerner., J.J., R.H. Rivers and Vockell, 1993. The computer in the science classroom. Watsonville, CA: Mitchell/ McGraw-Hill.

Wynn, R. and J.L Wynn, 1988. American Education. Haper and Row Publisher, Inc. Chicago.

Zalpha, R., 1986. The effect of Microcomputer Assisted Instruction on achievement in High school Chemistry. *Dissertation Abstracts International: The Humanities and social Sciences*, 46(11), 3310-A

ZASE., 2004. "Handling difficult topics in Physics." COSM-ZASE Planning Workshop, April 2004. Kabulonga. Lusaka.

APPENDIX A

KINEMATICS

TEST 1

Describing motion with words

Instructions to the candidate:

There are ten multiple choice questions in this paper. Answer all questions. For each question there are four choices, A, B, C and D. Choose the one you consider correct and record your choice in ink on the separate answer sheet.

Duration: 15 minutes.

1. A ball thrown vertically upwards from ground level takes 1 second to return to the ground.

   Which of the following is true about the ball?

   A its displacement in 1s is zero

   B its displacement in 1s is 1 m

   C it covers a total distance of 1m

   D its final velocity is 1m/s

2. Velocity is

   A the distance moved in a specified direction

   B the rate of change of distance with time

   C the rate of change of displacement with time

   D the rate of change of speed with time

3. A body whose displacement per second increases by equal amounts in equal time intervals is said to have

A a uniform velocity

B a uniform acceleration

C a uniform retardation

D a terminal velocity

4. What must be changing when a body is accelerating uniformly?

A the mass of the body

B the force acting on the body

C the speed of the body

D the velocity of the body

5. Acceleration can be calculated using

A average speed × time

B change in velocity × time

C change in velocity / time

D change in distance / time

6 Which of the following is represented by the area under a displacement–time graph ?

A distance

B speed

C velocity

D acceleration

7. The acceleration of a moving object may be found from

A the area under its velocity – time graph

B the slope of the velocity – time graph

C the area under its speed – time graph

D the slope of its distance – time graph

8. A feather dropped from the top of a cliff reaches a terminal velocity of 4m/s at point A and continues with this velocity until it reaches another point B. Which of the following is true about the feather between the points A and B ?

A it is in a vacuum

B it has no weight

C its acceleration is zero

D its acceleration is $4m/s^2$.

9. An experiment is carried out by an astronaut on the surface of the Moon. A metal and a piece of paper are dropped at the same instant from the same height. Which of the following statements is correct?

A The metal falls faster than the paper, but both take a longer time than if they were falling from the same height on the the Earth.

B The metal falls faster than the paper, but both take a shorter time than if they were falling from the same height on the Earth.

C They fall together, taking a longer time than the metal would in falling from the same height on the Earth.

D They fall together, taking a shorter time than the metal would in falling from the same height on the Earth.

10. Roads are tilted at an angle (banked) at the bends so

A as to increase the Earth's gravitational field on the vehicles

B as to reduce the friction between the car tyres and the road

C that vehicles can round the bends at higher speeds without slipping

D that the speed of the vehicles is reduced to minimise accidents

END OF TEST 1

TEST 2

Describing motion with diagrams

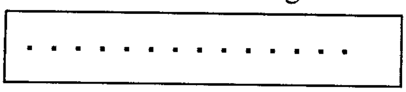
Instructions to the candidate:

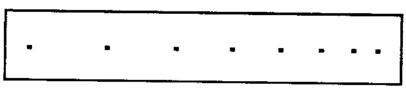
There are ten multiple choice questions in this paper. Answer all questions. For each question there are four choices, A, B, C and D. Choose the one you consider correct and record your choice in ink on the separate answer sheet.

Duration: 15 minutes.

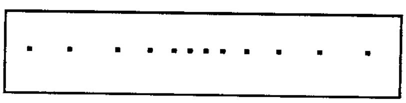
Use the ticker tapes below to answer questions 1and 2. Each answer may be given more than once.

1. Which of the following ticker tapes represents an object slowing down ?

A 

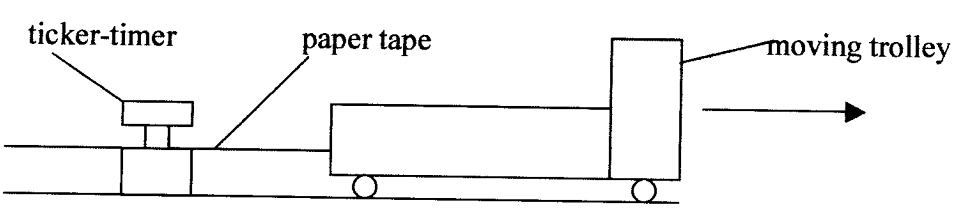
B 

C 

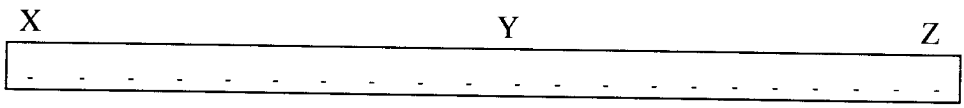
D 

2 Which of the ticker tapes above represents a coin which falls from the top of a cliff to the ground?

3 A pupil uses a ticker – timer to investigate the movement of a trolley.



Every second , the ticker- timer puts 50 dots on the piece of tape.



What length of time corresponds to the distance between X and Y on the tape?

A. 0.02 s

B. 0.10 s

C. 0.12 s

D. 0.20 s

4. On the tape in question 3, the distance from X to Y is 7.8 cm. What is the speed of the trolley?

A 14 cm/s

B 39 cm/s

C 78 cm/s

D 156 cm/s

5. On the same tape in question 3, the distance from Y to Z is 6.6 cm. What is the acceleration of the trolley between X and Z ?

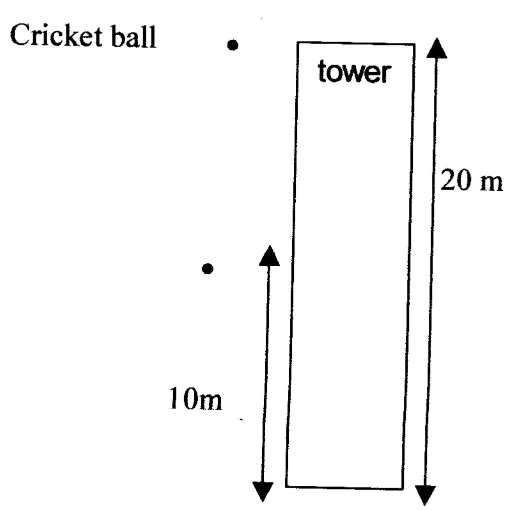
A. -30 cm/s^2

B. -33 cm/s^2

C. -39 cm/s^2

D. -60 cm/s^2

6 Two cricket balls are released from a 20m tower at the same time. One falls from the top, the other from half way up, as shown.



Which quantity is the same for both balls?

A acceleration

B final speed

C increase in velocity

D time of travel

6. The balls are now replaced with a feather and a piece of metal of mass 1 kg. The two objects are again released from the same tower at the same time but this time in a vacuum. The metal falls from the top, the feather from half way up. Which of the following is true about these objects?

A the feather moves slower than the metal

B the feather moves faster than the metal

C the feather quickily reaches a terminal velocity

D the feather and the metal have the same acceleration.

8. A pupil takes 7 seconds to move from point A straight to B and then to C as shown in the figure below.

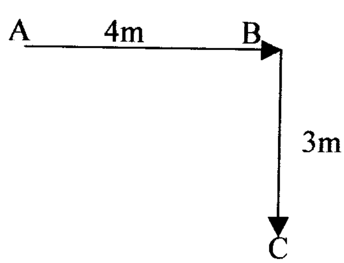


Fig.8

What is the displacement in 7 seconds ?

A 1m in the direction C

B 5m in the direction C

C 7m in the direction C

D 12m in the direction C

9. In fig.8, after moving from A to C, the pupil now moves from C straight to B and then back to A. The journey takes 7 seconds as before. Which of the following is true about the pupil ?

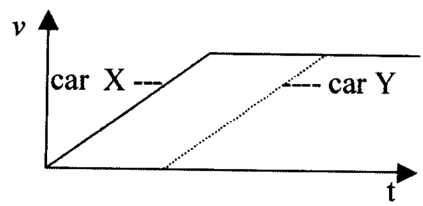
A from A to C his average speed is zero

B from A to C his acceleration is $1 m/s^2$

C his displacement in 14 seconds is zero

D his displacement in 14 seconds is 14 m.

10. The graph shows the speed of two cars over a period of time.



From the information in the graph, which statement is correct?

A Car X went faster than car Y

B Car X had more mass than car Y

C Car X and Y always travelled at constant speed

D Car X accelerated at the same rate as car Y

END OF TEST 2

TEST 3

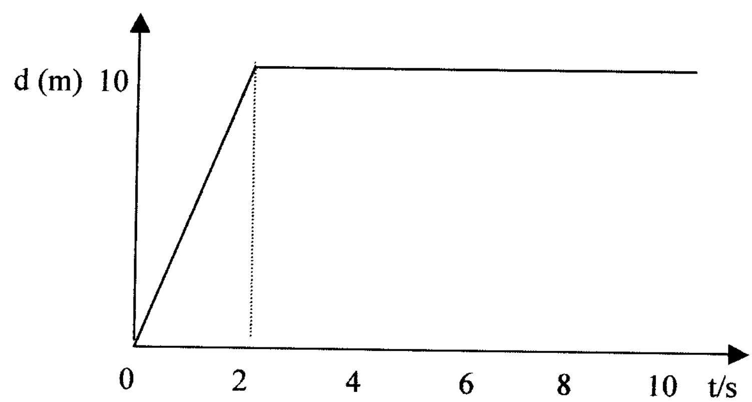
Describing motion with position - time graphs

Instructions to the candidate:

There are ten multiple choice questions in this paper.Answer all questions.For each question there are four choices, A, B, C and D. Choose the one you consider correct and record your choice in ink on the separate answer sheet.

Duration: 15 minutes.

1. The figure below represents a distance- time graph for a child who is on a bicycle for 8 seconds . Use the graph to answer questions 1 and 2. Each answer may be given more than once.



From 2 to 10 seconds the child

A is not moving

B has constant speed

C is accelerating

D has uniform velocity

2. What distance is covered by the child in 8 seconds?

A 10 m

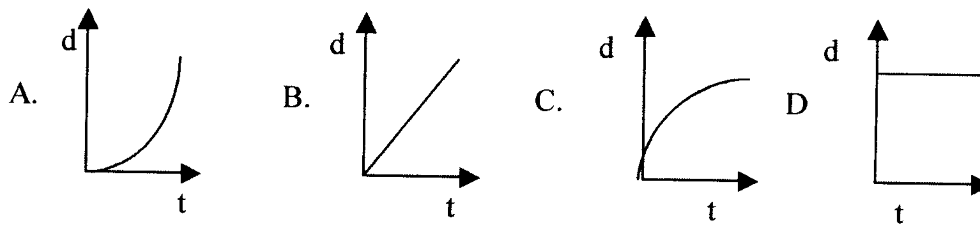
B 20 m

C 40 m

D 45 m

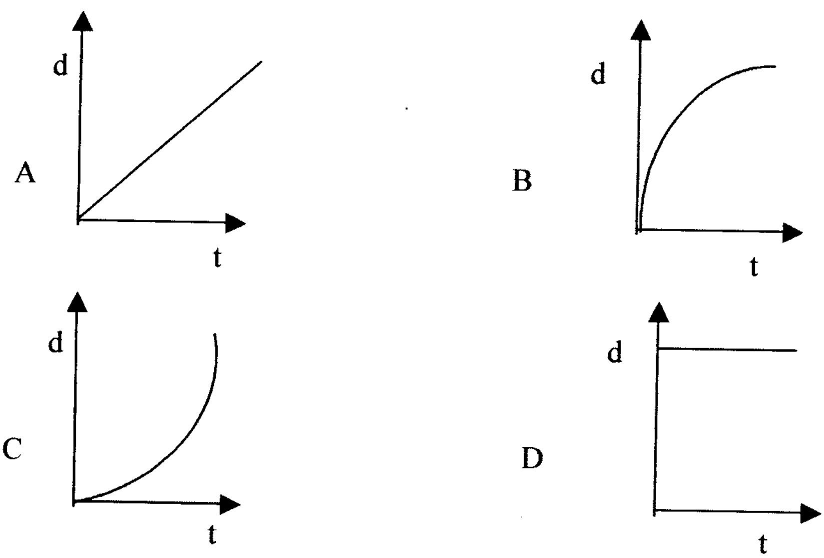
3. Below are four distance – time graphs. Which one of these represents motion of a body which has reached a terminal velocity?

fig. 3



4. Which of the graphs in fig. 3 represents motion of a body with uniform speed?

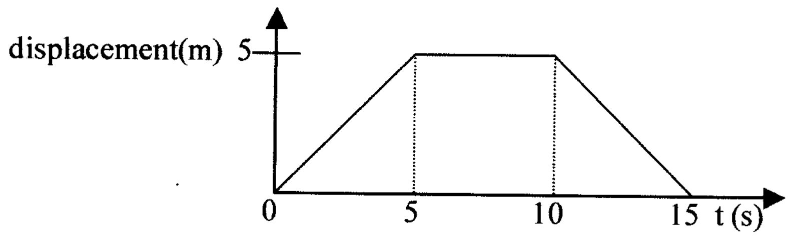
5. Use the distance – time graphs below to answer questions 5,6,7 and 8 that follow. Each answer may be given more than once.



Which graph represents the motion of a free falling object which has reached a terminal velocity?

6. Which graph represents motion of a body with a decreasing speed?
7. Which of the graphs represents motion of a body with an increasing speed?
8. In which of the graphs is the object stationery?

9. The motion of a cyclist is shown on the following displacement-time graph.



Which of the following is true about the cyclist?

A in the first 5 seconds the cyclist is accelerating at 1m/s

B between 5 seconds and 10 seconds the cyclist is not moving

C between 5 seconds and 10 seconds the cyclist has a constant velocity of 5m/s

D after 10 seconds the cyclist's speed is changing by 1m/s per second

10. What is the cyclist's speed at $t = 4$ seconds ?

A 1 m/s

B 4 m/s

C 5 m/s

D 10 m/s

END OF TEST 3

TEST 4

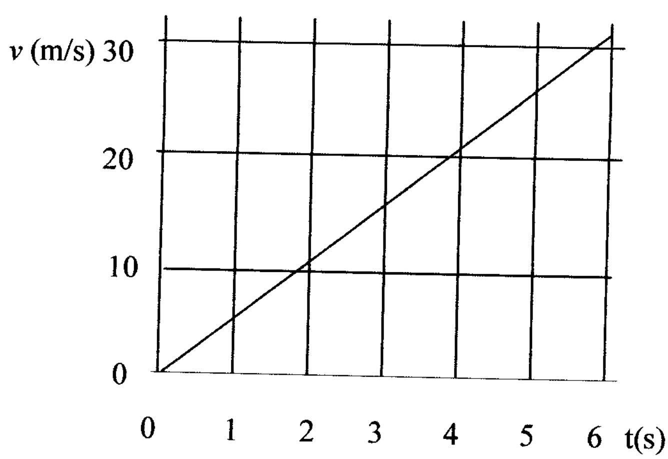
Describing motion with Velocity-time graphs

Instructions to the candidate:

There are ten multiple choice questions in this paper.Answer all questions.For each question there are four choices, A, B, C and D. Choose the one you consider correct and record your choice in ink on the separate answer sheet.

Duration: 15 minutes

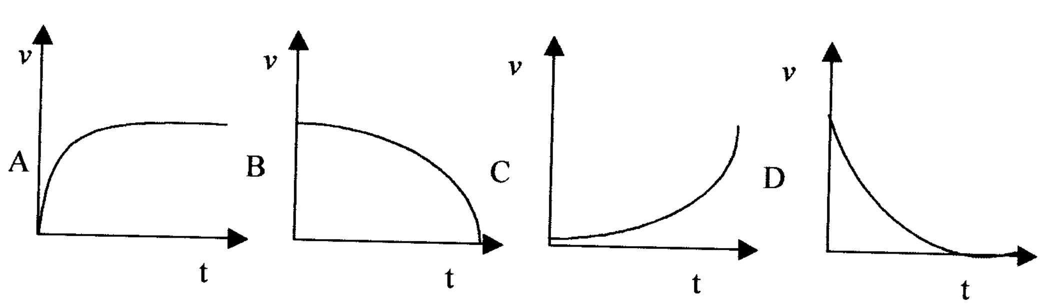
1. A car starts from rest and accelerates uniformly to a velocity of 30 m/s in 6 s.



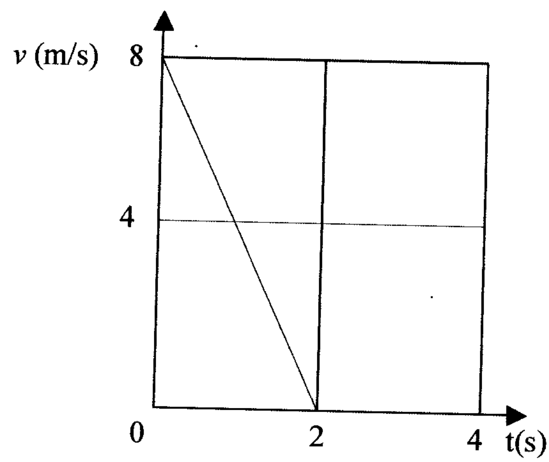
What is the displacement of the car in 6 s ?

A 5 m B 30 m C 90 m D 180 m

2 A body falling in air soon reached its terminal velocity.Which graph represents this fall ?



3 The graph below shows how the velocity of a ball changed when it was rolled up a smooth slope with an initial speed of 8 m/s. Using this graph, answer questions,3,4,5 and 6 that follow. An answer may be given more than once.



At what time did the ball reach its highest point?

A 0 B 1 s C 2 s D 4 s

4. What distance was covered by the ball from its starting point to the highest point on the slope?

A 2 m B 4 m C 8 m D 16 m

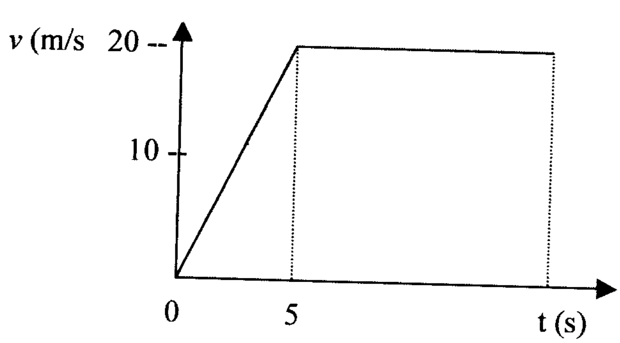
5. What was the acceleration of the ball as it moved up the slope?

A 0 B -2 m/s^2 C -4 m/s^2 D 4 m/s^2

6. At what time would the ball return to its starting point? (Ignore any friction forces).

A 0 B 2 s C 4 s D 8 s

7. The figure below shows an incomplete velocity-time graph for a car moving a distance of 150 m.



At what time does it cover the distance of 150m ?

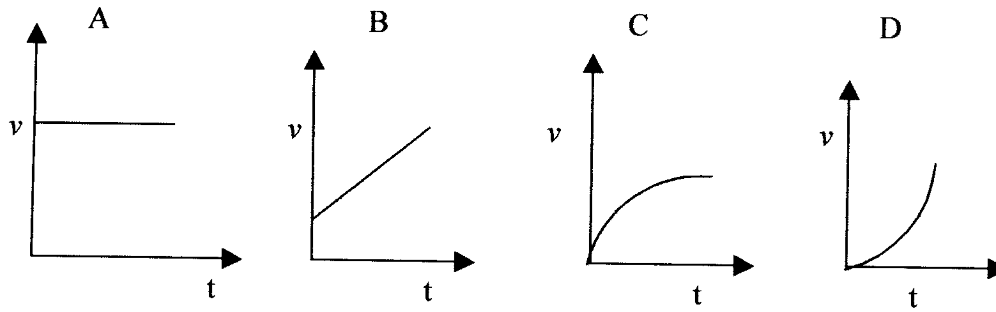
A 4 s

B 6 s

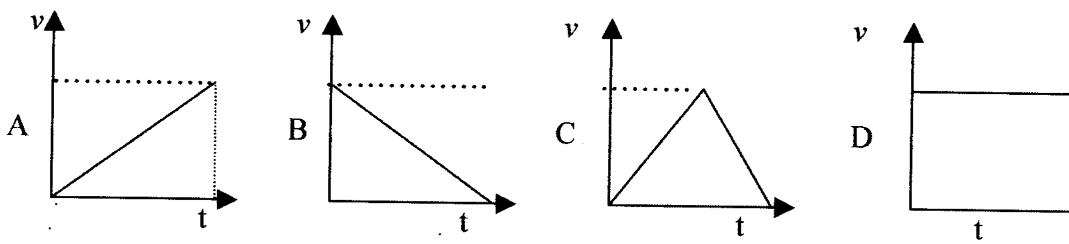
C 8 s

D 10 s

8. A constant force causes a car to accelerate from 4.0 m/s to 12 m/s in 8 s. Which graph shows how the velocity of the car varies with time?



9. Each of the Velocity –time graphs below represents the motion of a trolley in a lab. Use these to answer questions 9 and 10. An answer may be given more than once.



Which of the graphs represents the motion of the trolley with no acceleration?

10. The maximum velocity of all the trolleys and the time taken for the journey are the same. Which of the graphs in question 9 represents the motion of the trolley that covers the greatest distance?

END OF TEST 4

TEST 5

Describing motion with equations

Instructions to the candidate:

There are ten multiple choice questions in this paper.Answer all questions.For each question there are four choices, A, B, C and D. Choose the one you consider correct and record your choice in ink on the separate answer sheet.

Duration: 15 minutes.

1. A truck takes 20 seconds to travel the first 80 m, and another 10 seconds to travel a further 70 m. What is the average speed ?
   - A 0.20 m/s
   - B 2.3 m/s
   - C 4.0 m/s
   - D 5.0 m/s
2. A train increases its speed steadily from 10 m/s to 20 m/s in 60 seconds. How far does it travel while increasing its speed ?
   - A 100 m
   - B 300 m
   - C 600 m
   - D 900 m
3. An object moving at a constant speed of 30 km/h takes 2 hours to travel from point A to point B. Which of the following is true about the object?
   - A its final velocity is 15 km/h
   - B it is moving in a circular path
   - C after 2 hours it has a constant deceleration
   - D its displacement in 2 hous is 60 km
4. A car moving round a circular racing track takes 120 minutes to do a lap of 8km.What is the speed in km/h ?

A 4 km/h

B 8 km/h

C 15 km/h

D 667 km/h

5. A body initially moving at a velocity of 2 m/s ends with a velocity of 12 m/s after 5 s . What is its average velocity ?

   A 0 B 2 m/s C 5 m/s D 7 m/s

6. What is the acceleration of the body in question 5 ?

   A 1.4 m/s^2 B 5 m/s^2 C. 12 m/s^2 D 30 m/s^2

7. A boy on a bicycle accelerates uniformly at 1 m/s^2 for 10 seconds from an initial velocity of 4 m/s. What distance is travelled in this time?

   A 40 m B 50 m C 90 m D 130 m

8. A motor cyclist starts from rest and reaches a speed of 6 m/s after travelling with uniform acceleration for 3 seconds. What is his acceleration?

   A 2 m/s^2

   B 3 m/s^2

   C 9 m/s^2

   D 18 m/s^2

9. A body initially at rest , accelerates uniformly at the rate of 2 m/s^2 till it covers a maximum distance of 25 m. What is its final velocity ?

   A 2 m/s

   B 10 m/s

   C 50 m/s

   D 100 m/s

10. An object initially moving at a velocity of 4 m/s ends with a velocity of 10 m/s after 7 seconds. What is the displacement ?

    A 21 m

    B 28 m

    C 49 m

    D 70 m

END OF TEST 5

TEST 6

Free fall and the acceleration due to gravity

Instructions to the candidate:

There are ten multiple choice questions in this paper.Answer all questions.For each question there are four possible answers,A,B,C and D.Choose the one you consider correct and record your choice in ink on the separate answer sheet.

Duration: 15 minutes.

1. The acceleration due to gravity on Earth is 9.8 m/s^2. This means that on the Earth

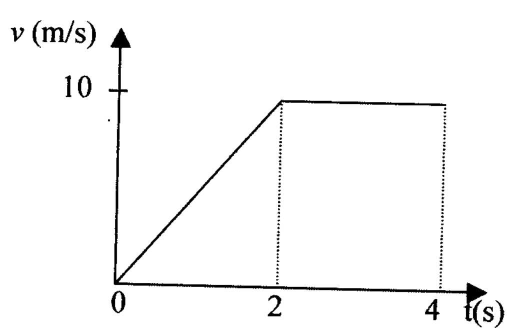
   A the velocity of a free falling body increases by 9.8 m/s every second

   B a free falling body moves at a constant speed of 9.8 m/s

   C the lowest velocity of a free falling body is 9.8 m/s

   D the highest velocity of a free falling body is 9.8 m/s

2. The diagram below shows a velocity-time graph for a light object that is dropped from a branch of a tree.



Use this figure to answer questions 2,3 ,4 ,5 and 6 that follow. An answer may be given more than once.

What distance does the object cover in the first 2 seconds of its motion?

A 2 m

B 4 m

C 6 m

D 10 m

3. What distance is covered by the object between the time 2 seconds and 4 seconds ?

   A 5 m

   B 10 m

   B 20 m

   C 40 m

4. At what time does the weight of the object become equal to the air resistance?

   A 0

   B 2 s

   C 4 s

   D 6 s

5. At what rate does the body accelerate after the first 2 seconds of its motion ?

   A 0

   B 2 m/s^2

   C 4 m/s^2

   D 10 m/s^2

6. With what velocity is the object in figure 2 expected to strike the ground ?

   A 10 m/s

   B 20 m/s

   C 40 m/s

   D 60 m/s

7. A tennis ball is dropped from a branch of a tree. It takes 1 second to hit the ground. If the acceleration of free fall is 10 m/s^2

   A the distance from the branch to the ground is 5 m

   B the ball makes a displacement of zero

   C the final velocity of the ball is 5 m/s

   D the final velocity of the ball is 11 m/s

8. On Earth the acceleration of free fall is about 10 m/s^2 . On the Moon it is about 1.7 m/s^2. This means that on the Moon, falling objects

A cover a distance of 1.7 m every second

B move at a constant velocity of 1.7 m/s

C have a displacement of 1m in every 1.7 s

D ve a change in velocity of 1.7 m/s every second

9. An object thrown from ground level moves vertically upwards till it reaches a maximum height of 10 m. Thereafter,it falls freely under gravity,till it strikes the ground. What is its velocity at the maximum height reached?

A 0

B 10 m/s

C 20 m/s

D 30 m/s

10. The initial velocity of the object in question 9 is 5 m/s. What is its final velocity? Ignore the air resistance.

A 0

B 5 m/s

C 10 m/s

D 20 m/s

END OF TEST 6

APPENDIX B

Attitude Questionnaire

S/NO	ITEMS	Strongly agree 7	Moderately agree 6	Slightly agree 5	4 Neutral	3 Slightly disagree	2 Moderately disagree
1	The use of the PCR software for learning Kinematics was an exciting experience.						
2	In understanding the concepts of a lesson the PCR method of presenting Kinematics is better than the traditional classroom presentations.						
3	The PCR approach allows one to discuss Kinematics with others much more than the traditional methods of learning Physics.						
4	My level of motivation on Kinematics has increased with the use of the PCR software.						
5	The information on all the lessons on Kinematics was clear .						
6	The amount and quality of materials in the PCR were just about right compared with what would normally be covered in a traditional classroom.						

7	The use of the PCR software has increased my degree of interest in Kinematics and Physics in general.							
8	The PCR learning method allowed me to work at my own pace (which the traditional classroom method does not do).							
9	The PCR software offered me greater flexebility in the sequence of various ideas / concepts on each lesson than traditional classroom methods							
10	The use of the PCR in learning Kinematics in Physics made me more creative.							
11	I learned more things about Kinematics through the use of the PCR software than I learned using Traditional methods.							
12	I recommend the use of the PCR software in the learning of Kinematics and other topics in Physics.							
13	I would like the Traditional method of learning Kinematics be replaced completely with the PC learning approach rather than only supplement it.							

APPENDIX C

Observation Schedule

Observation of learning

CRITERIA	FREQUENCY 1	2	3	4
Students report for lessons in/on time.				✓
All the students are present for lessons.			✓	
Students start their computers and immediately go to the 'Physicsclassroom' software to explore the new information.				✓
Students are well behaved during lessons.				✓
Students interact with the learning environment provided (the PCR software) in all possible ways, including animations that help make the lessons more interesting and clearer.				✓
Students solve all the problems provided in the software on each of the six Lessons on Kinematics.			✓	

	1	2	3	4
Students perform better in the 'Physicsclassroom' exercises than in the non PCR kinematics exercises	☐	☐	☐	☑
Students do better in their post-tests than in their pre-tests.	☐	☐	☑	☐
Students express the desire to continue learning Physics with the 'Physicsclassroom' software.	☐	☐	☐	☑

CODING 1 = not at all

2 = in rare cases

3 = most of the time

4 = all the time

Elaboration (record of any other relevant information e.g on the differences in performance or attitude between the students using the PCR software and those who are not).

....

....

....

....

....

APPENDIX D

Participant Reports on the PC software

All the participants in the experimental group will be asked to write a short report on the PCR learning approach that will be introduced to them. This will also help to answer the third question of this study on the attitude of the learners towards the PCR learning approach.

APPENDIX E

Short interview with Physics educators about the PCR learning approach

An effort will be made by the researcher to interview some Physics educators in COSM-Zambia, in Lusaka who have used the PCR software to get more views about its effects in the learning of kinematics in high school physics. The information obtained will be compared with the findings in the study.

APPENDIX F

Scores obtained by the pupils in pre- and post-tests

(a) Test 1 scores

Experimental group			
Participant	Pre-test %	Post-test %	Change in Marks %
P1	50	70	20
P3	40	60	20
P5	80	80	0
P7	60	80	20
P9	60	70	10
P11	20	40	20
P13	40	60	20
P15	50	60	10
P17	60	70	10
P19	50	60	10
P21	50	60	10
P23	30	70	40
P25	30	50	20
P27	50	60	10
P29	60	70	10
P31	40	40	0
P33	50	80	30
P35	50	50	0
P37	70	80	10
P39	50	70	20

Control group			
Participant	Pre-test %	Post-test %	C M
P2	40	50	
P4	60	60	
P6	80	60	
P8	50	50	
P10	60	70	
P12	40	60	
P14	70	70	
P16	30	30	
P18	50	50	
P20	80	80	
P22	50	50	
P24	40	40	
P26	70	70	
P28	70	70	
P30	30	30	
P32	60	40	
P34	50	50	
P36	60	70	
P38	40	50	
P40	-	-	-

(b) Test 2 scores

Participant	Experimental group		
	Pre-test %	Post-test %	Change in mark %
P1	80	90	10
P3	80	80	0
P5	70	80	10
P7	80	80	0
P9	40	80	40
P11	70	70	0
P13	60	80	20
P15	50	50	0
P17	30	70	40
P19	50	60	10
P21	50	50	0
P23	30	40	10
P25	70	50	-20
P27	40	40	0
P29	50	80	30
P31	60	80	20
P33	60	80	20
P35	60	90	30
P37	40	80	40
P39	60	60	0

Control group			
Participant	Pre-test %	Post-test %	Cl in
P2	60	60	
P4	60	70	
P6	50	50	
P8	60	80	
P10	30	30	
P12	-	-	
P14	-	-	
P16	40	40	
P18	40	40	
P20	60	60	
P22	30	50	
P24	80	80	
P26	80	70	
P28	50	50	
P30	80	70	
P32	20	20	
P34	-	-	
P36	-	-	
P38	40	40	
P40	40	40	

(c) Test 3 scores

Participant	Experimental group		
	Pre-test %	Post-test %	Change in mark %
P3	70	70	0
P5	40	40	0
P7	40	50	10
P13	50	50	0
P15	40	50	10
P17	20	60	40
P19	70	90	20
P21	30	30	0
P23	20	50	30
P25	50	50	0
P27	10	50	40
P29	60	80	20
P31	30	40	10
P33	50	60	10
P35	70	70	0
P37	30	50	20
P39	20	40	20

Control group			
Participant	Pre-test %	Post-test %	Change in Mark %
P2	60	80	20
P4	70	70	0
P6	30	30	0
P8	70	50	-20
P10	50	50	0
P12	60	40	-20
P14	60	60	0
P16	40	40	0
P18	40	40	0
P20	70	70	0
P22	40	40	0
P24	20	40	20
P26	20	30	10
P28	70	70	0
P30	50	30	-20
P32	10	30	20
P34	40	30	-10
P36	70	60	-10
P38	60	70	10
P40	60	60	0

(d) Test 4 scores

Participant	Experiment group		
	Pre-test %	Post-test %	Change in Marks %
P1	60	60	0
P3	50	50	0
P5	30	50	20
P7	20	40	20
P13	50	40	-10
P15	40	40	0
P17	40	50	10
P19	40	40	0
P21	50	50	0
P23	10	20	10
P27	40	40	0
P29	60	60	0
P31	50	70	20
P33	50	50	0
P35	50	50	0
P37	30	10	-20
P39	50	60	10

Participant	Control group	
	Pre-test %	Post-test %
P2	30	20
P4	50	50
P6	70	80
P8	40	40
P10	-	-
P12	30	30
P14	60	50
P16	60	60
P18	50	40
P20	70	70
P22	70	60
P24	60	50
P26	70	70
P28	50	40
P30	40	20
P32	-	-
P34	50	50
P36	60	60
P38	70	70
P40	50	50

(e) **Test 5 scores**

Participant	Experimental group		
	Pre-test %	Post-test %	Change in mark %
P1	50	50	0
P3	50	60	10
P5	20	50	30
P7	40	40	0
P13	40	60	20
P15	40	50	10
P17	30	40	10
P19	40	40	0
P21	40	50	10
P23	30	30	0
P25	30	20	-10
P27	60	80	20
P29	50	50	0
P31	30	40	10
P33	50	70	20
P35	60	60	0
P37	50	70	20
P39	40	50	10

Participant	Control group		
	Pre-test (%)	Post-test (%)	Change in mark %
P2	40	40	0
P4	60	60	0
P6	70	70	0
P8	30	50	20
P10	-	-	-
P12	30	20	-10
P14	40	40	0
P16	50	40	-10
P18	40	30	-10
P20	70	70	0
P22	30	30	0
P24	20	30	10
P26	70	70	0
P28	30	50	20
P30	60	50	-10
P32	-	-	-
P34	20	20	0
P36	-	-	-
P38	70	70	0
P40	60	60	0

(e) Test 6 scores

Participant	Experimental group		
	Pre-test %	Post-test %	Change in mark %
P1	70	70	0
P3	50	70	20
P5	70	70	0
P7	70	80	10
P13	70	90	20
P17	40	40	0
P19	70	90	20
P21	30	40	10
P23	20	20	0
P25	60	70	10
P27	60	60	0
P29	80	80	0
P31	60	90	30
P33	80	90	10
P35	80	90	10
P37	30	30	0
P39	90	90	0

Participant	Control group	
	Pre-test (%)	Post-test. (%)
P2	50	50
P4	70	70
P6	80	70
P8	80	80
P10	50	50
P12	40	40
P14	70	70
P16	70	70
P18	60	80
P20	80	70
P22	50	50
P24	40	40
P26	-	-
P28	70	70
P30	30	40
P32	40	40
P34	80	80
P36	40	40
P38	50	50
P40	80	80

APPENDIX G

Line graphs for comparing the performance of the two groups

The following line graphs compared the performance of the experimental and control groups in all the post-tests.

fig 1g Line graphs of post-test 1 scores verses participants

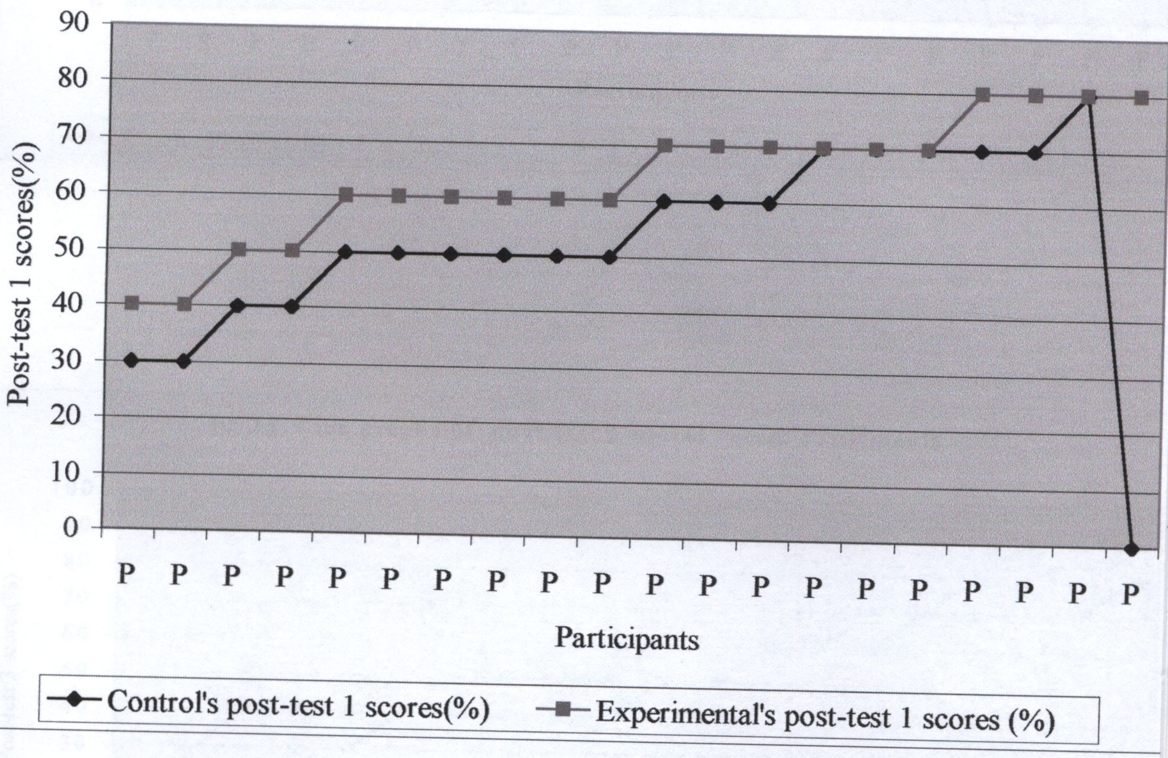


fig 2g Line graphs of post-test 2 scores verses participants

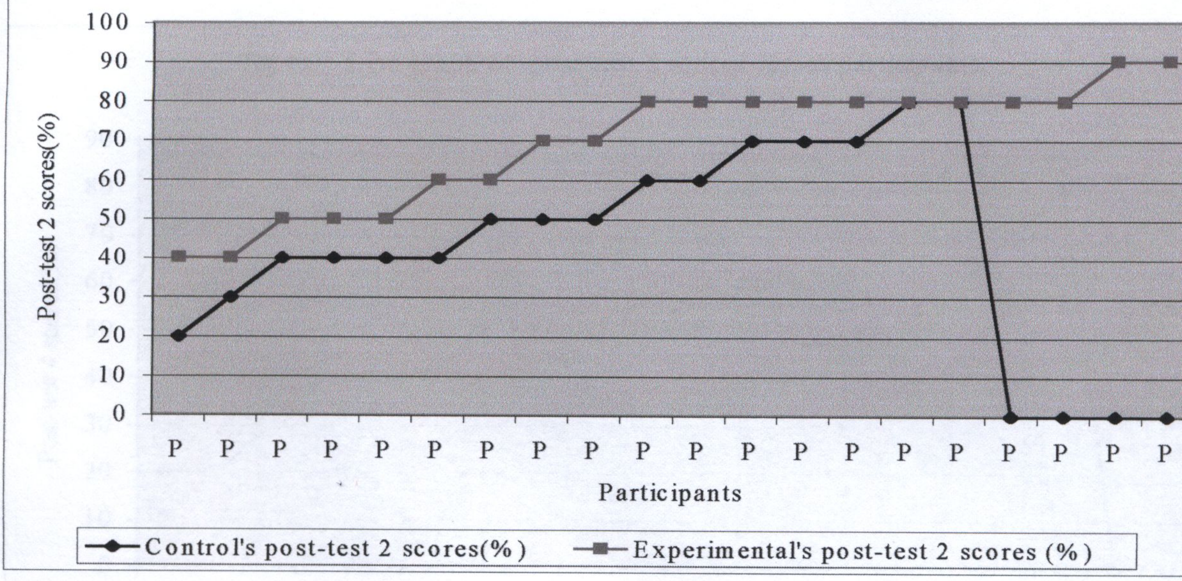
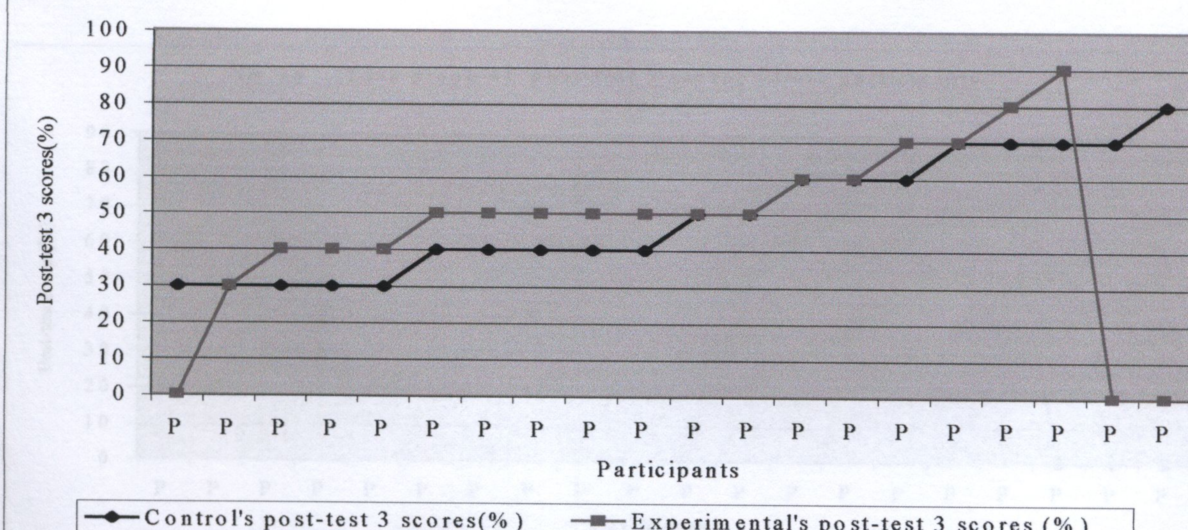


fig 3g Line graphs of post-test 3 scores verses participants



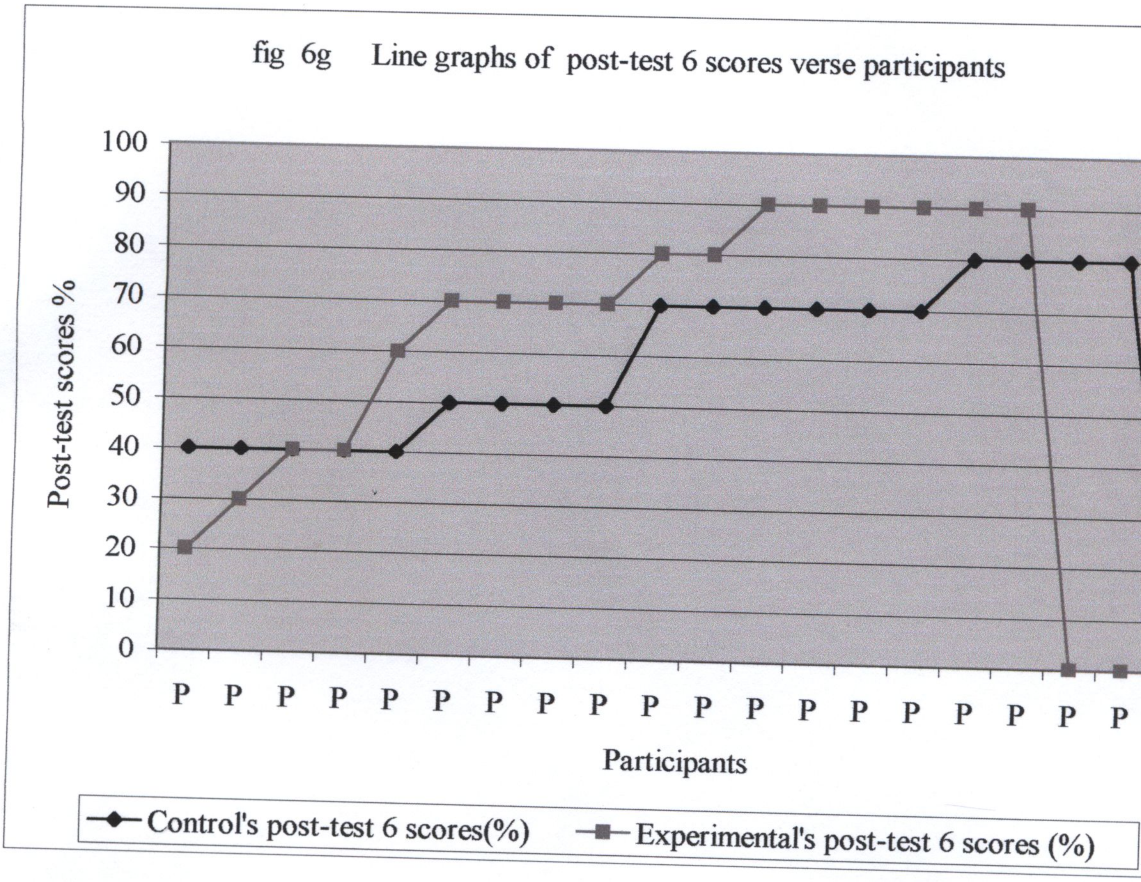


fig 6g Line graphs of post-test 6 scores verse participants
100
90
80
70
60
50
40
30
20
10
0
Post-test scores %
P P P P P P P P P P P P P P P P P P P
Participants
Control's post-test 6 scores(%)
Experimental's post-test 6 scores (%)