INFLUENCE OF PEDAGOGICAL TECHNIQUES ON STUDENTS' PERFORMANCE IN MECHANICS IN SELECTED TECHNICAL INSTITUTIONS IN KENYA

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DECLARATION

This thesis is my original work and has not been presented for any academic award at any other University

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DEDICATION

This thesis is dedicated to my son Samuel Muriithi, my wife Irene Wairimu and my mother Lucy Muthoni Mathenge.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA:	Analysis of Variance
ARP:	Apply Research to Practice
ASEI:	Activity-based teaching for Student-centered learning through Experiment which rely on Improvisation
AU:	African Union
AWE:	Assessing Women and men in Engineering
CBA:	Class Based Assessment
CCTV:	Closed Circuit Television Network
CAL:	Computer Assisted Learning
3-D:	Three Dimension
GPA:	General Point Average
H:Q:	Hamstring Torque to Quadriceps Torque
HOD:	Head of Department
FE:	Fundamental Engineering
IAAF:	International Amateur Athletics Federation
ICMI:	International Commission for Mathematics Instructions
ICT:	Information Communication and Technology
IE:	Interactive Engagement
ILO:	International Labor Organization
INSET:	In-Service Training
IQ:	Intelligence Quotient
KCSE:	Kenya Certificate of Secondary Education
KITI:	Kenya Industrial Training Institute
KNEC:	Kenya National Examinations Council
KTTC:	Kenya Technical Teachers' Training College

LD:	Lecturer’s Demonstration
MAP:	Measure of Academic Progress
MDGs:	Millennium Development Goals
MMP:	Millennium Mathematics Project
MoE:	Ministry of Education
MoHEST:	Ministry of Higher Education, Science and Technology
MRO:	Maintenance Repair and Operations
NCTM:	National Council of Teachers of Mathematics
NACOSTI:	National Council of Science, Technology and Innovation
NYS:	National Youth Service
OJT:	On-the-Job-Training
ODel:	Open and Distance Learning
PDSI:	Plan Do See Improve
PhiMSAMP:	Philosophy of Mathematics Sociological Aspects and Mathematical Practice
PR:	Pre-Test
PT:	Post-test
Q&A:	Question and Answer
QML:	Questionnaires for Mechanics Lecturers
SIS:	Steeplechaser’s Interview Schedule
SMASSE:	Strengthening Mathematics and Sciences in Secondary Education
STEM:	Science, Technology, Engineering and Mathematics
STA:	Steeplechase Activities
SPSS:	Statistical Package for Social Sciences
TEP:	Technical Education Program
TIVET:	Technical, Industrial, Vocational and Entrepreneurship Training

TMT:	Traditional Methods of Teaching
TSC:	Teachers' Service Commission
TTIs:	Technical Training Institutes
UNESCO:	United Nations Educational, Scientific, and Cultural Organization
UNEVOC:	UNESCO International Centre for Technical and Vocational Education and Training
UNICEF:	United Nations Children's Fund

ABSTRACT

Mechanics plays an important role in developing students' capacity to experiment, analyze, synthesize and evaluate situations in and out of college. It is a catalyst for developing students' cognitive and interpersonal abilities such as analytical, creative, critical and logical reasoning as well as problem solving. Despite the significant role played by mechanics in students' abilities, poor performance is global problem. The purpose of this study was to explore the influence of pedagogical techniques on students' performance in Mechanics in selected diploma technical institutions in Kenya. The specific objectives of this study were: to compare students' performance in mechanics when students are taught using steeplechase activities and when students are taught using traditional methods; to compare students' performance in mechanics when students are taught using steeplechase activities and when students are taught using lecturer's demonstration; to establish the influence of using steeplechase activities for teaching on students' performance in mechanics for different ability groups; and to find out the influence of using steeplechase activities on students' performance in mechanics for gender groups. The study aimed at contributing to knowledge on modeling mechanics problems. Causal comparative research design was used for this study on influence of using steeplechase activities for teaching on students' gains (as predictor of performance) in mechanics. Sixteen (16) colleges were randomly selected to participate in the study based on geographical location and type of group targeted. Simple stratified random sampling was used to pick student and steeplechaser respondents. Purposive sampling was used to pick the chosen first year 96 ($male = 75$; $female = 21$) lecturers. Sixteen (16) colleges had 768 first year students from which a sample of 384 students was randomly selected. The study worked with 120 steeplechasers from which a random sample of 60 was selected. Data was collected by use of questionnaires for mechanics lecturers, pre-test, post-test; and steeplechasers' interview schedule. Categorical data was presented in distribution tables and graphs showing frequencies and percentages. Quantitative data was presented in tables showing arithmetic means, standard deviations, ordinary gains and normalized gains. Quantitative data was analyzed using t-statistic as used in Statistical Package for Social Sciences (SPSS) to establish whether there was a significant difference between the means of the groups being compared in hypotheses testing. The study found that traditional method of teaching such as: lecture method, questioning, dictation of notes and lecturer's demonstration were the most predominant (85%) in mechanics lessons. Test of hypothesis suggested that when students were taught using steeplechase activities, their performance in mechanics could be improved compared to alternative methods of teaching. The normalized gain made by experimental group was 47% ($std.dev. = 12.376$) compared to traditional methods of teaching (15%;$std.dev. = 10.480$) and lecturer's demonstration (22%;$std.dev. = 9.383$). The results in the test of hypotheses also suggested that the high ability group benefitted more from using steeplechase activities for teaching than the low ability group. The results on test of hypothesis also suggested that using steeplechase activities for teaching had the capacity to reduce gender difference in students' performance in mechanics. The study also found that teaching students using steeplechase activities could develop their mathematics skills. The study found that when steeplechase activities were used for teaching, they might have the capacity to make learning of mechanics more meaningful and captivating. The research findings lead to the conclusion that steeplechase activities have the capacity to improve students' performance in mechanics. The study recommended the use of steeplechase activities as pedagogical techniques for improving students' performance in mechanics. The study recommends the replication of this study to other branches of mathematics and other science based disciplines.

CHAPTER ONE
INTRODUCTION

1.0 Background to the Study

Mechanics is a branch of mathematics used to describe the behavior of physical bodies when displaced or assume a state of rest when force is exerted on them and subsequent effect of the state of the bodies on their surrounding (Fang, 2014; Jackson, Dukerich & Hestenes, 2008). Fang (2014) and Huang (2011) found that mechanics has essential content areas including: displacement and velocity; force and acceleration; work, energy and power; momentum and impulse as well as vibrations which are fundamental to understanding of applied mathematics, physics and engineering programs. The content areas in mechanics described by Fang (2014) and Huang (2011) play a critical role in developing students' ability to visualize the interaction of forces and moments with the physical world. Huang (2011) described mechanics as an introductory course which has pre-requisite knowledge and skills serving as essential basis for the numerous subsequent and advanced dynamics courses. Subsequent and advanced mechanics (or dynamics) courses include: machine design, advanced structural design, system dynamics and control (Huang, 2011). Hence mechanics has capacity to link observations in experimental mathematics and theoretical physics (Jackson, 2009). In teaching of mechanics, lecturers are expected to use interactive engagement (IE) methods which could encourage students to use heuristic, intuitive and approximate arguments (Fang, 2014; Wells, 1987). Using activity-based learning students are expected to study mechanics through research and solving problems inspired by theoretical physics within mathematical framework (Nzama, 2000; Wells, 1987). Hence, mechanics involves mathematical as well as statistical modeling which uses rigorous symbolization to bridge the theoretical world of the technologists and the practical approach to developing skilled work-force. Hence, the study was necessary and urgent.

Mechanics is considered as a catalyst for developing students' skills such as analytical, critical, logical thinking as well as creative problem-solving (Jackson, 2009). It is useful in formulating new ideas as well as theories, discovering and interpreting phenomena as well as developing experimental, computational tools as well as use computer software for machinery and product design (Kerre, 2011; Bostock, & Chandler, 1996). Mechanics is also expected to develop students' ability to make informed decisions, use appropriate language to explain ones reasoning to non-scientific audience; write reports, complete tasks on time and meet standards and specifications as well as pass curriculum-based examinations (Kerre, 2011; Majumdar, 2011). Hence, in-depth understanding of mechanics could develop students' capacity to carry out structural and system design, sourcing for essential systems parts, maintenance, repair and operations (MRO) needed in the service industry (Kerre, 2010).

Despite the critical role played by mechanics, students' poor performance is a global problem (Jackson, 2009; Nzama, 2000; Wells, 1987). Huang (2011) observed that in Utah University, many of the mechanics students performed poorly or fail in the course. Specifically, the mean score of the final comprehensive examination in mechanics class was below 70% at Utah University in 2009 (Huang, 2011). Analysis of the examination scripts by Huang (2011) observed that 53% of the mechanics questions were answered correctly while 47% were answered incorrectly in curriculum-based (fundamentals of engineering (FE) examinations in US in 2009. Analysis of examination results from diploma technical colleges in KwaZulu Natal in South Africa showed that the pass rate was impressive at 73% (282 out of 384) with a failure rate of 27% (Nzama, 2000). Although the pass rate in mechanics in South Africa was impressive at 73%, a closer examination of the results revealed that in 67% of the technical institutions, the failure rate was between 50% and 58% (Nzama, 2000). The concern over the situation in South Africa was because the study by World Bank (2004) in Mureithi (2008) showed that youth unemployment in South Africa was 78% compared to Kenya at 73%. World Bank (2004) in

Mureithi (2008) observed that poor performance in mechanics suggested that students' lack of employable skills needed in labor market might hamper the desire to reduce youth unemployment.

Poor performance among students taking mechanics had persisted in Central, Eastern, Nairobi and Rift Valley Regions in Kenya as illustrated in curriculum-based examination results in Table 1 below:

Table 1: **External Examination Results in Mechanics in four Regions in Kenya**

Year	Dist.	Credit	Pass	Fail	Referral	Absent	Total
2005	0	27 (10.6)	50 (19.7)	71 (28.0)	97 (38.2)	9 (3.5)	254 (100.0)
2006	0	22 (5.9)	80 (21.3)	84 (22.3)	182(48.4)	8 (2.1)	376 (100.0)
2007	0	34 (8.4)	113 (27.8)	121 (29.8)	132 (32.5)	6 (1.5)	406 (100.0)
2008	0	40 (7.7)	112 (21.5)	176 (33.8)	184 (35.4)	8 (1.6)	520 (100.0)
2009	1(0.2)	55 (10.0)	123 (22.4)	186 (33.9)	178 (32.5)	5 (1.0)	548 (100.0)
2010	2 (0.3)	42 (7.8)	116 (21.8)	154 (28.9)	213 (39.9)	7 (1.3)	534 (100.0)
2011	1(0.2)	78 (13.2)	148 (25.1)	174 (29.5)	183 (31.0)	6 (1.0)	590 (100.0)
Total	4 (0.1)	260 (8.2)	742 (23.3)	966 (30.3)	1169 (36.6)	49 (1.5)	3190 (100.0)

Key: Percentage (%) in Parentheses

Poor performance in mechanics in examination results in Central, Eastern, Nairobi and Rift Valley Regions in Kenya in Table 1 between 2005 and 2011 had a pass rate of about 32% (1006 out of 3190 candidates) and wastage rate of 68% among students taking mechanics showing poor performance in Kenya. Similarly, poor performance in mechanics in former Nyanza, Rift Valley and Western Regions in Kenya had a pass rate of between 30% and 40% while the wastage rate was between 63% and 73% (Amuka, Olel & Gravenir, 2011; Bukhala, (2009). Wastage rate refers to fail, referral and drop-outs (Nzama, 2000). According to Amuka, Olel and Gravenir (2011), performance in mechanics in Rift Valley and Nyanza Regions was characterized by mass failure and referrals. Amuka, Olel and Gravenir (2011) also observed that wastage rate of between 63% and 73% was too high for public diploma colleges. Documentary analysis of internal examination results between 2007 and 2011 also showed that poor performance among students taking mechanics in technical institutions in Central, Eastern, Nairobi and Rift Valley

Regions in Kenya had persisted. Internal results of students taking mechanics are summarized in Table 2.

Table 2: **Internal Examination in Mechanics Results in four Regions in Kenya**

	1st Year						2nd Year					
Year	2007	2008	2009	2010	2011	Total	2007	2008	2009	2010	2011	Total
Entry	356	375	387	367	405	1890	353	348	354	396	412	1863
Mean Grade	4.15	4.23	4.45	4.86	5.13	4.57	5.38	4.89	4.56	5.28	5.34	5.10

Key: Distinction 1 (excellent grade) and a Fail 8 (lowest grade)

Results in Table 2 indicate that majority (60%) of the students got a pass 5. A mean pass of 5 shows that majority (60%) got less than 40% marks. Less than forty per cent (40%) marks show poor performance in the mechanics (Kerre, 2010 and Nzama, 2000). A comparison of results in Table 1 and Table 2 showed that students' poor performance in mechanics diploma technical institutions in Kenya had been realized.

Poor performance contributed to the numerous labor market related challenges faced by mechanics graduates in service related applications in Kenya among other developing countries (Dasmani, 2011; Kerre, 2010; Nzama, 2000). In South Africa, 70% ($N = 407$) of the mechanics graduates lacked technical skills needed for the labor market (Nzama, 2000). In Kenya, 77% ($N = 53$) of the industrial supervisors said that the training did not satisfy the market demands while 23% said they were satisfied (Sang, Muthaa, & Mbugua, 2012). Poor performance suggested also that mechanics graduates lacked capacity to respond to the rapidly changing technological and scientific changes, lack complex cognitive skills such as logical reasoning, lack concrete intelligence (Mureithi, 2008). Therefore, poor performance associated with lack of employability skills among students taking mechanics was a source of concern to students, graduates, academic staff and employers among other stakeholders because the investment was not commensurate with expected learning outcomes (Dasmani, 2011; Kerre, 2010; Mureithi, 2008; Nzama, 2000). Hence, the study was urgent and necessary.

Poor performance in mechanics had been associated with the teaching strategies (Amuka, Olel & Gravenir, 2011; Jackson, 2009). At global level, the study by Jackson, Dukerich and Hestenes (2008) noted that:

> The challenge in physics education research for more than a decade has been to identify essential conditions for learning mechanics and thereby devise more effective teaching methods (p.15).

That report suggested that teaching and learning of Newtonian mechanics had pedagogical issues not yet addressed.

Similarly, in United States of America, unwillingness by students to take science, technology, engineering and mathematics (STEM) related courses at higher level had been documented (Congressional Research Services, 2007; McDermott, et al., 1986). Lack of motivation for students to take STEM-related courses such as mechanics in the USA was associated with teaching and learning based on linear procedural knowledge, memorization of facts, principles, laws and theorems instead of aiming at developing conceptual understanding, critical and analytical thinking skills (Goldfinch, Carew, & McCarthy, 2009). In Norway, the explanations for students' poor performance in mechanics were that students found teaching and learning of science, mathematics and technology boring and lacked connection between the mathematical calculations to real world applications (Norbech, 2002). Poor performance among technical and vocational graduates in Bangladesh and the Mongolia was associated with shortage of instructors, limited funds and a mismatch between supplied and demanded skills (ILO, 2010). In KwaZulu Natal in South Africa, poor performance in mechanics was associated with students' weak mathematics and science background, poor teaching as well as lack of adequate modern training facilities and equipment (Nzama, 2000). In Nigerian technical and vocational training had high instructor-student ratio, obsolete equipment, and low morale among teaching staff (Mudashir, 2011). In Kenya the challenges which seemed to contribute to poor performance in mechanics include: inadequate supply of instructional materials, inadequate training facilities, lack of collaborative industrial attachment for students as well as lecturers, lack of stake-holders participation in curriculum development and implementation, inefficient training of students and over-emphasis on passing of examination at the expense of acquisition of technical and practical skills (Sang, et al., 2012 and Mureithi, 2008). These challenges seemed to undermine efforts made toward developing graduates cutting edge needed for creative innovations. Students' performance in mechanics had been shown to significantly depend on pedagogical strategies (Absi, Nalpas, Dofour, Huet, Bennaser, & Absi, 2011; Kerre, 2010). Hence, pedagogical techniques also contributed to poor performance in mechanics.

In Africa, traditional (expository) teaching strategies formed over 80% of the teaching methods used in technical courses (Kerre, 2011; Muthaa, 2009; Nzama, 2000). Traditional methods of teaching used in mechanics include: lecture method; dictation of notes; question and answer; use of examples and lecturer's demonstration (Ngerechi, 2003). That meant that in traditional methods students were passive recipients of lecturers' presentations (Ngware, 2000). The challenge of the passive nature of students when traditional methods of teaching were used suggested that there was need to transform the learning environment to make students active participants. The study by Jackson, Dukerich and Hestenes (2008) observed that expository methods posted less (23%) performance in mechanics compared to interactive teaching and learning styles (modeling mechanics problems (48%). Traditional methods of teaching could be enriched and transformed into a more dynamic by use of alternative teaching strategies (lecturer's demonstration and interactive engagement (IE) methods) (Government of Kenya, 2010a). Lecturer's demonstration and IE (such as steeplechase activities) could improve teaching and learning of mechanics.

Ability grouping could be used as a teaching and learning strategy (Davis, 2012; Steel, 2005). Ability grouping refers to forms of placement of students into homogeneous classroom groups based on students' performance (Dweck, 2006). In Israel institutions, same-ability grouping were practiced while in Japan, mixed-ability grouping was preferred to same ability-grouping (Steel, 2005). Ability grouping was done for purposes of acceleration, curriculum compacting, enrichment, cluster grouping or differentiation (Borovik, & Gardiner, 2006).

Another intervention strategy suggested for improving learning of mechanics by Dasmani (2011) was provision of special packages for ladies. The intervention strategy arose from 'over-representation of men' in mechanics (Wai, Cacchio, Putalla & Makel, 2010). The problem of gender disparity in mechanics had been mentioned by Wells (1987). Similarly, Amuka, Olel and Gravenir (2011) observed that 23.6% (82 out of 348) of students were female but none was registered for curriculum- based examination in mechanics in Rift Valley and Nyanza Regions. Their absence could have been as a result of their massive failure and referrals in mechanics.

Other intervention strategies suggested for dealing with poor performance in mechanics included: use of ICT tools for individualized instruction, module-based teaching, collaborative industrial attachment for lecturers and students (Billington, Sheppard, Calfee & Boylan-Ashraf, 2014; Dasmani, 2011). The stakeholders could participate in: specialized training facilities, industrial trainers, interactive teaching strategies, pre-service and in-service training of lecturers, need to modernize training equipment and improving relevance of training to the market needs (Sang, et al., 2012; Dasmani, 2011; Kerre, 2010). Despite the efforts in the above interventions, poor students' performance in mechanics still persisted.

Although mechanics is offered as an introductory course for all students taking engineering, applied mathematics, and mechanical engineering technology at high school, diploma, undergraduate and post-graduate levels, studies in mechanics had concentrated on addressing issues related to teaching and learning of mechanics in high school and universities levels (Tammet, 2012; Serway & Jewett, 2004; Wells, 1987). However, not enough had been done to investigate the mechanics taken at diploma level by students in mechanical engineering technology in at least in technical institutions in Kenya. Although all the above intervention strategies had capacity to improve learning outcomes, this study only studied pedagogical techniques as critical for improving their performance in mechanics.

Modeling of mechanics problems could form part of ethno-mathematics (Francois & Kerkhove, 2010; Khakala, 2009). Francois and Kerkhove (2010) defined ethno-mathematics as any socio-cultural activities carried out by any people group, social movements, national societies, labor communities, religious groups and professional organizations which practice mathematical practice such as:

> Symbolic systems, spatial design, practical constructions techniques, calculation methods, measurement in time and space specific ways of reasoning and inferring and other cognitive and material activities which can be translated to formal mathematical representation (p. 128).

The report advocated using the rich socio-cultural diversity practices as a source of content, learning methods and pedagogical techniques. Steeplechase as a race is closely associated with Kenyans culture more so in Komora village in Marakwet in the North Rift Valley Region in Kenya (International Athletics Amateur Federation (IAAF, 2010; Komen, 2009).

Track and field athletics could be rich in simulation of mechanics problems related to: displacement and velocity; force and acceleration; as well as work, energy and power (Tammet, 2012; Millennium Mathematics Project (MMP), 2002). MMP (2002) suggested that there were other games and sports in field and track athletics activities which could provide opportunities for simulation of mechanics problems. Other games and sports rich in modeling mechanics problems included: steeplechase, swimming, rugby, cricket, hammer, lawn tennis, hockey, long jump, triple jump, high jump, pole vault, golf, cricket, and lawn tennis, among others (Tammet, 2012; Khakala, 2009). Sporting activities such as rugby, cross-country, long jump, triple jump and high jump could be rich in content such as: linear and projectile motion; work energy and power; friction and breaking; mathematical calculations done by trial and error; precision; estimations as well as mental calculation also found in steeplechase activities (Tammet, 2012; Khakala, 2009; Serway & Jewett, 2004). Wilber and Pitsidalis (2012) and Enomoto, Suzuki, Yokosawa and Okada (2011) pointed to biomechanics which can be useful in distance running studies for simulation of mechanics problems. Other sports and games listed above could be rich in mechanics content (displacement and velocity; force and acceleration; work, energy and power; momentum and impulse; and vibrations) related to introductory mechanics (Tammet, 2012; Huang, 2011). However, steeplechase was chosen because it had the capacity to combine several pedagogical techniques in one strategy of teaching desired in modeling instruction in mechanics.

The concept of biomechanics in Wilber & Pitsidalis (2012) and Enomoto, et al., (2011) suggested that long distance races including steeplechase activities had the capacity to facilitate students understanding of how Newton's laws of motion in dynamics (also in mechanics) were applied in human movement and muscular performance. The steeplechase world record holder is Saif Saaeed Shaheen of Qatar (formerly named Stephen Cherono of Kenya) in a record of 7 minutes, and 53.63 seconds (IAAF, 2013). Time spent for doing seven (7) hurdles and water jumps is 8.89 seconds while steeplechaser spends 1.27 seconds for each hurdle and water barrier (Tammet, 2012). The steeplechaser spends 14 seconds to do 28 ordinary barriers such that each hurdle requires 0.5 seconds. The steeplechaser also spends approximately 450.8 seconds for thirty five (35) 80m straight sprint suggesting that the average speed is 6.83 m/s. These mathematical calculations in steeplechase could be rich in experimental investigations needed in steeplechase activities (Beckmann, 1991 and Staiger, 1999). Excellent performance required applied knowledge and skills similar to what could be found in statistics, mechanics, logical analysis and documentary analysis which contribute to high level of endurance, coordination, agility, strength and balance (Barreau, 2011; Mackenzie, 2007). Again, Jackson (2009) and Wells, (1987) found that involving students in modeling mechanics problems had the capacity to post higher (48%) performance in physics compared to alternative teaching strategies which posted lower (23%) performance in mechanics. That meant that teaching using steeplechase activities as pedagogical techniques might have the capacity to improve students' performance in mechanics. However, the current study identified that not enough had been done to investigate what in steeplechase activities could be used to demystify the study of the abstract concepts dynamics in mechanics. Therefore, teaching students using steeplechase activities as a source of pedagogical techniques was investigated to establish its influence on students' performance in mechanics.

1.1 Statement of the Problem

Mechanics plays an important role in developing students' ability to perform experiments, describe, analyze and critically evaluate experimental data through research culture (Jackson, 2009; Wells, 1987). It is critical in helping students to understand and master the most commonly used mathematical and numerical methods used for carrying out calculations in problem-solving (Sang, et al., 2012; Jones, 2008; Mureithi, 2008). Despite the significant role played by mechanics, students' poor performance is a global problem (Absi, et al., 2011; McDermott, et al., 1986). In Kenya, the wastage rate in technical courses was between 63% and 73% (Amuka, Olel & Gravenir, 2011). Students' performance in mechanics in Kenya had high wastage rate which meant that high number of failures, referrals and drop-out rates (Amuka, Olel & Gravenir, 2011; Bukhala, 2009). Poor performance in mechanics is a source of concern to students, graduates, parents, academic staff and employers because the investment is not commensurate with expected learning outcomes (Kerre, 2011). The various studies that have been carried out have addressed factors such as: need for modern technical facilities; lack of opportunities for industrial attachment, lack of stake-holders participation in curricular development and implementation; students' poor preparation in mechanics; deeply seated misconceptions; drop-out; absenteeism; students' notion that mechanics is meant for low academic achievers; lecturers' mastery of the content, lecturers' negative attitude characteristics and lecturers' lack of motivation which contribute to students' poor performance in mechanics (Sang et a., 2012; Dasmani, 2011; Amuka, Olel & Gravenir, 2011). Other studies carried out on strategies of improving learning environment mechanics included: modeling; teaching and learning strategies; and use of ICT for teaching and learning among others (Maithya & Ndebu, 2011; Kerre, 2011). Despite the efforts, poor students' performance in mechanics had persistently been realized. That meant that the real cause of poor students' performance had not been established and adequately addressed. The solution could be laying in a combination of appropriate pedagogical techniques such as steeplechase activities. Yet, not enough had been carried out to investigate the influence of pedagogical techniques in steeplechase activities for demystifying the abstract concepts in dynamics on students' performance in mechanics. Other sports and games listed above could be rich in content (displacement and velocity; force and acceleration; work, energy and power; and momentum and impulse) related to introductory mechanics (Huang, 2011). However, steeplechase was chosen because of its capacity to combine several pedagogical techniques in one strategy of teaching desired in modeling instruction in mechanics. Abstract concepts in mechanics might be demystified through steeplechase activities as a teaching strategy. Therefore, it was envisaged that steeplechase activities as a pedagogical strategy could provide the insight into teaching and learning of mechanics in Kenya.

1.2 Purpose of the Study

The purpose of the study was to explore the influence of pedagogical techniques on students' performance in Mechanics in selected diploma technical institutions in Kenya.

1.3 Objectives of the Study

The specific objectives of this study were:

a) To compare students' performance in mechanics when students were taught using steeplechase activities with the students' performance when students were taught using traditional methods.

b) To compare students' performance in mechanics when students were taught using steeplechase activities with the students' performance when students were taught using lecturer's demonstration.

c) To find out the influence of teaching using steeplechase activities on students' performance in mechanics between high and low ability group of students.

d) To establish the influence of teaching using steeplechase activities on learners' performance in mechanics between male and female group of students.

1.4 Hypotheses of the Study

The research hypotheses of this study were:

H_{O1} –There was no significant difference in performance in mechanics when learners were taught using steeplechase activities and when they were taught using traditional methods.

H_{O2} –There was no significant difference in performance in mechanics when learners were taught using steeplechase activities and when they were taught through lecturer's demonstration.

H_{O3} –There was no significant difference in performance in mechanics when learners were taught using steeplechase activities between high and low ability group of students.

H_{O4} – There was no significant difference in performance in mechanics when learners were taught using steeplechase activities between male and female group of students.

1.5 Significance of the Study

The study had both theoretical and practical implications for mechanics and mathematics education in Kenya today and in future. Theoretically, the study could contribute to the advancement of knowledge by adopting steeplechase activities as a source of pedagogical strategies as well as mathematical models for teaching Newton's laws of motion in dynamic in mechanics. Practically the study could be used by the technical instructors and technical educators as well as teachers' trainers in use of steeplechase activities for simulation of mechanics problems. The study could influence policy decision on use of steeplechase activities such as mathematical modeling for demystifying learning of abstract nature of the mathematical calculations in dynamic concepts in mechanics. Specifically the study could encourage educators in Mechanics to use steeplechase activities as a source of pedagogical strategies for improving students' performance in mechanics.

1.6 Limitations of the Study

The limitation of the study was that factors other than instructional strategies could influence the students' performance in mechanics. Factors that could influence students' performance in mechanics include instructors' characteristics such as: academic and professional qualifications, work experience, training, and mastery of subject matter. Background in science and mathematics and attitude towards mechanics could influence students' performance in mechanics. However, normalized gain in mechanics (as calculated using the formula investigated by Jackson, Dukerich & Hestenes (2008:15) data analysis techniques) could be used to iron out initial difference due to background in science and mathematics. The ability of the participants and interviewers to communicate effectively might influence the quality and accuracy of data collected. However, use of follow up question to clarify certain points could be used. Editing of the feed-back from respondents was meant to ensure that only the information relevant to the objectives of the study was recorded in the results.

1.7 Delimitations of the Study

First, several pedagogical strategies such as students' participation in steeplechase activities, traditional methods of teaching (lecture and question) and lecturer's demonstration, ability grouping, Socratic probing, industrial attachment, stakeholders' participation in curricula development and implementation, modernization of technical facilities and could improve students' performance in mechanics. However, only steeplechase activities as teaching strategies were compared to traditional methods of teaching (lecture and question) and lecturer's demonstration. When students participate in steeplechase activities, their performance in mechanics was compared between different ability groups and gender. The study confined itself to diploma students and their lecturers in selected technical institutions in Kenya. Secondly, the students and lecturers who took part in this study were sampled from those in the respective study institutions during the study; and steeplechasers that were in the country at that time. Third, groups chosen to take part in the study were equivalent in terms of entry behavior as well as learning environment. Fourth, participation in steeplechase activities contributed equally to both male and female students' performance in mechanics. Finally, this study was carried out in technical institutions in Kenya.

1.8 Assumptions of the Study

The assumptions of the study were listed as shown here. First, students are willing to participate in steeplechase activities. Secondly, pedagogical techniques in steeplechase activities had the capacity to improve students' learning gains (as a predictor of performance) in mechanics. Thirdly, groups chosen to take part in the study were equivalent in terms of academic abilities, entry behavior as well as learning environment. Fourth, steeplechase activities could make equivalent contribution to male and female students' performance in mechanics. Fifth, lecturers' characteristics such as attitude towards mechanics and life-long learning as well the period of industrial attachment do not make any contribution to students' performance in mechanics. Sixth, pedagogical techniques contribute equally to students' performance in mechanics.

1.9 Operational definition of Terms

Ability refers to students' capacity to carry out tasks related to mechanics

Ability grouping refers to the process of placing students in homogeneous groups to either above or below 50^{th} percentile in the pre-test scores in mechanics

Discovery learning refers to the process of students' acquisition of knowledge and skills through guided concrete, observational and symbolic experiences through learning activities.

Gender disparity refers to the difference attributed to scores attained between men and women in the pre-test and post-test when students taught using steeplechase activities.

High ability refers to the group of students with above 50^{th} percentile performance in pre-test scores in mechanics.

Lecturer's demonstration refers to the process of showing students how to carry out a certain task in mechanics lesson through oral explanation as well as a practically illustrating given content in controlled environment.

Low ability refers to the group of students with scores which were below 50^{th} percentile performance in pre-test scores in mechanics.

Mathematical skills refers to ones capacity to demonstrate interpersonal skills such as team-work, relations, adaptability, attentiveness, accessibility; leadership skills, planning, making informed decisions and ability to be mentored and to mentor others at all levels.

Mechanics refer to the study of motion of physical bodies or its state of rest resulting from application of force and the effect of the physical bodies' state on environment.

Performance in mechanics refers to students' achievement scores in post-test examination.

Pedagogy refers to approaches used by the instructors and students to develop content, learning styles and methods as well as lifelong training in mechanics.

Pedagogical Techniques refers to the process of teaching students using steeplechase activities, traditional methods of teaching (lecture, question and use of examples) and lecturer's demonstration, collaborative learning, modeling instruction, ability grouping and Socratic probing in mechanics

Steeplechase activities as a teaching strategy refers to the actions of students in plenary session, watch steeplechase video tape , data collection, witnessing steeplechasers running in the track, carry out measurement, make estimations, use data to make mathematical calculations as well as problem-solving and participating in concluding plenary session.

Students' learning gain in mechanics refers to the percentage ratio of the difference between post-test and pre-test to the difference between the highest score and pre-test.

Socratic probing refers to the process asking far-fetched questions by the lecturer as follow-up to students' responses to questions during presentation of group report on steeplechase activities in class to encourage in-depth understanding of mechanics concepts.

Traditional methods of teaching refer to expository teaching methods such as lecture method as well as question and answer method.

1.10 Organization of the Study

Chapter one addressed the following: background to the problem, problem of the study, objectives of the study and hypotheses of the study, the purpose and significance of the study. Chapter two dealt with review of related literature to identify gaps to be filled and provide basis for discussion of the research findings. Chapter three discussed the research methodology in terms of research design, the location of the study, the population, the sample and the sampling procedures, the data collection procedures, the instruments, the data collection procedure and data analysis techniques. Chapter four was concerned with the findings and discussion of the findings of the study. Chapter five has summary of the research findings, conclusion and recommendations.

CHAPTER TWO
REVIEW OF RELATED LITERATURE

2.0 Introduction

Related literature on teaching and learning of mechanics in technical, industrial, vocational education and training (TIVET) institutions, various countries was reviewed to gain insight into global, African and Eastern Africa perspectives for comparison with Kenyan situation on the influence of pedagogical techniques on the students' performance in mechanics. Specifically, related studies were reviewed to gain insight into: the students' performance in mechanics; the influence of steeplechase activities and traditional methods of teaching on students' performance in mechanics; the influence of steeplechase activities and lecturers' demonstration on students' performance in mechanics; influence of using activities for teaching on students' performance in mechanics between different ability groups; and influence of using steeplechase activities for teaching on students' performance in mechanics between male and female groups of students. This chapter also attempted to identify the pedagogical techniques found in steeplechase activities among other games and sports. This chapter also included summary of the related literature; theoretical framework and conceptual framework.

2.1 Students' Performance in Mechanics

Mechanics has introductory content which is fundamental to all students majoring in applied mathematics, physics; engineering programs such as: aerospace, biological, biomedical, mechanical and civil engineering among other science oriented disciplines taken at technical colleges, technical pre-university and technical university courses (Billington, et al., 2014; Fang, 2014; Huang, 2011; Sahin, 2010). In some cases mechanics is referred as introductory mechanics (Fang, 2014 and Sahin; 2010). Fang (2014), Huang (2011) and Sahin (2010) observed that in some institutions of learning, introductory mechanics is also referred to as engineering dynamics or Newtonian mechanics. It plays a critical role in cultivating students' ability to visualize the interaction of forces and moments with the physical world (Huang, 2011). Fang (2014) explained that introductory mechanics covers numerous applied mathematics, physics and engineering foundational concepts which include: displacement and velocity; force and acceleration; work and energy; impulse and momentum; as well as vibrations. Fang (2014) and Huang (2011) insisted that introductory mechanics is an essential pre-requisite and essential basis for the many subsequent and advanced dynamics courses which include: machine design, advanced structural design, system dynamics and control. Hence, introductory mechanics plays an important role in developing mathematical skills such as: flexible, creative, logical, analytical and critical reasoning for practical problem-solving (Jones, 2008). Specific learning outcomes in mechanics also include mathematical calculations, graphical and diagrammatic representations of the problem and brief explanation of students' mathematical and scientific results (Jackson, 2009).

Despite the critical role played by introductory mechanics poor performance has been a long-standing global problem (Fang, 2014; Huang, 2011; CRS, 2007; Eryilmaz & Tatli, 1999; Wells, 1987). Huang (2011) worked with 323 engineering dynamics students at Utah State University in a period of four (4) semesters using six (6) combinations of predictor variables representing: students' prior achievement, prior domain knowledge and learning progression using mathematical modeling techniques to develop a validated set of mathematical models to predict students' academic performance in engineering dynamics found that majority of the students perform poorly or fail in this course. Huang (2011) found that the mean score of final comprehensive examination in the dynamics class was below 70% at Utah University in 2009. Huang (2011) also found that showed that 53% of the questions were answered correctly in the fundamental engineering (FE) examinations in the US in 2009. These results show poor students' performance in mechanics.

Similarly, Fang (2014) working with 71 (62 male and 9 female) undergraduate engineering students in one semester using a correlational design in technical university to investigate whether there existed a statistically significant correlation between students' motivated strategies for learning and students' academic achievement in engineering dynamics course found that majority of the students performed poorly or failed in mechanics. Specifically, Fang (2014) found that in mechanics in the US, 54% of the students average examination scores were below 70% while 46% got between 70% and 90%. These showed poor performance because the pass mark was 70% (Fang, 2014; Huang, 2011). Poor students' performance in mechanics suggested that the problem needed an urgent solution.

Similar concerns over poor students' performance in mechanics were raised by Goldfinch, Carew and McCarthy (2009) in Mann, Thomson and Howard (2008). Goldfinch, Carew and McCarthy (2009) carried out a study in order to create awareness on the factors which affect students' performance in introductory mechanics to assist engineering educators to understanding, describe, identify and deal with the causes of poor performance in introductory mechanics through analysis of engineering mechanics examinations scripts worked with a sample of 200 scripts found that the pass rate in mechanics courses tended to be unacceptably low. That meant that although introductory mechanics was taken by all first and the second year engineering students, their performance in the discipline was poor. Since students' poor performance had continued, the studies by Fang (2014), Huang (2011) and Goldfinch, Carew and McCarthy (2009) suggested the real cause of students' poor performance in mechanics in technical institutions in the US had not yet been understood or dealt with. This study does not intend to carry out an investigation on the influence of the pedagogical techniques on students' performance in technical institutions in the US. However, this study carried out a study to investigate the influence of the pedagogical techniques on students' performance in technical institutions in Kenya.

Poor performance in mechanics in the in the US in the 1960s and 1970s had contributed to lack of adequate pool of scientists and engineers (Wells, 1987; CRS, 2007). Similarly, poor performance in mechanics in the 1980s had led to lack of scientifically and technologically literate citizens (Wells, 1987). The problem of poor students' performance in mechanics was also reflected by the following account. A research in technology, mathematics and engineering by CRS (2007) in institutions of learning in USA showed that students had lower achievement compared to their counterparts from Hong Kong, Singapore, and Malaysia. Consequently, the US industries were negatively affected by poor performance in mechanics among higher education graduates (Jackson, 2009; CRS, 2007). The problem was compounded by reducing numbers of students taking hard sciences courses (mathematics, mechanics, technology and engineering) compared to soft sciences (home economics, hospitality management, tourism and natural resources management) (CRS, 2007). The US industries responded by hiring of scientists and engineering from overseas to make up for the mechanics technologists and engineers shortfall (CRS, 2007). In response to the low students' achievement in mechanics, the research project aimed at equipping students with a competitive edge for the 21st century creative innovations, prepare scientists, technologists, engineers and mathematicians who were globally and strategically placed for technological and scientific advancement. The problem was addressed by examining the curriculum in terms of content, teaching skills used in mechanics, process of learning and techniques (Jackson, 2009). Inquiry-based teaching and learning of mechanics was to be adopted (Jackson, 2009; CRS, 2007).

Poor performance in South Africa was also observed among students taking mechanics in KwaZulu in Natal in South Africa. The report by Nzama (2000) showed that in 67% of technical institutions in South Africa, poor performance was between 50% and 58% in mechanics. Nzama (2000) showed that 73.4% of the students who wrote the examination passed (282 out of 384 students) while 26.6% failed. The results show that there is high percentage (73%) of pass rate in mechanics in South Africa and a reasonably low (27%) failure rate (Nzama, 2000). Further, it was observed that 70% (198 out of 282) passes were concentrated in one technical institution. Although failure rate was reasonably low (27%), the failure rate in over 66.7% of the technical institutions was between 50% and 58%. Besides, report by Nzama (2000) showed that in South Africa, only 30% of the graduates were able to access full time employment while 70% were unable to find full-time employment. In ability to find full employment could point to lack of formal employment opportunities or lack of employability skills needed in the labor market. When lack of employability skills was the cause, lack of appropriate skills in mechanics could disadvantage the graduates in terms of loss of income (Muthaa, 2009 and Ngware, 2000). However, the study by Nzama (2000) did not show the extent of the lack of employability skills, a gap that might need a systematic study. The current did not intend to study the presence of employability skills but investigated the influence of the pedagogical techniques on students' performance in mechanics in technical institutions in Kenya.

Poor performance among TIVET graduates had also been reported in Nigeria (Mudashir, 2011). Similarly, in Uganda, graduates lacked knowledge and skills needed in solving technical and practical problems (Okello, 2011). Students' lack of technical and practical skills could be due to the attitude that practical skills were meant for less academically able persons (ILO, 2010; Ngware, 2000). Despite the efforts made by Mudashir (2011), Okello (2011), Ngware (2000) and Nzama (2000) to deal with declining standards in technical and vocational courses, the problem of poor performance has persisted.

Poor performance in TIVET institutions in Kenya was marked by high wastage rate (failure, referral, students' drop-out and absenteeism from college during examination) as shown in results analysis between 2006 and 2009 (Amuka, Olel & Gravenir, 2011; Bukhala (2009). The study by Bukhala (2009) was carried out in the former Western Province in Kenya to investigate the factors affecting students' academic performance in national examination technical examinations in selected technical institutes in former Western Province in Kenya. The study was a cross-sectional descriptive survey. The study worked with a group of ($n = 170$) students comprising 92 males and 78 females and had a group ($n = 129$) of graduates who had taken curriculum-based examinations in mechanics. The study aimed at improving students' academic achievement in mechanics. The curriculum-based examination results in technical courses were analyzed between 2006 and 2008 in the Western Region in Kenya was summarized as shown below.

Bukhala (2009) showed that in the Western Region in Kenya revealed that in a group ($n = 129$) the wastage rate was 68%. The same results by Bukhala (2009) showed that technical training in the Western Region in Kenya between 2006 and 2008 ($n = 129$) had a pass rate of 31.78% (41 out of 129 candidates) and a wastage rate of 68.22% (fail, referral or absent). The study recommended that to improve students' academic achievement in mechanics, physical and instructional facilities could be improved. However, the study did not investigate the pedagogical techniques which could improve the students' performance in mechanics, a gap filled by this study.

The study by Amuka, Olel and Gravenir (2011) was carried out in former Nyanza, Western and Rift Valley Regions in Kenya to investigate the influence of cost sharing on science and technology education and training in Kenyan national polytechnics. The study was carried out using a casual-comparative research design. The study worked with a group ($n = 1119$). The results in Nyanza and Rift Valley Regions in Kenya in 2008 and 2009 are discussed as shown below.

In the former Nyanza Region in Kenya in 2008 ($n = 348$) had pass rate of 39.58% (152 out of 384 candidates) and wastage rate of 60.42%. The same results in former Nyanza Region in 2009 had a pass rate of 26.91% (102 out of 379 candidates) and a wastage rate of 73.09%. Results from former Rift Valley Region in Kenya in 2009 had a pass rate of 44.2% (325 out of 735 candidates) and a wastage rate of 55.8%. Similarly, the results from former Nyanza and Rift Valley Provinces in Kenya in 2008 revealed that in group the wastage rate was between 60% and 70% (Amuka, Olel & Gravenir, 2011). Mechanics as one of the courses offered in technical institutions contributed to the high wastage rate (between 60% and 70%) in technical training courses. Similarly, results in Table 2 revealed that in years between 2005 and 2011 results from former Eastern, Nairobi, Central and Rift Valley Provinces in Kenya in group ($n = 3190$), the wastage rate was between 60% and 70% (Government of Kenya, 2012). Despite the research efforts made by Amuka, Olel & Gravenir (2011), Bukhala (2009), Government of Kenya (2012) and Nzama (2000), the problem of students' poor performance in mechanics has persisted.

Factors which influence performance in mechanics are discussed as shown here. Eryilmaz & Tatli (1999) working with 30 prospective physics teachers at Middle East Technical university to investigate factors affecting students' achievement in introductory mechanics by employing Factorial Modeling Procedure using Statistical Package for Social Sciences (SPSS) program observed that in the last ten (10) years, teaching of the course has faced instructional challenges because mastering the concepts is troublesome to majority of the students. Similarly, Huang (2011) observed that majority of the students performed poorly or failed in introductory mechanics because it required students to have solid mathematics skills as well as good understanding of fundamental concepts and principles in the dynamics which were lacking. Similarly, Goldfinch, Carew and McCarthy (2009) observed that majority of the students experience substantial difficulties with learning introductory mechanics.

Presence of learning difficulties in introductory mechanics had been reported by various studies (Fang, 2014; Huang, (2011; Goldfinch, Carew & McCarthy, 2009; Wells & Hestenes, 1994;

Wells, 1987). Specifically, Meltzer (2002) carried out a study to investigate factors which were associated with variations in students' ability to achieve conceptual learning gains in physics courses that employs interactive-engagement methods using correlational design found that 75% of the university engineering students where the sample was 137 ($female = 82 \; and \; male = 55$) there was a significant correction between normalized learning gain and students' pre-instructional mathematical skills. Meltzer (2002) had observed that there were "hidden variables" other than instructional method which affect learning gains in mechanics. Similarly, Hake (2002) in a study carried out a study with the aim of investigating the "hidden variables". He argued that the "hidden variables" if found and dealt with might provide explanation for what need to deal with poor performance in mechanics especially at the beginning of teaching a course, reduce frustration cause by learning difficulties, improve the learning gains in and create qualified technical workforce in America and world over. Hake (2002) listed the possible variables as: mathematics proficiency, spatial visualization ability, completion of high school physics courses, scientific reasoning skills, physical aptitude, personality type, motivation, socio-economic level, IQ, and GPA. Similarly, Jackson (2009) in a study carried out to investigate the influence of the modelers' experience using interactive instructional strategies in various learning cycles to deal with misconceptions in mechanics found that low students' performance in mechanics was associated with inadequate preparation in science and mathematics in high school leading to the presence of misconceptions. The study by Jackson (2009) suggested that Hake (2002) did not provide a lasting solution to poor students' performance in mechanics other than instructional interventions. That means that the solution to poor performance in mechanics might be found in the pedagogical techniques. Hence, this study studied the interactive pedagogical techniques which have the capacity to improve students' performance in mechanics in technical institutions in Kenya.

The problem of poor performance in mechanics had been attributed to outdated mathematics and science curriculum and inadequate pre-college trained teachers (Wells, 1987; CRS, 2007). The problem had also been attributed to emphasis on developing college-bound and college students' needs in mechanics but ignoring majority of the other group of students (Jackson, 2009; Wells, 1987). Students' poor performance in mechanics was associated with misconceptions (Jackson, 2009; Nzama, 2000). Poor students' performance in mechanics had also been witnessed due to lack of analytical skills among graduates who had taken the discipline (Wells, 1987). These challenges were compounded by the absence of pedagogically trained lecturers that limited the effectiveness of training (Kerre, 2010; Nzama, 2000).

The problem of poor performance in mechanics was correlated to poor performance in mathematics as well as other mathematics-based technical courses (Jackson, 2009; Kate, 2002). These observations meant that lecturers' characteristics, personnel and facilities related factors were also named as cause of poor performance in mechanics. Obengo (2011) carried out a study to investigate the factors associated with decline in performance in mathematics in Kenyan technical institutions using a case study design with a sample of 807 ($male = 771$; $female = 36$) group of students and four (4) engineering Heads of Department (HOD) found that poor performance was due to: 23.2% inadequate physical facilities, 33.1% inadequate training equipment and lack of efficient and modern facilities and equipment. Amuka, Olel & Gravenir (2011) found that the reasons for poor performance in engineering courses which include mechanics in Rift Valley and Nyanza Regions in Kenya were: lack of adequate space, inadequate learning materials and inadequate competent resource persons. Similarly, Bukhala (2009) in his study on factors which affect performance in technical courses in the former Kakamega District technical institutions found out that poor performance of students was 17.4% (4 out of 23) due to lecturers who teach in areas they were not trained to teach, 4.3% do not use appropriate training tools, while 8.7% was due to lack of training in pedagogy. Similarly, Amuka, Olel & Gravenir

(2011) also found that 35.7% (5 out of 14) had the required knowledge for that particular area of teaching while 64.3% (9 out of 14) were learning on the job. Amuka, Olel & Gravenir (2011) also found that lecturers lacked the right academic qualifications as well as relevant practical and technical skills. Amuka, Olel & Gravenir (2011) also found that there was a shortage of 60 lecturers in Rift Valley and Nyanza Regions. The lecturers also were found to play critical role in providing encouraging and supportive learning environment to foster students' success by providing positive feedback and giving more attention to students with low self-efficacy as well being more patient with them (Fang, 2014).

The important role played by analysis of students' scripts as a follow-up to the quality of pedagogical processes in mechanics lessons were also discussed in studies by Inghan (2008) and Baldwin and Yun (2012). Results of analyzed examination scripts could provide information necessary for choice of appropriate teaching and learning strategies (Goldfinch, Carew & McCarthy, 2009). Goldfinch, Carew and McCarthy (2009) found that a third (38%) of students mistakes were concentrated in questions that required higher cognitive levels such as conceptual understanding of mechanics. The findings by Goldfinch, Carew and McCarthy (2009) suggested that students had the highest number of mistakes associated with procedures, suggest that majority (62%) of the questions tested mathematical procedures and algorithms instead of conceptual understanding, critical and analytical skills.

2.2 Traditional Methods, Steeplechase Activities and Performance in Mechanics

At a global level, ILO (2010), Sahin (2010), CRS (2007), Meltzer (2002), Wells & Hestenes (1994) showed that expository teaching and learning strategies were extensively used in over 60% of science, technology, and in engineering as well as in mathematics (STEM) at tertiary institutions. Meltzer (2002) asserted that lecture method was most popular pedagogical technique in teaching mechanics. At the regional level, chalk and talk was the most (in over

60%) common used strategies in STEM lessons (Amuka, Olel & Gravenir, 2011; Nzama, 2000). A study by Obengo (2011) in Kenya indicated 25.8% of the students did not attend scheduled lessons hoping to catch up later, while other students avoided answering questions pointing to lecturer's domination in the lessons. Students' characteristics thought to contribute to poor performance included: students avoid challenging tasks; they don't recover from discouragement or failure; do not more effort in studying mechanics they were pessimistic; they did not set realistic and achievable learning goals (Fang, 2014). Other students' characteristics thought to affect performance in mechanics included: perceptions, cognitive levels and achievement in mathematics and physics (Eryilmaz & Tatli, 1999). Similarly, Muchemi, Muthoni, Mutahi, Gunga and Origa (2013) observed that expository teaching approaches are the most common strategies used in training of technologists in Kenya. Use of expository teaching and learning strategies in science and mathematics led to situations such as: over 40% of the students observing that they did not find practical applications of mathematics in post-training-life; 14% of the students felt that their lecturers were not supportive; 54.3% of the students said that lecturers criticized them for not doing well; while 14.3% of the students said that the lecturers were not committed and were not clear in their teaching (Obengo, 2011). In the same study by Obengo (2011), 11.5% of the students said that they did not like their lecturers.

Wells & Hestenes (1994) who carried out a study to investigate what instructional modifications could improve students' ability to accommodate a cognitive conflict, undergo self-regulation, model mechanics problems and apply concepts developed in problem solving following the step-by step procedure developed by the student for dealing with unfamiliar situations and problems found that expository teaching and learning strategies include lecture and textbook presentations. Huang (2011) insisted that lecturer method was deeply rooted that to replace it with interactive-based pedagogical techniques required a lot of funding, effort and determination on the part of the instructors and their scholarly sponsors. Wells (1987) had observed that lecture method and dictation of notes encouraged verbal or linguistic models instead of appropriate symbolic or diagrammatic models. However, symbolic models were easier to manipulate than linguistic or verbal models (Wells, 1987 and Hestenes, 1987). Linguistic or verbal models lack precision and brevity making them more difficult to manipulate (Wells, 1987).

The expository teaching strategies had been found to be very popular with lecturers in technical institutions in Kenya (Twoli, 2006). Traditional teaching strategies such as: lecture methods; question and answer; use of examples; and dictation of notes were the most commonly used for the instructional processes in technical institutions in Kenya (Maithya & Ndebu, 2011). The work by Mbugua, et al., (2013), Khakala (2009), and Twoli (2006) suggested that in between 60% and 85% of the technical lessons, students were passive listeners of lecturers' presentations. The same work suggested that in lecture, question and answer techniques, use of examples and dictation of notes, students are forced listen to or note the formulae or procedures as the lecturers solve mechanics problems on the board (Mbugua, et al., 2013). Lecturers' actions led students becoming passive participants. These might lead to loss of interest making the mechanics lessons boring and unfruitful. Loss of interest and boring lessons might lead to poor performance in mechanics because traditional strategies used did not encourage students to actively participate in the mechanics lessons.

Expository teaching strategies were considered an important part of science and mathematics: lecturer-students, content, teaching and learning activities interaction model (Khakala, 2009) Specifically, Cockcroft (1982) mathematics teaching and learning activities interaction model suggested that teaching of mathematics at all levels are expected to provide opportunities for the elements discussed here. First, exposition by the lecturer involves provision of explanation or lecturers' discourse useful especially during introduction of a lesson or when consolidation of ideas after group discussions or summing up the lesson. Secondly, small-group or whole-class discussion between students-students or students-teacher-students was useful to provide opportunity for self-expression of mathematical ideas. Third, students are engaged in appropriate practical work in learning activities where learners make observations, carry out estimations, and make models such as expressions as well as equations which are used in calculations. Fourth, students are involved in supervised-individualized-class-exercises or group assignments for consolidation of ideas and practice. Fifth, students are involved in problem-solving and applications of concepts in real-life situations. Sixth, students are involved in investigational work which was meant to develop learners' capacity in application of mathematics knowledge during adult-life and in further studies. Seventh, students are involved in some form of recreational mathematics which provides opportunities for students enjoy and appreciate mathematics. Recreational mathematics activities include playing: draft, cards, scramble, darts, chess, snake and ladder among others. Lastly, students are made aware that mathematics provides a powerful means of communication through use of abbreviations and symbols. Cockcroft (1982), Khakala (2009) and Twoli (2006) suggest that teaching of science and mathematics require the use of a combination of teaching strategies used together in a single lesson.

Huang (2011) was able to show the link between sports and games in simulation of mechanics problems especially in dynamics. Skiing and hitting a golf-ball were used for illustrating that projectile motion problems could be modeled through in-doors and out-door sports. Similarly, practical work in steeplechase activities can develop students' critical and analytical thinking skills as well as encourage life-long training (Tammet, 2012). Students taking mechanics can engage in scientific inquiry through steeplechase activities by making and using mathematical models used to describe, explain, predict, design and control physical phenomenon (Jackson, 2009; MMP, 2002). Steeplechase activities can encourage students to use scientific tools such as manual and automatic electric stop watches for collecting, organizing, analyzing, visualizing and modeling real data to justify and support their predictions (MMP, 2002; Serway & Jewett, 2004). Steeplechase activities can develop ability to make effective decisions and solve problems in real-life situations. Hence, the students' learning gains when students were taught using steeplechase activities and traditional methods of teaching in mechanics were compared to gain insight into the pedagogical techniques as predictor variables to performance in mechanics.

2.3 Lecturer's Demonstration, Steeplechase Activities and Performance in Mechanics

Demonstration refers to a process of showing something such as a specimen, a model, an experiment, or a skill that need to be acquired while students watch (Nzama, 2000). When a lecturer is involved in the "showing" as students make observations is referred to as lecturer's demonstration (Twoli, 2006). According to Twoli and Maundu (2013) lecturer's demonstration involves oral explanation as well as a practical demonstration of content. That means that lecturer's demonstration takes place in controlled environment such as in mechanical or electrical workshops, laboratories or classrooms or real life environment (Murila, 2013). The lecturers use sketches, drawings, photos, models and pictures to support their oral explanations (Kerre, 2010; Muriithi, et al., 2013 Nzama, 2000; Obengo, 2011). Hence, a suitable environment is useful to help students to demonstrate specific skills in their work place especially in situations rich with complexities faced by learners (Nzama, 2000). Lecturer's demonstration is compared to problem-solving strategies of teaching mathematics because both have some level of students' involvement (Arthur, O'Connor, Rukangu & Masingila, 2013). The studies by Arthur, O'Connor, Rukangu & Masingila (2013), Nzama (2000), Twoli (2006), Twoli & Maundu (2013) and Murila (2013) suggests a need for use of lecturer's demonstration when introducing the theory, working out mathematical calculations or new information or skills to be practiced. Hence, lecturer's demonstration might be an important part of the plenary session in steeplechase activities.

Although resources can play an important role in lecturer' demonstration lack of demonstration models such as running engines, gear boxes and brake-systems in motor mechanics workshops in South Africa (Nzama, 2000). Lecturer's demonstration has the capacity to reduce the challenge of the abstract nature of mathematics since they encourage students to relate the concepts learnt in real life situations (Obengo, 2011). Lecturer's' demonstration has the capacity to provide an anchor for the conceptualization process in learning of science (Bukhala, 2009 and Twoli, 2006). However, more mistakes associated with procedural aspects of mechanics suggest that mechanics is mainly taught using demonstration by lecturers (Jones, 2008). Lecturer's demonstration using examples and illustration in mechanics is based on the 'correct procedures only' without leaving room for creative mathematics, critical thinking and analytical skills among students (Jackson, 2009; Jones, 2008). Hence, there is need to explore the contribution of both the lecturer's demonstration and steeplechase activities on students' performance in mechanics.

Lecturer's demonstration might use virtual laboratories based on the information communication and technology (ICT) tools for learning experiences (Gunga, et al., 2006). A lectures' demonstration plays an important role in introducing virtual lab experiences (UNESCO, 2013). A study by Gunga, Ngesu, K'Odhiambo, Murithi, Wachira & Muthoni (2013) on Open, Distance and electronic learning (ODel); and educational technology can facilitate:

> Definition of what is to be learnt, provision of information, examples, explanations, questions, setting learning tasks for individuals and groups, marking the work, provision of feedback, assessment of achievement of objectives, provision of learning resources, provision of study advice and helping with individual problems (p.242).

The report indicated that use of electronic media could provide a suitable environment for class based in-class and out-of-class activities as well as self-assessment needed for instant feedback as a follow-up to lecturers' demonstration. Use of ICT tools makes it possible for both steeplechase activities and lecturers' demonstration for teaching as well as self-assessment needed for instant feedback as a follow-up (Bellington, et al., 2014). Steeplechase activities could be improved through ICT related tools such as closed circuit television network (CCTV).

2.4 Steeplechase Activities, Ability Groups and Performance in Mechanics

Wells (1987) emphasized the need to identify students' ability in physics before analysis of data related to gain made when modeling instructions was used in order to ensure that scores were standardized to take care of their entry behavior. Ability grouping refers to the process of placing students in homogeneous classes for better strategies in instruction (Davis, 2012). Identifying students' ability is the first step in forming mixed ability learning groups (Muthoni, 2007). Students can be grouped into high ability (highly motivated or gifted and talented) group, moderate ability (moderately motivated or middle ability or average ability students) group and low ability (students with less motivation to learn or low ability or low ability students) group (Amelink, 2012; Davis, 2012; Johnson, 2000 and Steel, 2005). Identifying students' ability is an effective instructional strategy to provide for within-class grouping for differentiation as well as fostering mathematical creative thinking (Steel, 2005).

In New Zealand and Israel institutions, same-ability or heterogeneous grouping are practiced while in Japan, mixed ability grouping is preferred to the same ability-grouping (Steel, 2005). In countries like Britain and in the United States of America, ability grouping is done for purposes of acceleration, curriculum compacting, enrichment, cluster grouping or differentiation (Steel, 2005). Ability grouping for differentiation providing different curricular, resources, assessment, use different approaches in teaching (Steel, 2005). Although ability grouping was meant to provide for differentiation, Johnson (2000) observed that in 84% of the instruction time, teachers of mathematics tended to ask high performing students to do the same activities as average performing students.

The study by Meltzer (2002) documented the difference between high and low ability (based on pretest scores) groups' learning gains in mechanics. The results in Meltzer (2002) showed that the difference between high and low ability groups learning gains in mechanics 1998 and 1999 were 19% and 9% respectively (differences are statistically significant; $p = 0.0001$). In 1998 and 1999, the low ability groups had higher variability than in their learning gain in mechanics than the high group. The results in Meltzer (2002) of higher learning gain for high ability group (19%) in mechanics than low ability group suggested that the instructional processes in mechanics were more beneficial to the high ability group than low ability group. However, Meltzer (2002) did not investigate what learning gain could be made when interactive pedagogical techniques were used a gap which this study attempted to fill.

Ability grouping may form part of students' labeling (Johnson, 2000) considering that Amelink (2012) and Davis (2012) agreed that there were two main views on students' level of performance which were the innate ability view and the product of hard work view. Students' view of their performance in mathematics as an innate ability or product of hard work could influence their interest in the subject (Davis, 2012). In ability-grouped classes, above average students might experience diminished overall self-concept (Steel, 2005). Hence, diminished self-concept might lead to low performance in mechanics. Students who hold the innate-ability view tended to give up when they face challenges or when others who were important suggested that mathematics concepts were hard to grasp while students who hold the hard-work view continue to perform well even when they face challenges or there was negative influence (Davis, 2012). The general view about technical courses in Kenya was that they were meant for students who were academically weak (Muthaa, 2009 and Ngware, 2000). This observation was confirmed by Bukhala (2009) who observed that among students taking mechanics in the former Western Province in Kenya, 40% (51) had qualified with Average Grade of C- and above while 60% (78) had D+ and below in KCSE. Those observations by Bukhala (2009) had suggested that entry behavior plays and important role in determining students' performance in mechanics in Kenya. However, Bukhala (2009) had not attempted to investigate the learning gains made when interactive teaching strategies were used in mechanics lessons a gap which was to be filled by this study.

2.5 Steeplechase Activities, Gender and Performance in Mechanics

The review of literature by Pollock, et al. (2007) in Kost, Pollock and Finkelstein (2009) had indicated that despite the use of interactive engagements techniques, the gender gap on conceptual learning survey persisted from pretest to posttest in mechanics instruction in the University of Colorado at Boulder. Similarly, Kost, Pollock and Finkelstein (2009) found that gender gap in mechanics exists in interactive techniques based classes in the technical institutions in the US. Meltzer (2002) worked used correlational design to investigate the gender difference in learning gain in introductory mechanics when students are exposed to interactive-engagement (IE) methods and traditional course that make use of little or no use of IE methods. However, the study by Meltzer (2002) did not specify the instructional strategy which employs little IE. The pedagogical techniques likely to make use of little IE is lecturer's demonstration which is used this study for teaching mechanics. Meltzer (2002) found that 75% of cases of difference in learning gaps for male and female students independently showed significant positive correlation between learning gain in mechanics and pre-instructional mathematical skills.

Meltzer (2002) showed that in 50% of both male and female cases of independently showed significant positive correlation between learning gain in mechanics and mathematical skills. These results suggests that there statistical evidence to support the view that learning gain in mechanics for both male and female depend on students' mathematical skills. However, the views held by Niederle and Vesterlund (2010), Wai, et al., (2010), Benbow, Lubinski, Shea, and

Eftekhari-Sanjani (2000) on gender disparity in overall mathematical ability were different in that their study had found that gender disparity was negligible or non-existent. This observation might have been applicable in lower levels of study but not in mechanics at diploma or university level.

Factors which seem to contribute to gender gap in mechanics were discussed here. The study by Kost, Pollock and Finkelstein (2009) had found that factors which account for 70% of the gender gap include differences in previous physics and mathematics knowledge and incoming attitudes and beliefs. In spatial visualization abilities were related to performance in mechanics differently for females than for males (Amelink, 2012). Similarly, Davis (2012) observed that females tend to achieve higher than males on lower level cognitive problems in mechanics while males tend to achieve higher than females on more complex cognitive problems. Spelke (2005) observed that since male students are more focused on objects throughout their lives, they were likely to perform better in learning about mechanical systems. Men's performance was encouraged by their better ability in spatial and numerical abilities that produce greater aptitude in mechanics (Akala, 2010 & Spelke, 2005). The studies by Amelink (2012), Akala (2010), Kost, Pollock and Finkelstein (2009), Dweck (2006) and Spelke (2005) suggests that the problem of gender gap in mechanics instruction might need a more thorough investigation especially in technical institutions in Kenya especially when IE techniques are employed.

Possible interventions suggested for improving gender equity in mechanics include what Wells (1987) suggested that there was need for more research need to be done to establish the modeling strategies which could reduce the difference between genders in physics. Well (1987) recommended further research to investigate the perceived differences between initial knowledge status in physics for male and female; the reasons for these differences and the necessary modeling techniques needed to accommodate differences if any. However, no systematic study had been done to establish the strategies of modeling that could reduce the disparity in students' performance in mechanics in technical institutions in Kenya a gap which this study attempted to attend to investigate how the gender gap in learning gain can be reduced.

Teaching and learning for male and female in mechanics could be improved through enquiry-based strategies to promote effective scientific thinking and conceptual understanding (Abdullar & Shariff, 2008). The study findings by Meltzer (2002) also show that when IE methods are used, the students' performance in mechanics tend to be significantly higher by a factor about two or more. However, the study by Meltzer (2002) did not show the magnitude of the gender gap in learning gain when IE methods were used a gap which the current study attempted to fill. In IE pedagogical techniques, the study by Meltzer (2002) used interactive lecture and group work using tutorials which were partly expository in nature. However, this study intended to find out the difference in learning gains between male and female when students were taught using steeplechase activities which was based on heuristic learning approaches.

The abstract nature of mechanics could be simplified by helping students to 'visualize' the processes through outdoor activities (Billington, et al., 2014; Twoli, 2006). Hands-on opportunities which could provide meaningful and interesting learning experiences in mechanics for both female and male students in mechanics include computer simulation and providing concrete experiences through interactive techniques (Huang, 2011 and Twoli, 2006). Although the studies by studied the need for experiential learning, the scholars did not investigate what were the difference in learning gain between male and female when steeplechase activities were used for teaching in mechanics in mechanics in technical institutions in Kenya.

2.6 Summary of the Reviewed Literature

Mechanics is fundamental to all students majoring in applied mathematics, physics; engineering programs among other science oriented disciplines taken at technical institutions, technical pre-university and technical university courses (Billington, et al., 2014; Fang, 2014; Huang, 2011; Sahin, 2010; Jackson, 2009; Eryilmaz & Tatli, 1999; Wells, 1987). It plays a critical role in cultivating students' ability to visualize interaction of forces and moments with the physical world (Huang, 2011). Hence mechanics has been referred to as introductory mechanics (Fang, 2014 and Sahin; 2010). Fundamental concepts covered in mechanics include dynamics, statics as well as work and energy, vibrations (Fang, 2014 and Jackson, 2009). Mechanics concepts are essential pre-requisites for many subsequent and advanced dynamics courses in design, operation and control (Fang, 2014; Huang, 2011). Hence, effective understanding of mechanics concepts could assure students of passing curriculum-based examinations and develop competent graduates in design, maintenance, repair, operations and quality control (MRO).

Despite the critical role played by mechanics in students' lives, poor performance has been a long-standing global problem (Fang, 2014, Nzama, 2000; Wells & Hestenes, 1994). In the US, found that the mean score of final comprehensive examination in the dynamics class in the US, 54% of the students average examination scores were below 70% while 46% got between 70% and 90% at Utah University in 2009 (Huang, 2011). In particular, 53% of the questions were answered correctly in the fundamental engineering (FE) examinations in the US in 2009 (Huang, 2011). These observations show that in mechanics, majority of the students score poor grades or fail in curriculum-based examinations (Fang, 2014; Huang, 2011; Wells & Hestenes, 1994; Wells, 1987).

Poor performance in mechanics has also been observed in technical institutions in Africa (Kerre, 2011; ILO, 2010; Ngware, 2000). In South Africa, the failure rate in over 66.7% of the technical institutions was between 50% and 58% (Nzama, 2000). In Kenya, failure rate in mechanics is between 63% and 73% (Amuka, Olel & Gravenir, 2011; Bukhala, 2009). These results show that in mechanics, majority of the students score poor grades or fail in curriculum-based examinations (Amuka, Olel & Gravenir, 2011; Bukhala, 2009; Nzama, 2000). These observations also show that the problem of poor performance in mechanics might need an urgent systematic study to deal with the wastage of material and financial resources.

Studies have documented that mastering mechanics concepts was troublesome to majority of the students (Fang, 2014; Eryilmaz & Tatli, 1999 and Wells, 1987). Similarly, Goldfinch, Carew & McCarthy (2009) observed that majority of the students experience substantial difficulties with learning mechanics. Studies evidence showed that majority of the students lacked solid mathematics skills and good understanding of fundamental concepts as well as principles in the dynamics leading to poor performance or failure in mechanics (Huang, 2011; Eryilmaz & Tatli, 1999; Wells, 1987). Specifically, Hake (2002) listed the possible variables associated with variation in students' ability to develop conceptual understanding of mechanics concepts which include: mathematics proficiency, spatial visualization ability, completion of high school physics courses, scientific reasoning skills, physical aptitude, personality type, motivation, socio-economic level, IQ, and GPA. These observations meant that the solution to poor performance in mechanics might be found in the pedagogical techniques. Hence, this study studied the interactive pedagogical techniques which have the capacity to improve students' performance in mechanics in technical institutions in Kenya.

Poor performance in mechanics has also been associated with use of expository teaching strategies (Mbugua, et al., 2013; Jackson, 2009; Wells, 1987). In expository teaching strategies such as lecture, question and answer techniques, use of examples and dictation of notes, students are forced listen to or note the formulae or procedures as the lecturers solve mechanics problems on the board (Mbugua, et al., 2013). Lecturers' actions led students becoming passive participants. These actions might lead to loss of interest making the mechanics lessons boring and unfruitful. Expository strategies could be improved by use of interactive lecturer methods using whole class discussions or teaching small groups using tutorial approach (Meltzer, 2002; Wells & Hestenes, 1994). Hence, this study attempted to find out the learning gain associated with expository teaching strategies and compare students' learning gain when steeplechase activities are used for teaching mechanics.

Meltzer (2002) and Wells (1987) mentioned that there are pedagogical techniques which involve use of little or no interactive engagement (IE) methods. These pedagogical techniques suggest involving students in lecturer's demonstration. Lecturer's demonstration is limited because students are not able to have a 'feel of do it myself' hence the need for an alternative teaching strategies. Hence, this study compared students' learning gains when lecturer's demonstration and steeplechase activities are used for teaching mechanics in technical institutions in Kenya.

Giambatlisa, Betty & Richardson (2007) illustrated that simulation of mechanics problems in involving long jump, catapult, football, and lawn tennis among others can be used for improving students' learning gains in mechanics. Using sports and games to model mechanics problems especially in steeplechase activities might have the potential to improve students' learning gain mechanics through interactive engagement (IE) methods (Tammet, 2012). Hence, this study explored influence of steeplechase activities as a teaching strategy on students' performance in mechanics in technical institutions in Kenya.

Ability grouping finds application in analyzing data related to modeling instructions (Wells (1987). Further, identifying students' ability is the first step in forming mixed ability learning groups (Muthoni, 2007). Ability grouping is done for purposes of acceleration, curriculum compacting, enrichment, cluster grouping or differentiation (Steel, 2005). Ability grouping for differentiation providing different curricular, resources, assessment, use different approaches in teaching (Steel, 2005). In Meltzer (2002) of higher learning gain for high ability group (19%) in mechanics than low ability group (9%) suggested that the instructional processes in mechanics were more beneficial to the high ability group than low ability group. However, Meltzer (2002) did not investigate what learning gain could be made when interactive pedagogical techniques were used. Hence, this study compared the students' learning gains for high and low ability groups when students are taught using steeplechase activities.

The review of literature indicated that despite the use of interactive engagements techniques, the gender gap on conceptual learning survey persisted from pretest to posttest in mechanics instructions in the University of Colorado at Boulder (Kost, Pollock & Finkelstein, 2009). Similarly, Kost, Pollock & Finkelstein (2009) found that gender gap in mechanics exists in interactive techniques based classes in the technical institutions in the US. Meltzer (2002) found that 75% of cases of difference in learning gaps for male and female students independently showed significant positive correlation between learning gain in mechanics and pre-instructional mathematical skills. Meltzer (2002) also found that in 50% of both males and females case of independently showed significant positive correlation between learning gain in mechanics and mathematical skills.

Relevant literature reviewed in this study was analyzed to estimate the relative frequency of the research design used. Descriptive research was the most frequently used design with 42.9% (9 out of 21). Higher frequency suggests that the design was meant to provide quick-fix solutions to penitent issues. Quasi-experimental was the second most frequently used research design with 33.3% (7 out of 21). High frequency could be because of the desire of educational researchers to manipulate the independent variable to determine the influence on the dependent variable. However, certain variable such as gender and scholastic abilities used in this study could not allow the manipulation of the independent variable. To overcome these challenges of non-manipulated independent variables (gender and scholastic abilities), correlational research design was relatively frequently used with 19% (4 out of 21) (Sousa, Dnessnack & Mendes, 2007;

Thompson, Diamond, McWilliam, Snyder & Snyder, 2005). Although correlational design could have been used, it does not allow "pre-test, treatment and post-test". "Non-quantitative" design might have been necessary (Thompson, et al., 2005). Casual-comparative research design had the lowest frequency of 4.8% (1 out of 21). The choice was made because of two main reasons. First, casual-comparative allowed the researcher to pose hypotheses about the differences in variables between three (3) student groups (Sousa, Dnessnack & Mendes, 2007; Thompson, et al., 2005). Second, casual-comparative allowed the researchers to infer the influence of variables such as students' ability and gender which could not be controlled in the design (Sousa, Dnessnack & Mendes, 2007; Thompson, et al., 2005). Third, the choice was made because researcher intended to use pre-test, treatment and post-test, for gender and scholastic abilities as well as using questionnaire and interview guide for data collection, which were possible in this casual-comparative research design (Thompson, et al., 2005; Schenker & Rumrill, 2004). Schenker & Rumrill (2004) had observed that casual-comparative research makes it possible for the researcher to identify the subjects' experiences consistent with a "treatment" and compare it with those subjects who had no treatment or different treatment. Therefore, this study adopted casual-comparative research design. The section below outlines the theoretical framework.

2.6.1 Theoretical Framework

The theoretical framework is based on Hestenes (1987) theory of modeling instruction. Ideas from Abdullah & Sherriff (2008) cooperative learning environment for developing scientific reasoning were also adopted in the theoretical framework. Abdullah & Sherriff (2008) observed that new information or terms introduced were interpreted in terms of the pre-existing mental structures or schema. Abdullah & Sherriff (2008) observed that any attempts to work on their own, students found it difficult to deal the complexities arising from their pattern of reasoning. Abdullah & Sherriff (2008) further observed that extended desire to resolve the incongruities and new information lead to a feeling of imbalance or disequilibrium. The conventional attempted to deal with the imbalance or disequilibrium is by telling students what to do or leading them to a relevant text-book or other relevant reference materials. Abdullah & Sherriff (2008) observed that individual attempts might lead to frustrations or encourage misconceptions further which were counter-productive. However, Abdullah & Sherriff (2008) suggested that students to active participation in small-group investigations encouraging development of concrete experiences in cooperative setting. Abdullah & Sherriff (2008) postulated that three stages are needed in the learning cycle: assimilation, accommodation and re-organization steered by peer-interaction and class presentation in learning gas laws in physics. First, students' active participation in small-group efforts encouraged exploration and interpretation of events in terms of existing cognitive structures in what is referred to as assimilation. Second, the term introduction phase promoted new state of understanding or equilibrium or self-regulation when new concepts are derived from exploration experiences. Self-regulation allows the existing knowledge or schema to alter the current to allow accommodation to occur. Third, concept application phase provides additional experiences which aid discovery of further application of newly discovered concepts and principles providing opportunities for re-organization. Re-organization is encouraged by extension activities where discovered new and related principles were used in subsequent open-inquiry experiments for stabilization of new principles. Peer interaction might provide new insight through offering alternative perspectives and challenge students' line of thought to be consistent with the correct state which works.

Hestenes (1987) had observed that introduction of new information or terms were expected to be interpreted in terms of the pre-existing mental structures or schema. However, Hestenes (1987) observed that any attempts to interpret the introduced materials might be difficult due to the unsuccessful efforts to deal with the complexities arising from the existing pattern of reasoning. Hestenes (1987) further observed that extended desire to resolve the incongruities and new information lead to a feeling of imbalance or disequilibrium. Hestenes (1987) had observed that verbal or written attempts to develop accurate mental structures were misinterpreted to the extent to which the students' preexisting mental structures are incorrect. Hestenes (1987) observed that any attempt to use theoretical teaching of mathematical expressions and equations was likely to deal with the inconsistencies amounted to linguistic model. Linguistic models would encourage students to interpret what they heard to be consistent with their misconceptions. According to Hestenes (1987), no conflict appeared because students' misconceptions remained unaltered by instruction. Hestenes (1987) observed that such a situation might lead to the new information and terms introduced becoming irreconcilable conflict with preexisting mental structures. Hestenes (1987) said that the end result was that the proposed model was rejected and no learning had taken place.

Hestenes (1987) proposed three stages of modeling instruction in mechanics: exploration-description; concept introduction-formulation; and discovery-ramification-evaluation. First, exploration-description stage involved directed but unstructured laboratory activities. Here, the students identify and describe variables related to the phenomena under consideration. At the concept introduction-formulation stage, related data is collected, analyzed and presented graphically. The stage also involved evaluation of data presented to develop mathematical relationships between relevant variables. The stage then involved physical interpretation of the relationships. In the third stage discovery-ramification-evaluation took place. In the stage, procedures, tactics and techniques necessary for utilization of the concepts, laws, theorems, principles and relationships developed are deployed and utilized. In this stage students evaluate their application of those processes in new tasks to check their suitability. Evaluation also involves public discourse where students' presentations of the group finding are questioned by the lecturers and peers through Socratic probing. Therefore, this study's conceptual framework is summarized as shown below.

2.6.2 Conceptual Framework

The conceptual framework involved steeplechase activities which followed the follows stages: exploration, description and assimilation; concept introduction, formulation and self-regulation through accommodation; and discovery, ramification, evaluation and re-organization. First, in the exploration, description and assimilation stage, students were involved in directed but unstructured steeplechase activities. Students were involved in running in the track; data collection; analysis; presentation in tables. Here, the students identified and described related variables to the phenomenon under consideration. At the concept introduction, formulation and self-regulation through accommodation stage, related data is collected is refined further, analyzed and presented graphically. That stage also involved evaluation of data presented to develop mathematical relationships between relevant variables. That stage then involved physical interpretation of the relationships. In the third stage discovery-ramification-evaluation took place. In the discovery, ramification, evaluation and re-organization stage, procedures, tactics and techniques necessary for utilization of the concepts, laws, theorems, principles and relationships developed are deployed and utilized. In this stage students evaluated their application of those processes in new tasks to check their suitability in subsequent situations. Evaluation also involved public discourse where students' presentations of the group finding are questioned by the lecturers and peers through Socratic probing. The study attempted to establish the difference in learning gains when students are taught using expository strategies and when steeplechase activities is used for teaching. The study attempted to establish the difference in learning gains when students are taught using lecturer's demonstration and when steeplechase activities is used for teaching. The study attempts to establish the difference in learning gains between top and bottom ability groups when steeplechase activities are used for teaching mechanics. The study attempted to establish the difference in learning gains between male and female when steeplechase activities are used for teaching mechanics. Figure 1 shows the conceptual framework which captures the major variables and their inter-relationships.

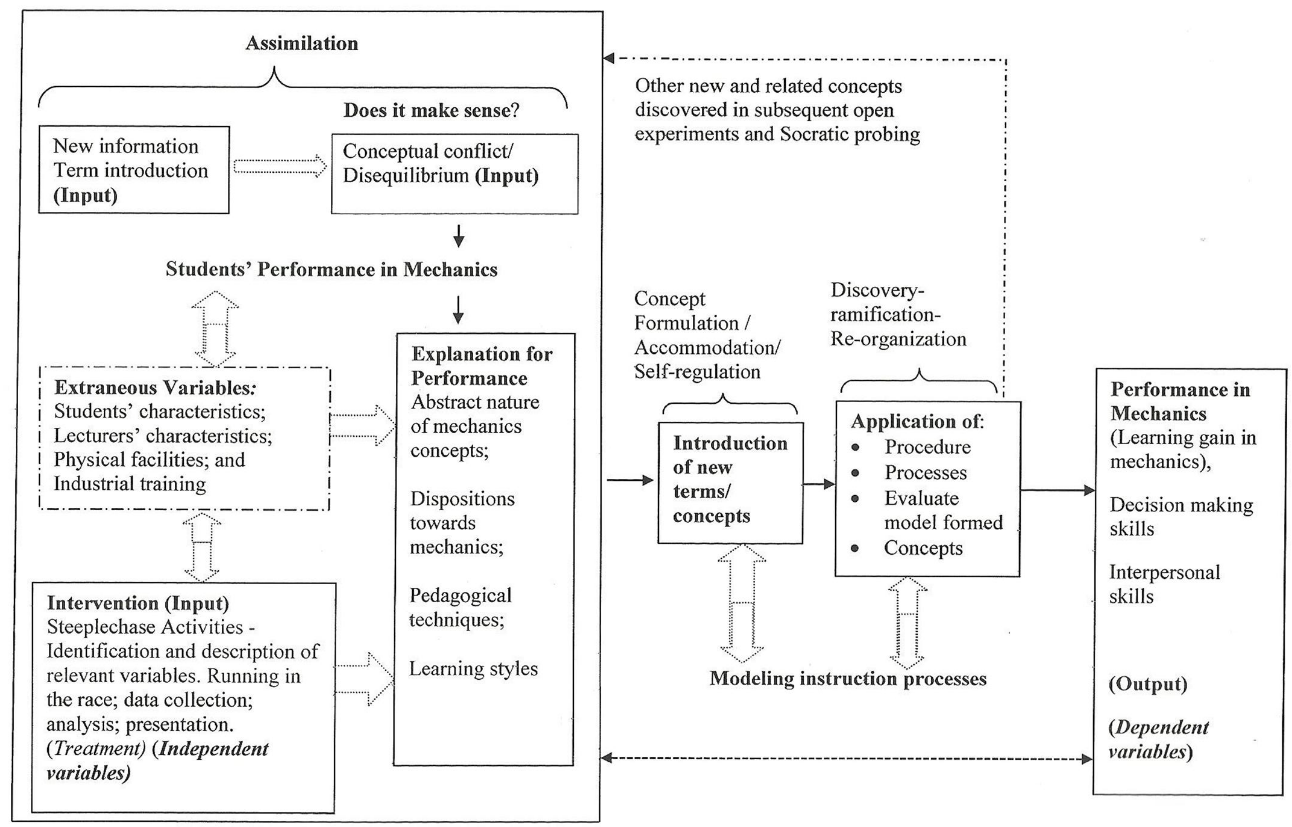


Figure 1: **Conceptual Framework**

CHAPTER THREE
RESEARCH METHODOLOGY

3.0 Introduction

The chapter attempts to describe the research design, location of the study, target population, sampling and sample size, research instruments, pilot study, validity of the research instrument, reliability of the research instrument, data collection procedures, data analysis techniques and ethical considerations.

3.1 Research Design

The research design used in this study was casual-comparative research design because of the following reasons. First, casual-comparative research design allowed the researcher to pose hypotheses about the difference in variables between student groups. Second, casual-comparative research design allowed the researcher to work with the subjects in pre-test and post-test for comparison groups assigned to “treatment” and “no treatment” while at the same time attempt to identify the past experiences of the subjects (Thompson, et al., 2005; Schenker & Rumrill, 2004). Comparison groups were based on: teaching styles (steeplechase activities (STA) and traditional methods; STA and lecturer’s demonstration (LD); high and low ability group of students; and male and female group of students. The study also aimed at establishing the lecturers’ opinion on the pedagogical techniques used for mechanics instructions.

The study process of assigning groups to “treatment” or “no treatment” groups proceeded as shown here. The study considered that one treatment group (TG) required four (4) colleges (Kothari, 2009). Four (4) treatment groups required three (3) control groups (CG_1, CG_2 and CG_3). Therefore, “treatment” and not “non-treatment” groups were four. Three (3) control groups required twelve (12) colleges (Kothari, 2009). Hence, treatment and control groups made sixteen (16) colleges that were to participate in this study. Sixteen (16) colleges were considered sufficient to provide adequate number of subjects for analysis of quantitative data using inferential statistics. The distribution of the 16 colleges is represented as shown in Table 3.

Table 3: **Treatment and Control Groups**

Group	Pre-test	Treatment	Post-test
TG	Pre-test (PR)	STA- Steeplechase Activities	Post-test (PT)
CG_1	Pre-test (PR)	TMT- lecture method	Post-test (PT)
CG_2	Pre-test (PR)	TMT-Q&A and use of examples	Post-test (PT)
CG_3	Pre-test (PR)	Lecturer's Demonstration (LD)	Post-test (PT)

Key: STA-Steeplechase Activities; TMT- traditional methods of teaching; LD-lecturer's demonstration Q&A-question and answer

Table 3 has treatment group (TG) and control groups of students (CG_1, CG_2 and CG_3) were involved in traditional methods of teaching (TMT) as well as control groups of students involving lecturer's demonstration (LD).

In treatment group, TG students were taught using steeplechase activities (modeling of mechanics problems) through mental model formulation. Mental model formulation is effective when students are involved in development of targeted concepts through guided concrete experimental experiences (Abdullar & Shariff, 2008). The students were exposed to unstructured process (steeplechase activities) of developing models to deal with cognitive conflict or disequilibrium systematically induced. In control group, CG_1 students were taught using lecturer method and printed lecture notes (to be handed in to students after the lesson except for diagrams). The students were presented with logically ordered sequence of arguments leading to the desired conclusions. Conclusion required practice and consolidation of ideas through problems in exercises and assignments. The exposition aimed at developing understanding of a range of interrelationships among essential elements defined by some systems of concepts. In control group, CG_2 students were taught using question and answer which was more interactive expository teaching style and printed lecture notes (to be handed to students after the lesson). The students are presented with logically ordered sequence of arguments leading to the desired conclusions through questioning. Responses of students were used for developing the ideas to be learnt through exposition. The exposition was aimed at developing understanding of a range of interrelationships among essential elements defined by some systems of concepts. In conclusion students are involved in practice and consolidation of ideas through problems in exercises and assignments. The instructional processes are aimed at creating meaning in a given context. The students are also expected to have in their mental structures observations made as they interact with their environment. The students are also expected to deal conceptual conflict encountered through discussion with peers of items in assignments (Abdullar & Shariff, 2008). The study was to establish the suitability of the lecturer's demonstration in inducing conceptual conflict, capacity to encourage modification and dealing with misconceptions. In the control group, CG_3, students were taught using lecturer's demonstration (learning cycle) which comprised of the following elements. The concepts in mechanics are introduced by exposition meaning that students receive explanation on concepts. Exposition was followed by demonstration on how the toy tractor worked then the lecturer showed students how to work out problems using examples and illustrations related to the concepts related to the working of the toy tractor. The lecturer also illustrated how expressions are used to derive equations. The important points were summarized on how to solve problems in real life situations through problem solving techniques.

3.2 Location of the Study

The study technical institutions were drawn from eight (8) out of 47 (17%) counties in Kenya. Eight (8) counties were drawn from Eastern, Rift Valley, Nairobi and Central Regions. This implied that the sample was drawn from four (4) out of eight (8) regions which was 50% of the total locations in Kenya. The selected technical institutions were considered a fair representative because they represented all possible categories of the technical institutions in Kenya (see Table 4). Great care was taken to ensure confidentiality was guaranteed in terms of the name of institutions, counties or location of institutions to reduce chances of identification of respondents (Nzama, 2000).

3.3 Target Population

The study worked with all the 41 technical institutions categorized as National Polytechnics, Technical Training Institutes (TTIs) and Institute of Technology (ITs) in Kenya. The students' population was 768 ($female = 320$; $males = 448$) students with 18-21 years of age. The target population of lectures teaching mechanics among first year students at diploma level was 328 ($female = 72$; $males = 256$). First year students were involved in the study because they also take the introductory mechanics at diploma level and had greater gender mainstreaming. The accessible population of steeplechasers was 120 ($female = 48$; $males = 72$).

3.4 Sampling Procedures and Sample Size

Sixteen (16) technical institutions were selected to represent nine (9) categories based on institution type or geographical area as shown in Table 4. The institution types were based on categories such as: National Polytechnics, Professional Training, Disciplined Training Institutions and Ministry of Industrialization. The categories based on geographical area where institutions were located included: peri-urban, rural areas as well as arid and semi-arid areas. The study worked with sixteen (16) technical and vocational institutions which formed 39.02% of the technical and vocational institutions in Kenya. The formula used for determining the students' sample size was adapted from Gupta (2009:494):

$$n = \frac{z^2pq}{d^2}$$

Where: n = Desired sample size

z = Standard normal deviation at the required confidence level (5%)

p = Proportion of accessible population estimated to have the characteristic which was being measured

q =1-p (proportion of population not involved in the study)

d = Level of statistical significance set (maximum allowable sampling error)

In this study, the proportion of accessible population involved in the study was 384 out of 768 (0.5 or 50%), hence, p = 0.5. The study considered that the appropriate level of significance was set at $\propto = 0.05$ (Boslaugh and Watters, 2008). Since the sample size, $n \geq 30$, z-test statistic was used in test of hypothesis at 5% level of significance. The critical value (z-table value) obtained from student's t-test table when $n \geq 30$ is $z_{\frac{\propto}{2}} = 1.96$ (Gupta, 2009:694). Substituting the values, the sample size was:

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.05^2} = 384.16 \approx 384$$

Therefore, sample size of students obtained by calculation was 384 which were 50% of the target population. Table 4 presents the sampling grid.

Table 4: **Sample Space in Sampling Grid for Students and Lecturers**

Code	Institution Type or Geographical Area	Number of Institutions	Number of Lecturers		Number of Students		Population (% Sample)
			Male	Female	Male	Female	
A	National Polytechnic	2	9	2	38	10	88 (54.55%)
B	Professional	2	9	2	38	10	88 (54.55%)
C	Peri-Urban	2	10	3	38	10	88 (54.55%)
D	Disciplined Training	1	5	1	19	5	76 (31.58%)
E	Arid and Semi-Arid	2	9	2	38	10	88 (54.55%)
F	Industrialization*	1	5	2	19	5	76 (31.58%)
G	Rural Areas	2	10	3	38	10	88 (54.55%)
H	Technical Training Institutes	2	9	3	38	10	88 (54.55%)
I	College of Science and Technology	2	9	3	38	10	88 (54.55%)
	Sub-Total		75	21	304	80	768
	Grand Total	16	96		384		(49.44%)

*Ministry of Industrialization

The sample size of students was divided into (304 males and 80 females) who are 18-21-year-old. Six (6) lecturers from each selected technical institutions make 96 which was 29.27% of the target population. Proportional stratified random sampling was used to select sixteen (16) technical institutions offering mechanics at diploma level to participate in the study (Gupta, 2009). The researcher first prepared separate lists for each gender in each technical institution selected. The random numbers were used to separately select male and female students to participate in the study. A lottery method was used to place the sixteen (16) colleges into "treatment" or "non-treatment" groups. The sixteen (16) technical colleges were assigned alphabets from A to P. Sixteen (16) wooden beads were labeled with sixteen (16) alphabets from A to P and placed in a leather bag. The beads were mixed thoroughly by swirling. A blindfolded person picked four (4) beads at random, one at a time without replacement. Purposeful selection of lecturers was considered appropriate because their students were involved in the treatment and their lessons were observed. The study worked with sixty (60) which was 50% of the accessible population of steeplechasers in Kenya.

3.5 Research Instruments

The details on the research instruments used for collecting data were provided as shown here.

3.5.1 The Pre-Test (PR)

The pre-test (PR) was used for measuring students' pre-requisite knowledge and skills. The content areas mechanics in the pre-test paper include: displacement and velocity; force and acceleration; work and energy; as well as impulse and momentum. These content areas were sampled to ensure that the same content areas were tested in pre- and posttest. Pre-test (PR) had twelve (12) structured questions whose weight was between one (1) and four (4) marks which gives a total of 100 marks. Pre-test (PR) was used for measuring quantitative data for determining students' pre-requisite skills in mechanics. The marking schemes for pre-tests was moderated with technical assistance from two lecturers of mechanics in technical institutions one from Dedan Kimathi University of Technology and Meru Technical. Pre-test examination paper and its marking scheme were considered important in the study because the pre-test was administered in the actual study and marking was done. Item analysis of the marked scripts was done to establish the students' pre-requisite skills as well as common mistakes identified for purposes of planning for teaching experiments.

Piloting was meant to validate the items in pre-test used during the actual study. The piloting was done to determine the validity and reliability of the research instruments used. Validity of pre-test (PR) was done to establish if the instrument has the capacity to measure what it was expected to measure. The researcher involved competent judges: one mechanical Engineering Department Academic staff, one from the Departments of Educational Communication and Technology of the University of Nairobi. One of the judges from the University of Nairobi involved in this study was the current thesis supervisor. The accompanying supervisor's role was to assess the relevance of the items in the instruments as the piloting was taking place. The judge provided feedback and the necessary corrections which were considered useful during the actual implementation and analysis of data. The Mechanical Engineering Department academic staff was involved in ensuring the adequacy of the content tested in pre-test (PR). Hence, pre-test (PR) content validity was established. The references used for comparison with the constructed test items in the pre-test (PR) include: Bostock and Chandler (1996), Giambatlisa, Betty & Richardson (2007) and Halliday, Resnick and Walker (2008) to check on referenced-criterion validity. The materials in the above references were considered ideal because they cover junior, middle high school and college mechanics content areas.

Test-retest technique was used for determining the degree of reliability of pre-test. Test-retest using the instruments was done during the piloting and pre-test was carried out to ascertain its reliability on a larger quantitative basis (Boslaugh & Watters, 2008). Cronbach's Alpha model was used for determining the reliability statistics for the research instruments. Cronbach's Alpha for pre-test was + 0.687; ($n = 384$). Relatively high reliability of pre-test show that pre-test (PR) was considered ready for use during the actual study. The accompanying supervisor assisted in confirming the reliability as observed during piloting. During the analysis of the quantitative data, split-a-half approach was used to test the reliability of pre-test (PR) on a larger basis ($n = 144\ pairs$). Cronbach's Alpha for pre-test was +0.658; ($n = 144$) showing relatively high level of reliability of the pre-test (PR) as an instrument for investigating students' pre-requisite skills.

3.5.2 Post-Test (PT)

Post-test (PT) was used for measuring quantitative data for determining students' performance in mechanics. The content areas in the post-test include: linear and projectile motion; motion under free fall; work, energy and power; machines and coefficient of friction; moments, resolution of forces, tractive force; breaking force, speed of sound in air as well as collision and momentum. The marking schemes for post-test were moderated with technical assistance from two lecturers of mechanics in technical institutions. Post-Test (PT) has ten (10) structured questions whose weight was between one (1) and eight (8) marks giving a total of 100 marks. The suitability of the marking schemes for PT was confirmed by technical assistance from two (2) lecturers of Newtonian Mechanics from Karatina and Dedan Kimathi Universities.

Validity of post-test (PT) was done to establish if the instrument has capacity to measure what they were expected to measure. The researcher involved competent judges: one Mechanical Engineering Department academic staff, one from the Departments of Educational Communication and Technology of the University of Nairobi. One of judges from the University of Nairobi involved in this study is the thesis supervisor. The accompanying supervisor's role was to assess the relevance of post-test being piloted. The mechanical engineering department academic staff was involved in ensuring the adequacy of the content tested in post-test. The judge provided feedback and the necessary corrections which were considered useful during the actual implementation. Hence, the post-test content validity was established.

Test-retest of post-test was done during the piloting to ascertain its reliability. Cronbach's Alpha for posttest was + 0.675; ($n = 384$). Later, split-a-half approach was used to test the reliability of the post-test on a larger ($n = 144\ pairs$) basis (Boslaugh and Watters, 2008). Cronbach's Alpha for posttest was + 0.659; ($n = 144$) confirming that post-test was ready for use in the actual study. The accompanying supervisor assisted in confirming the reliability as observed during piloting.

3.5.3 Questionnaire for Mechanics Lecturers (QML)

Questionnaire for Mechanics Lecturer (QML) was used for collecting categorical data related to: students' performance in mechanics; gender disparity in performance in mechanics; influence of students' ability on performance in mechanics; influence of teaching and learning strategies on students' performance in mechanics; and benefits of teaching students using steeplechase activities for teaching mechanics. The questionnaires also provided follow up on the observations made from the students' performance in pre-test and post-test. The purpose of piloting was to test if the instruments specifically questionnaire for mechanics lecturer (QML) had the capacity to provide the information expected in the study.

Validity of the instruments involved establishing if questionnaire for mechanics lecturer (QML) have the capacity to measure what they were expected to measure. The researcher involved competent judges: one Mechanical Engineering Department academic staff, one from the Departments of Educational Communication and Technology of the University of Nairobi. One of judges from the University of Nairobi involved in this study was the thesis supervisor. The role of competent judges was to assess the relevance of the instruments being piloted. The judge provided feedback and the necessary corrections which were considered useful during the actual implementation. Hence, the validity of the questionnaire for mechanics lecturer was established.

The Mechanical Engineering Department academic staff was involved in ensuring the adequacy of the content tested in pre-test and post-test.

Test-retest technique was used for determining the degree of reliability of mechanics lecturer's questionnaires (Boslaugh and Watters, 2008). Cronbach's Alpha for questionnaire for mechanics lecturers was + 0.641; ($n = 96$). Relatively high reliability of the test instruments meant that the instrument was ready for use during the actual study. The accompanying supervisor assisted in confirming the reliability as observed during piloting. Hence, the reliability of the questionnaire for mechanics lecturer was established.

3.5.4 Steeplechasers' Interview Schedule (SIS)

Steeplechasers' Interview schedule (SIS) was used to collect categorical data relevant to steeplechase activities from Kenyan steeplechasers. The steeplechasers' views collected were related to the dynamics of winning a race in terms of: predicting likely action by fellow competitors, estimation, precision, mental calculations among other ideas related to teaching and learning mechanics. The reliability statistics used for Steeplechasers' Interview Schedule was Cronbach's Alpha model. Cronbach's Alpha for steeplechaser's interview guide was + 0.633; ($n = 60$). Steeplechasers' Interview Schedule (SIS) was meant to provide an added opinion on mechanics teaching and learning mechanics content as it happens in track athletics specifically steeplechase.

3.6 Data Collection Procedures

Hawthorne Effect was taken care of during the piloting and the main study by making several visits to the study stations before the actual collection of data. Several visits were made in an attempt to ensure that students could accept the presence of researcher as part of their lesson. Quantitative data (students' learning gain as a predictor of students' performance in mechanics) was collected by administering and marking of pre-test, post-test papers related to students' performance in mechanics. Item analysis of the marked scripts was done to identify major pedagogical issues which were to be addressed during the modeling instructional processes. Categorical data (related to respondents' opinion of teaching and learning mechanics) was collected by administering questionnaire for mechanics lecturer (QML) to lecturers. Categorical data was also collected by carrying out interview with steeplechasers using steeplechaser's interview schedule. The data collected from the steeplechasers was considered important for providing insight into modeling of mechanics problems through steeplechase activities.

3.7 Data Analysis Techniques

Qualitative data collected by use of questionnaire for mechanics lecturers (QML) and steeplechasers' interview schedule were pre-processed by editing, coding, classification and tabulation in preparation for analysis. Views and opinions from the respondents were presented in frequency tables showing frequencies and percentages. The observations made during the teaching experiments were backed by statistical procedures. Qualitative data was collected and summarized in themes. Themes which were analyzed include: students' performance in mechanics when students are taught using traditional methods of teaching and steeplechase activities (STA); students' performance in mechanics when students are taught using lecturer's demonstration and STA; influence of teaching using steeplechase activities on students' performance in mechanics for different ability groups; and influence of teaching steeplechase activities on students' performance in mechanics for gender group of students. Data was also collected from common errors obtained from analysis of items in the pre-test marked scripts. Data on common errors was considered critical in guiding the instructors and researchers in getting in-depth understanding of students' pre-requisite knowledge and skills to guide in planning for teaching as well as learning processes in the teaching experiments.

In item analysis of the marked scripts (pre-test), study considered that formative assessment was based on Bloom, et al., (1956) Taxonomy. A comparison of Bloom, et al., (1956) in Volpe (2000) and Twoli (2006) identified four domains of learning objectives which included: cognitive, the affective, the psychomotor and the social domains. Bloom, et al., (1956) in Volpe (2000) came up with six levels of learning objectives in cognitive domain which include: (1) knowledge, (2) comprehension, (3) novel application, (4) analysis, (5) synthesis and (6) evaluation. To ensure that low and high ability groups were adequately represented, the scripts were arranged from the highest score to the lowest. Then the scripts were divided into two equal parts. From each of the group, a sample 50 scripts were picked at random to make a total of 100 scripts. The scripts were analyzed by identifying the number of times a misconception appeared on pre-test students' scripts in mechanics. Cronbach's Alpha model was used for determining the reliability statistics for the research instruments. The instruments were considered ready if their Cronbach's Alpha was +0.7000 or more. Although the Cronbach's Alpha for pre-test, post-test, questionnaire for mechanics lecturers and steeplechaser's interview guide were below +0.7000, their reliability was almost 0.7000. Therefore, the instruments were considered suitable for use (Thompson, et al., 2005).

Test of the symmetrical distribution or normal curve for the distribution of the students' scores was obtained by use of coefficient of skewness and coefficient of kurtosis. When the coefficient of skewness was zero (0), the distribution of students' scores was symmetrical or had a normal distribution. When the coefficient of skewness was positive, the students' scores were skewed to the lower performance. When the coefficient of skewness was negative, the students' scores were skewed to the upper performance. When the coefficient of kurtosis was equal to 3.0, the distribution of students' scores was mesokurtic (normal distribution). When the coefficient of kurtosis was less than 3.0, the distribution of students' scores was less peaked (platykurtic). When the coefficient of kurtosis was greater than 3.0, the distribution of students' scores was more peaked (leptokurtic). When distribution was both mesokurtic (coefficient of kurtosis = 3.0) and coefficient of skewness had been zero (0), the students' scores were symmetrically or normally distributed.

Scores from marked scripts of pre-test and post-test were recorded. Results in pre-test and post-test were processed by calculating the arithmetic means and standard deviations using descriptive statistics. The arithmetic means were useful in determining the difference between the learning gains in mechanics as a predictor of students' performance in curriculum-based examination for various groups (steeplechase activities (STA) and traditional methods of teaching; STA and lecturer's demonstration; male and female groups; high and low ability groups). Analysis involving difference between means of groups was based on student's t-test statistics (Abdullar & Shariff, 2008). Student's t-test statistics (calculated) was compared with p-value (t-table value) in test of hypotheses. Students' normalized gains for any given group was obtained as illustrated in the formula used by Jackson, Dukerich and Hestenes (2008, p.15) and Meltzer (2002, p. 1260) with slight modification to convert decimal scores to percentage students' scores:

$$Normalized\ Gain = \left[\frac{\%Posttest - \%Pretest}{100 - \%Pretest}\right] \times 100\%$$

Hence, students' learning ordinary gains and normalized learning gains in mechanics for the group pairs were established and compared between: steeplechase activities (STA) and traditional methods of teaching; STA and lecturer's demonstration; high and low ability; female male groups as well as group involved in Socratic probing and the group where it was not used.

Inferential statistics was used in test of hypothesis on the significant difference in students' performance in mechanics when students were taught using steeplechase activities and when students are taught using alternative teaching strategies traditional methods of teaching and lecturer's demonstration at 5% level of significance. Test of hypothesis on influence of steeplechase activities on different ability groups and gender disparity in performance in mechanics was done at 5% level of significance. The findings from the inferential statistics were backed up by descriptive statistics to help the researcher make meaningful generalization. Statistical procedures were carried out in the Statistical Package for Social Sciences (SPSS).

3.8 Ethical Considerations

The key ethical issues considered in this study include: getting participants' informed decision, voluntary participation and ensuring confidentiality. All the respondents were assured of confidentiality orally and by the letter of introduction. To ensure informed decision, discussions were held with administrators (Principals or Deputy Principals), Heads of Department (HOD), mechanics lecturers and students. These discussions were held to explain the goals, importance and the procedure of research and a guarantee of confidentiality. The role of each person was explained and the data collection instruments were discussed. During the piloting, pre-test (PR) was discussed with Heads of Department (HODs), automotive and mechanical engineering, mechanics lecturers and students taking mechanics. Discussion with the Heads of Department (HODs) was done to ensure that informed consent to work with students and lecturers was guaranteed. Discussion with the respondents was done to ensure that their participation was voluntary. Then instruments were administered for piloting. The completed instruments were returned for data analysis. Careful cross-checking was done to ensure that all returned research instruments were completed. The students were familiar with their lecturers showing that students' welfare issues related to learning environment and content delivery were put into consideration. Other precautions taken to ensure the good will of the respondents include: observing time in appointment, observing basic courtesy and exercising patience. The researcher obtained a research permit from the National Council for Science, Technology and innovation (NACOSTI) in Kenya. A copy of research permit and an introduction letter were handed in to the provincial technical education officers in the areas visited and principals of technical institutions involved in this study.

CHAPTER FOUR
RESEARCH FINDINGS AND DISCUSSIONS

4.0 Introduction

This chapter presents findings and discussions of study results in themes which contain both categorical and quantitative data in themes. The study themes included: influence of steeplechase activities (STA) and traditional methods of teaching on the students' performance in mechanics; influence of STA and lecturers' demonstration on the students' performance in mechanics; influence of STA on the students' performance in mechanics for different ability groups; influence of steeplechase activities (STA) and traditional methods of teaching on the students' performance in mechanics for male and female students. Categorical data was also related to: observations made from pre-test item analysis, common errors and misconceptions, teaching and learning strategies in mechanics from questionnaire for mechanics lecturer (QML) and responses from interview with steeplechasers. Quantitative data was related to pre-test and post-test results used in the test of hypotheses on the following. The difference between students learning gains as a predictor of performance in mechanics when students are taught using steeplechase activities (STA) and traditional methods (as pedagogical techniques) was estimated. The difference between students learning gains as a predictor of performance in mechanics when students' were taught using STA and lecturers' demonstration (as pedagogical techniques) was estimated. The difference between students learning gains as a predictor of performance in mechanics when students were taught using STA (as pedagogical techniques) between high and low ability group of students. The difference between students learning gains as a predictor of performance in mechanics when students' students' are taught using STA (as pedagogical techniques) between male and female group of students is estimated.

Discussion on results was done as shown here. First, the students' learning gains in mechanics when students were taught using steeplechase activities (STA) and traditional methods (as pedagogical techniques) were discussed. Second, students' learning gains in mechanics when students were taught using steeplechase activities (STA) and lecturer' demonstration (as pedagogical techniques) was discussed. Third, students' learning gains in mechanics when students were taught using STA (as pedagogical techniques) for high and low ability group of students were discussed. Fourth, students' learning gains in mechanics when students were taught using STA for male and female group of students were discussed.

4.1 Research Instruments Return Rate

Once the instruments were administered, sorting out of the returned instruments was done to ensure that only the needed information was analyzed. Once tallying was done, the data was summarized using tables with frequencies and percentages as well as graphs. Table 5 presents the results on return rate of research instruments.

Table 5: **Research Instruments Return Rate**

Instrument	Number Given	Number Returned	Return Rate
Questionnaires for mechanics lecturers	96	95	98.9%
Pre-Test answer sheets	384	384	100.0%
Post-Test answer sheets	384	384	100.0%
Steeplechase Interview schedule	120	116	96.7%

The return rate of questionnaires for mechanics lecturers was 95 out of 96 (98.95%). The number of answer sheets collected for marking and analysis were 384 (100%) pre-test and 384 (100%) post-test. The return rate of steeplechaser's interview schedule was 116 out of 120 (96.67%). The researcher ensured that all returned instruments were fully completed to ensure that results were as adequate as possible. The return rate (96% and above) showed that the results from the research instruments were adequate for data analysis. The return rate (96% and above) also showed that the sample characteristics found out were a representative of the population parameters.

4.2.0 Biographic Data

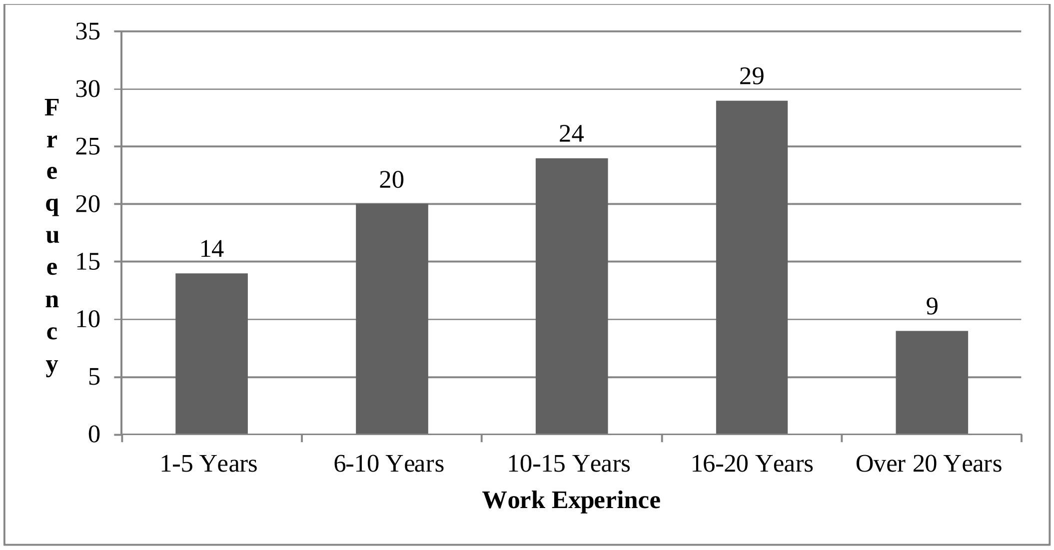
The study found a total of 384 students in the lessons observed in sixteen (16) institutions. The enrollment of female students was 80 (20.83%), lower than that of their male counterparts at 304 (79.73%). These results showed a gender disparity among students of 49%. The number of lecturers in the institutions involved in the study was 96. Table 6 presents data on lecturers' academic and professional qualifications.

Table 6: **Lecturers' Academic and Professional Qualifications**

Gender	H.Dip	B.Tech	BSC	MSC	Total
Female	3 (3.13)	16 (16.67)	2 (2.08)	0	21(21.88)
Male	48 (50.00)	2(2.08)	24 (25.00)	1 (1.04)	75 (78.12)
Total	51 (53.13)	18(18.75)	26 (27.08)	1 (1.04)	96 (100.00)

(n = 96)

The results in Table 6 revealed that 21 (21.87%) of lecturers were female compared to their male colleagues who were 75 (78.12%). The results showed that majority, 18 (85.71%) of the female lecturers had either Bachelor of Technology with Education (B.Tech) or Bachelor of Science (B.Sc) degree while majority, 48 (50%) of the male lecturers had higher diploma. The proportion of the lecturers with bachelor's degree and above was 45 out of 96 (46.88%) while one (1) (1%) had masters' degree. The results also showed that lecturers had adequate professional and academic qualification for training technologists in mechanics. Figure 2 presented the lecturers' work experience.



$(n = 96)$

Figure 2: **Lecturers' Work Experience**

The results in Figure 2 showed that 85.42% ($n = 82$) of the lecturers had work experience above six (6) years making their responses rich in terms of pedagogy and process of preparing technologists in mechanics. Hence, the data from the lecturers in Figure 2 was considered useful in providing information on work experience needed for effective teaching of mechanics. Table 7 showed results on lecturers' in-service training (INSET).

Table 7: **Lecturers' In-Service Training (INSET)**

INSET Attendance	Male	Female
• Yes	66 (68.8%)	18 (18.8%)
• No	9 (9.4%)	3 (3.1%)
Total	75 (78.1%)	21 (21.9%)
• Seminars, workshops and conferences (e.g., SMASSE)	36 (37.5%)	8 (8.3%)
• Training Abroad: Two weeks, six months, one year	5 (5.2%)	3 (3.1%)
• School-based program (bachelors' and master's degree)	13 (13.5%)	2 (2.1%)
• UNESCO-UNEVOC e-Forum		
• Conference	4 (4.2%)	2 (2.1%)
• Discussion	5 (5.2%)	2 (2.1%)
• Article	3 (3.1%)	1 (1.0%)

The results in Table 7 showed that 13.6% ($n = 15$) of all the lecturers attended school-based program (Bachelor's and Master's degree) while 8.3% ($n = 8$) were in-serviced in short courses.

The results in Table 7 also showed that 45.8% ($n = 44$) participated in workshops such as SMASSE, seminars and conferences. The results show that majority of the lecturers were involved in various forms of professional development which confirmed their suitability in the teaching mechanics for technologists at diploma level. Table 8 represents the number of students in the technical institutions involved in the study.

Table 8: **Number of Students in Diploma Technical Institutions**

Course	Building/ Civil	Motor Vehicle	Electrical/ Electronics	Mechanical Engineering	Total
Female	8 (2.08)	16 (4.17)	32 (8.33)	16 (4.17)	80 (20.83)
Male	60 (15.89)	88 (22.92)	76 (19.79)	80 (20.83)	304 (79.17)
Total	68 (17.71)	104(27.09)	108 (28.13)	96 (25.00)	384 (100.00)

($n = 384$)

The results in Table 8 showed that more male 79.2% (304) take engineering courses than females 20.8% (80). The results indicated that electrical and electronic engineering was the most popular at 28.1% (108) followed by motor vehicle engineering at 27.1% (104). Building and civil engineering had lowest number of students ($n = 68$, 17.7%). The results showed that majority of the female 32 (40.0%) students involved in the study take diploma in electrical and electronic engineering. Table 9 presented the age of students in technical institutions could use steeplechase activities for learning.

Table 9: **Students' Age Distribution**

Age (Years)	Frequency	Percentage
Less than 18	10	2.60
18- 20	282	73.44
20-22	70	18.23
22 -24	20	5.21
25 and above	2	0.52
Total	384	100

($n = 384$)

The results in Table 9 showed that majority 362 (94.27%) of the students in the lessons observed were between the age of 18 and 22 making it possible for them to use steeplechase activities for learning. Table 10 presented the experience of the steeplechasers in providing appropriate data for steeplechase activities.

Table 10: **Steeplechasers' Experience at National and International Level**

Steeplechasers	County	National	Olympic Trials	Africa Games	Olympics	Total
Male	12 (10%)	12 (10%)	12 (10%)	12 (10%)	12 (10%)	60 (50%)
Female	12 (10%)	12 (10%)	12 (10%)	12 (10%)	12 (10%)	60 (50%)
Total	24 (20%)	24 (20%)	24 (20%)	24 (20%)	24 (20%)	120 (100%)

$(n = 120)$

The results in Table 10 showed that 48 out of 120 (40%) steeplechaser had participated in local events while 72 (60%) had participated in international events showing how important the Kenyan athletes were at international level. The results also show that the steeplechasers have a wide range of experience making their responses rich in terms of training techniques and programs. The data provided by the steeplechasers was useful in providing necessary suggestions rich in opportunities for simulation of mechanics problems in students' activities.

4.2.1 Discussion on Biographic Data

The results revealed that 21 (21.87%) of lecturers were female compared to their male colleagues who are 75 (78.12%). The results showed that majority, 18 (85.71%) of the female lecturers had either Bachelor of Technology with Education (B.Tech) or Bachelor of Science (B.Sc) degree while majority, 48 (50%) of the male lecturers had higher diploma. The proportion of the lecturers with bachelor's degree and above was 45 out of 96 (46.88%) while one (1) (1%) had masters' degree. The results show that 50% of the lecturers had adequate academic and professional competence needed to handle mechanics. The results show that 85.42% $(n = 82)$ of the lecturers have work experience above six (6) years making their responses rich in terms of pedagogy and process of preparing technologist in mechanics. Jackson (2009) had observed that long working experience was considered an important factor in determining the success of the modeling instructions. The current study was different from what Jackson, Dukerich and Hestenes, (2008) in a study of 14 mathematics related courses observed that when an experienced lecturer is involved in modeling, performance was higher than when a less experienced lecturer is involved. The current study had not attempted to quantitatively account for the influence of lecturers' length of service as a determinant of performance in mechanics. Hence, lecturers' experience in modeling mechanics problems is considered important as an extraneous variable.

Results showed that 13.63% (n = 15) of all the lecturers attended school-based program (bachelors and master's degree) while 8.33% (n = 8) were involved in short courses. The results also showed that 45.83% (n = 44) participated in seminars, SMASSE, workshops and conferences. The results showed that majority of the lecturers were undergoing a form of professional development. The study by Muthoni (2012) and Kerre (2010) the current study concurred that lecturers' in-service training had the capacity to improve students' performance in mechanics.

The results showed that majority 362 (94.27%) of the students in the lessons observed were between the age of 18 and 22 making it possible for them to take part in steeplechase activities. The results showed that 48 out of 120 (40%) steeplechaser had participated in local events while 72 (60%) had participated in international events showing how important the Kenyan athletes were at international level. The results also showed that the steeplechasers had a wide range of experience making their responses rich in terms of training techniques and programs as well as mechanics of training and winning a race. The current study was similar to what Tammet (2012) observed that interaction of mechanics students with experienced steeplechasers was considered important because content areas in which simulation of mechanics problems through track and field athletics (which in this case involves steeplechase activities) could include: work done to raise the steeplechaser's center of mass, mathematical advantages of using a certain doing water jump in terms of energy spent and time taken from take-off to landing, angle of take-off. Similarly, the current study is similar to what Barreau (2011), Beis, Willkomm, Ross, Bekele, Wolde, Fudge and Pitsidalis (2011) and Janusz and Walaszczyk (2011) observed that experienced steeplechasers had better techniques of leaping from water jump rail by staying as low as possible and pushing as hard against the rail.

4.3.0 Steeplechase Activities, Traditional Methods and Performance in Mechanics

This section presented results in response to the first (a) objective on the students' learning gains in mechanics (as predictor of students' performance) when they were taught using steeplechase activities and traditional methods. Table 11 presented factors which influence students' performance in mechanics.

Table 11: **Factors Influencing Students' Performance in Mechanics**

Factors which influence students' performance in mechanics:	f (%)
Mechanics has abstract mathematical calculations	64 (66.7%)
Teaching strategies	79 (82.3%)
Opportunities for practical applications	71 (73.9%)
Attitude towards mechanics	72 (75.0%)
Availability of teaching and learning facilities	80 (83.3%)
Contextualizing learning of mechanics through games and simulations	27 (28.1%)
Industrial training and attachment	73 (76.0%)
Other factors which affect students' performance in mechanics include:	**f (%)**
• Preparation to learn mechanics	19 (19.8%)
• Lecturers adequacy to handling mechanics contents	12 (12.5%)
• Inadequate equipment and apparatus	21 (21.9%)
• Course having too much content to be taught over limited time	13 (13.5%)

(n = 96)

The results in Table 11 showed that the factors which affect students' performance in mechanics included: 79% teaching strategies; 71% opportunities for practical application of mechanics in real life situation; 83% lecturers' characteristics; 67% the abstract nature of mechanics; 81% contextualization of mechanics through games and simulations; 20% students' characteristics, and 84% adequacy and accessibility of teaching and learning resources.

Categorical data from the analysis of the pre-test scripts was considered appropriate for teaching and learning processes. Item analysis of pre-test scripts provides data for understanding of the short falls in pre-requisite knowledge, skills as well as misconceptions in mechanics to facilitate planning for teaching. The data obtained was useful for designing the instructional objectives. The data obtained also provided an impetus for improved teaching and learning processes, class activities, formative evaluation and research in teaching and training processes.

Table 12 presented the results of the item analysis of the pre-test of the constructed type of responses in terms of content tested, difficulty of the test item and students' average performance per question or test item. Cognitive levels considered in Table 12 were described by Twoli (2006) and Volpe (2000) as: (1) knowledge: students carry out minds-on activities related to recall of facts, principles, theories to broaden their level of conceptual understanding (2) comprehension: students use specific rules, work with a network of ideas to form concepts and use methods in a situation typical to those used in class activities (3) application: students use specific rules, work with a network of ideas to form concepts and use methods in a situation typical to those used in class activities; (4) analysis: students break down complex information and look closely at each part to identify relationships among ideas needed in problem-solving activities (5) synthesis: students identify relevant information, construct their own points so as to form a logical and reasonable patterns or structure of ideas clearly not there before; and (6) evaluation: students make informed choices about the suitability of the work done and decisions made against alternative solutions. All the above cognitive levels were considered vital for modeling mechanics problems in steeplechase activities as a combination of various pedagogical techniques used together.

Table 12: **Results from Pre-Test Item Analysis in Mechanics**

Item	Cognitive Level	No. of Students completing item	Value	Content Tested	Average	Facility Value (Difficulty)
1	2	384	3	Linear Motion	2.36	68.0
2	3	384	4	Motion under free fall	1.32	12.0
3(a)	2	384	2	Motion under free fall	1.08	36.4
3(b)	2	384	3	Motion under free fall	1.05	37.6
3(c)	2	384	2	Motion under free fall	1.28	55.2
4(a)	3	384	2	Motion under free fall	1.02	34.9
4(b)	3	384	4	Work at inclined effort	3.05	24.5
4(c)	2	384	2	Kinetic energy	0.97	32.1
4(c) (ii)	4	384	5	Work done and Power	2.00	26.4
5(a)	3	384	2	Work and energy	1.80	71.8
5(b)	4	384	2	Efficiency	1.64	56.3
5(c)	3	384	2	Gear system	1.36	42.7
5(d)	4	384	5	Velocity-time graphs	4.36	65.0
6.	4	384	5	Power generated	2.25	14.3
7(a)	3	384	3	Linear motion	1.90	46.8
7(b)	3	384	3	Linear motion	1.50	41.2
8(a)	2	384	2	Work	0.81	80.1
8(b)	3	384	3	Work done on inclined plane	2.04	42.2
8(c)	3	384	2	Crankshaft power	1.62	53.2
9(a)	3	384	2	Motion under free fall	0.99	49.5
9(a)	3	384	2	Momentum	0.91	45.8
9(b)	5	384	4	Inertia	2.12	53.2
9(b)	5	384	4	Circular motion	1.98	44.9
9(c)	2	384	2	Linear velocity	1.03	51.4
9(c)	2	384	2	Linear velocity	1.02	49.2
9(c)	2	384	2	Linear velocity	1.04	50.5
9(c)	4	384	2	Linear velocity	1.03	51.2
10(a)	3	384	3	Pendulum and time	1.44	37.1
10(b)	3	384	3	Motion under free fall	1.47	39.4
10(b)	5	384	4	Kinetic energy	1.36	38.5
11(a)	4	384	3	Coefficient of friction	1.33	22.6
11(b)	5	384	4	Work done against gravity	1.15	11.4
12(a)	4	384	1	Pulley system	1.00	47.3
12(b)	3	384	1	Work done	0.56	45.1
12(c)	3	384	1	Work done	0.62	48.2
12(d)	2	384	2	Machines Efficiency	0.53	47.7
			Total = 100			

Key: Cognitive level: 1-knowledge; 2-comprehension; 3-application; 4-analysis; 5-synthesis; 6-evaluation

The results in Table 12 showed that in 5-point items, 3% ($n = 10$) of the students got more than half of the average expected scores while 10% ($n = 40$) got less than half. In 4-point questions, 5% (n = 20) got more than half of the expected average scores while 13% (n = 50) got less than half. In a 3-point questions, 10% (n = 40) got more than half while 13% (n = 50) got less than half. In 2-point questions, 29% (n=100) got more than half while 31% (n = 50) got less than half of the expected average scores. In 1-point items, less than 1% (n = 3) got more than half. These results also showed that 18% of the students got more than half of the average expected scores while 32% got less than half in high cognitive items. Thirty seven percent (36%) got more than half of the expected average scores while 31% got less than half in low cognitive questions. These results show that majority (over 50%) of the students got correct questions that are less demanding in terms of cognitive ability. The results also show that 44% of the questions have a 50% (facility value) level of difficulty, 12% have above 50% level of difficulty and 44% have below 50% level of difficulty. These results show that the items in the pre-test which need revision to be suitable for reuse form about 48%. Hence, on average, the items used in pre-test had fair level of difficulty (50%) suggesting that the pre-test items were relatively good for test students' pre-instructional experiences in mechanics related content.

The results related to common errors identified during the item analysis of the students' scripts were presented here. The question related to linear motion was well done by majority of the students. Common errors related to calculations on linear motion were observed. Students were unable to convert speed from kilometers per hour (km/h) to meters per second (m/s). Students were observed to lack basic arithmetic abilities related to addition facts, subtraction facts, multiplication facts as well as division facts. Students were also unable to plot the velocity-time graph. They were also unable to find area of velocity time graph when computing distance. Students are also unable to interpret the graphs or even find area of a trapezium. The students were unable to use diagrammatic representation of situations in the question as an important step in problem-solving techniques.

The question related to motion under free fall was poorly done by majority of the students. The common errors found in calculations related to motion under free fall included the following. Students used velocity in kilometers per minute (km/min) instead of km/h as required in the question. Challenges related to calculations on time were also observed. Students' other errors were related to linear motion equations where calculations of distance students used the formula: $d = mgh$. Calculations involving formulae showed confusion of motion under free fall and potential energy as observed in students' working. These observations showed that those students use formula for calculating potential energy in the place of the equation:

$s = ut - \frac{1}{2}gt^2$. Students were unable to form and solve quadratic equations using linear motion equations.

In solving problems related to linear motion, students were found to confuse equations related to projectile motion with linear motion equations needed for solving problems related to free fall. For example, students applied the formula: $H = \frac{(usin\emptyset)^2}{2g}$ usually used for calculating the maximum height in projectile motion. Students calculated the range suggesting that they attempted to apply the concepts of projectile motion. These observations suggested that there was need for hands-on experiences and use of models for visualization necessary for concept learning. In calculation of initial velocity, other students demonstrated misconception when they correctly applied the equation: $v^2 = u^2 - 2gs$ but were unable to substitute $g = 9.81$ and $u = 0$ leading to two unknowns u and s in a function. The students were not able solve the values of the two unknown. Some students were unable to work out square roots while others were unable to manipulate equation involving change of subject especially when working out problems with square root. Lack of basic manipulation facts suggests that more practice and consolidation of ideas might be a solution in mechanics instruction. Visualization calls for provision of concrete experiences as well as use of appropriate teaching and learning resources such as those found in steeplechase activities.

In calculation of initial velocity, some students demonstrated misconceptions involving application of the equation: $v = u - 2gs$ instead of the equation: $v^2 = u^2 - 2gs$ indicating confusion of the two equations. When the formula: $v = u - 2gs$ was used, initial velocity was found to be 1962m/s and time of 400 seconds. The working suggested that students make mistakes related to premature approximation.

Other common errors include: inability to work out resolution of forces; wrong substitution; misconception related to decimal fractions and inability to present information diagrammatically. Other common errors were related to calculations on forces and use of incorrect symbols. In calculation of kinetic energy, students did not convert mass from grams to kilograms. Some students used velocity in calculation of work instead of acceleration while others demonstrated misconception related to conversion from meters per minute to meters per second. These observation showed that fundamental concepts (displacement and velocity; force and acceleration; work and energy; projectile and constant angular motion) in mechanics might need special attention when being taught using interactive engagement. Study on alternative pedagogical techniques was therefore necessary.

Some of the students were able to make a diagrammatic presentation of the situation in the question correctly but interchanged the forces $Psin38°$ and $Pcos38°$. It was observed that other students attempted to make a diagrammatic representation but did not represent the situation correctly. In one of the responses, the diagram representing the situation is shown in Figure 3.

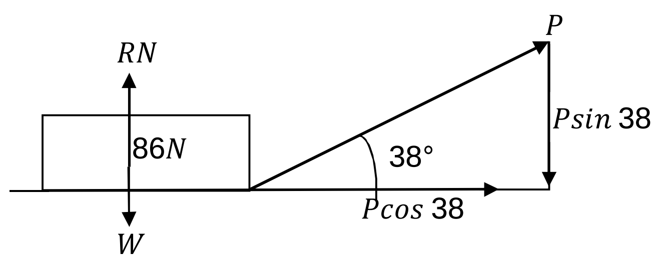


Figure 3: **Resolution of Forces**

From Figure 3, the force toward point P and $Psin\,38$ were in the opposite direction. As a result, students attempted to resolve the forces incorrectly. That led to confusion of the forces that needed resolution. The expressions: $Pcos\,38$ and $Pcos\,38$ seemed not have the symbol for degrees (°). It was not clear in which direction the force $86N$ was observed to act upon. After drawing, the student worked out the problem. That might explain the reasons for making mistakes in the students' responses. These observation showed that fundamental concepts (displacement and velocity; force and acceleration; work and energy; projectile and constant angular motion) in mechanics might need special attention using interactive engagement such as simulation of mechanics problems through sports and games as an important ingredient of recreational mathematics. The question related to work, efficiency and gear system, common errors involved a mix-up of velocity ratio and mechanical advantage for example some students computed efficiency by the same approach to get 1.33. Some students got 1.333 which was unrealistic because efficiency is usually below 1.0 due to the energy spent to overcome friction, energy converted to sound and heat forms. Some students multiplied $\frac{10N\times 8m}{30N\times 2m}$ by 100 to get 133.3, a figure that was unrealistic. The result suggested that efficiency was higher than 100%. Some students worked out efficiency by $\frac{60}{80}\times 100 = 15\times 5 = 65$% instead of 75%.

In computing efficiency some students correctly divided distance moved by load. Other students divided distance moved by effort to get velocity ratio (V.R) as 2 but wrongly divided effort by load to get mechanical advantage (M.A) of 0.3 instead of dividing the load by effort to get 3. When the same students multiplied ratio of M.A to V. R by 100, they got a machine efficiency 16.67% (which was unrealistic) instead of 75%. In that case those students got M.A correct but their V.R was wrong. Following the same approach, some students got both M.A and V.R wrongly because they divided effort by load to get V.R of 0.25 instead of 2. Some students divided load distance by effort distance to get M.A of 0.3 instead of 3. Wrong values on machine efficiency obtained were 133.32 which were unrealistic. Machine efficiency cannot be 100% or more due to the amount of energy used to overcome friction of the moving parts. Those observations showed that fundamental concepts (displacement and velocity; force and acceleration; work and energy; projectile and constant angular motion) in mechanics might need special attention as taught using interactive engagement such as steeplechase activities.

In computing the ratio of the gear system, some students divided twice the number of teeth of the driven wheel by number of teeth of the driven wheel minus the number of teeth of the driving wheel ($V.R = \frac{2\times 74}{74-32}$) to get 3.524 instead of $V.R = \frac{74}{32}$ to get 2.3125. Some students worked out the ratio of the gear system as the ratio of the number of the teeth of the driving wheel to the number of teeth of the driven wheel to get 16:37 or 32: 74. Similarly, other students worked out the ratio by dividing 32 by 74 to get 0.4324. Those students computed the velocity ratio by calculating the reciprocal of 0.4324 to get 2.3125. In computing the ratio of the gear system some students correctly divided 74 by 32 to get 2:3 instead of 2.3125. That suggested that students concept of the ratio was not developed.

In a question testing on knowledge and skills on momentum, inertia and circular motion, the common errors include: inability to work out square root; premature rounding-off; misconception on momentum as a product of velocity and mass; inability to compute the average force; inability to work out the linear speed of a point which is a product of angular speed and radius; and misconception related to linear speed of a point. In a question testing skills on pendulum, time and linear motion, common errors include: inability to work out average velocity; inability to work with pendulum motion as to and from; lack of in-depth understanding of concepts in linear motion equations needed when working out related problems and misconception related to constant acceleration. Hence, there was need to use pedagogical techniques useful for simulation of mechanics problems such as steeplechase activities.

In a question testing skills on coefficient of friction and work done against gravity, the common errors included: lack of ability to understand concepts related to equilibrium attained by a sliding object. Other common errors included frictional force remaining approximately constant and equal to limiting friction. Students demonstrated misconception related to coefficient of kinetic friction concepts; confusion on limiting frictional force and normal reaction. Students were also unable to identify the information that they need to find in the question. Students demonstrated misconceptions related to trigonometric ratios; calculations related to inclined planes and work done by effort in a machine. Other students had misconception related to machine efficiency since some students found efficiency as 110% which is unrealistic. The presence of misconceptions as well as mistakes above suggested a need for alternative strategies for encouraging visualization for concept learning in mechanics. Explanation for the above common errors could be found in the pedagogical techniques used for teaching mechanics in diploma technical institutions. Results in Table 13 presented lecturers' responses on the most frequently used mechanics teaching strategies.

Table 13: **Lecturers' Responses on Most Frequently Used Teaching Strategies**

Most frequently used teaching strategies:	Frequency	(%)
Lecture method	18	18.8%
Dictation of notes	16	16.7%
Question and answer	15	15.6%
Use of examples and illustrations	9	9.4%
Lecturers' demonstrations	7	7.3%
Exercises & Assignment	4	4.2%
Library research	3	3.1%
Practical work and students experiments	6	6.3%
Small-group discussion	3	3.1%
Collaborative learning	2	2.1%
Steeplechase activities	-	-
Others teaching strategies include:		
• Field trips and educational visits	5	5.2%
• Use of ICT for collaborative learning through the internet	4	4.2%
• Industrial-related training strategies used in mechanics?	4	4.2%
Total	96	100.0%

Results in Table 13 show that 60% ($n = 58$) of all the lessons depends on expository teaching strategies, while 26% ($n = 25$) depend on interactive strategies while 14% ($n = 13$) depend on other strategies of teaching. The results from observation were different since 85% of all the mechanics lessons observed in the study depended on traditional teaching strategies. Twenty eight 15% of the lessons observed depended on interactive teaching strategies.

The data obtained from students' work for modeling mechanics problems when steeplechase activities were used for teaching were presented in tables. Table 14 presents the student Group A's responses on the rationale of using steeplechase activities for learning mechanics.

Table 14: **Group A's Responses on Using Steeplechase Activities for Learning Mechanics**

Steeplechase Activities	Simulation of Mechanics problems	Mathematical modeling on:
Take off from the ground	Time of flight, distance from the ground to the hurdle, projection velocity	Principles of projectile motion, optimum friction needed
Leaping from water jump rail	Time of flight, distance from the ground, projection velocity, force, work and power, height of the center of mass and friction	Principles of projectile motion, force, work energy, power and optimum friction
Running through water	Force of water, Friction Modeling equation of the path of the center of mass	Principles of viscosity, motion, force, work energy and power, optimum friction,
Doing an ordinary hurdle	Time of flight, distance from the ground, projection velocity and friction Equation for clearing ordinary hurdles	: Principles of projectile motion, force, work energy and power, optimum friction needed
Speed sprint on the track	Average speed and friction	Principles of speed and optimum friction needed
Athletes statistics	Likelihood of a particular athlete or team winning in a race	Principles of probability of athletes or team winning a race
Use of matrix	players or teams statistics random numbers to determine who they will be competing with	Application of matrices in problem-solving, random numbers
Participating in a heat	Number of contestants used to determine if in the first heat or second or any other	Probability of winning in a heat in terms of time

Data in Table 14 showed that the observations in the show that fundamental concepts (displacement and velocity; force and acceleration; work and energy; projectile and constant angular motion) in mechanics could be modeled using steeplechase activates for teaching.

Table 15 presented Group B's responses on the mathematical skills developed when steeplechase activities were used for teaching and learning.

Table 15: **Group B's Responses on Mathematical Skills in Steeplechase Activities**

Steeplechase Activities	Mathematical skills in Mechanics	Concept modeling in mechanics
Running in the actual race	Estimation of peers likely move, velocity of team mates	Principles of predicting sprint finish, keep up pace and do sprint finish
Measurement	Estimation of time, angles, velocity and changes in pace, angular velocity	Principles of estimation, use of technical tools, estimation skills
Small-group discussions	Problem-solving skills, interpersonal skills, listening skills, speaking skills, preparation for group presentation skills, leadership skills,	Principles of problem to be solved, role of each member in the learning process, take responsibility
Group results presentation and responding to questions	Skills in making logical arguments, critical thinking, analytical thinking skills and problem- solving skills	Understanding of the problem to be solved, in-depth understanding of concepts developed through Socratic probing

The data in Table 15 showed that the mathematical skills which could be developed when steeplechase activities were used for teaching include: skills in making logical arguments, critical thinking, analytical thinking skills and problem-solving skills, interpersonal skills, listening skills, speaking skills, preparation for group presentation skills, effective decision making skills, data handling skills, mental well-being, emotion stability, social interaction skills, leadership skills, estimation of time, angles, velocity, changes in pace and angular velocity. The data also showed that the major mathematical skills developed revolved around: cognitive skills and interpersonal skills, data handling skills, effective decision skills and effective communication skills.

Table 16 presented the Group C's responses on simulation of mechanics problems used when steeplechase activities were used for teaching and learning.

Table 16: **Group C's Responses on Simulation of Mechanics in Steeplechase Activities**

Steeplechase Activities	Mathematical Calculation in Mechanics	Rationale
Take-off from the ground to land on the water-jump hurdle	Time of flight (between $0.1s$ and $0.2s$) Distance from the ground to the hurdle (between $1.5m$ to $2m$) Angle of projection (between $40°$ to $45°$) Projection velocity (between $5m/s$ and $6m/s$) Friction	Principles of projectile motion Principles of projectile motion Optimum friction needed
Leaping from water jump rail (the steeplechaser is as low as possible then presses as hard as possible against the rail)	Time of flight (between $0.4s$ to $0.6s$) Angle of projection (between $40°$ to $45°$) Projection velocity (between $6m/s$ and $7m/s$) Force ($855N$), work ($3.181kJ$) and power ($6361J/S$) for take off Height of the center of mass from the ground(between $6m/s$ and $7m/s$) Friction	Principles of projectile motion, force, work energy and power (steeplechaser aim at saving time) Optimum friction needed
Impact on the leg (instep, toes , arch & ankle of heel) when landing on sand-bags	Velocity slightly before landing is $6m/s$ Average mass of athlete if female is $65kg$ Impact on the leg is approx. $390kg/s$ Average mass of athlete if male is $75kg$ Impact on the leg is approx. $450kg/s$	Conservation of linear momentum: The greater the impact, the worse of the athlete Need for lighter weight
Cumulative impact of the sand-bag	The number of athletes is fifteen (15). Cumulative impact is $6300kg/s$	Conservation of linear momentum: impact may move the sand-bags
Running through water	Force of water to overcome Nearer the hurdle, more force needed compared to away from the deep end Friction	Principles of viscosity, motion, force, work energy and power Optimum friction needed
Doing an ordinary hurdle	Time of flight (between $0.1s$ and $0.2s$) Height of the hurdle from the ground (between 0.72 to $0.914m$) Angle of projection (between $40°$ to $45°$) Projection velocity (between $6m/s$ and $7m/s$) Friction	Principles of projectile motion, force, work energy and power Optimum friction needed
Speed sprint on the track	Average speed ($5m/s$ to $7m/s$) Friction	Steeplechasers aims at saving time Optimum friction needed

The data in Table 16 showed that content areas in which steeplechase activities could be used for simulation of mechanics problems included: angular velocity, impact, conservation of momentum, friction, speed, time spent, projectile motion, linear motion, force, work energy and power. Those concepts illustrated were fundamental in introductory mechanics. Table 17 presented calculation results on angular velocity from students' measurements.

Table 17: **Group D's Responses on Calculations on Angular Velocity**

Running Zone	Arc Subtends Angle of:	Radius	Distance of Arc	Time	Angular Velocity	Remarks
World record of 7 minutes and 53.63 seconds with average velocity of 6m/s						
Starting/finishing line	31.38°	36.5m	12.2m	2.03s	15.46°/s	Fast pace
Bend between steeplechase 1st& 2nd hurdle	125.52°	36.5m	80m	13.33s	9.42°/s	Sharp bend (work on balance)
Start of 200m&100m sprint	42.52°	36.5m	13.3m	2.21s	19.24°/s	Fast pace
Start &end of water-jump straight	47.45°	16.0m	13.6m	2.27s	20.90°/s	Fast pace (sprint)
Steeplechasers' men time of 9 minutes and 45.17 seconds (manual) with average velocity of 5.35m/s						
Starting/finishing line	31.38°	36.5m	12.2m	2.28s	13.76°/s	Fast pace
Bend between steeplechase 1st& 2nd hurdle	125.52°	36.5m	80m	14.95s	8.39°/s	Sharp bend (work on balance)
Start of 200m&100m sprint	42.52°	36.5m	13.3m	2.53s	16.81°/s	Fast pace
Start &end of water-jump straight	47.45°	16.0m	13.6m	2.54s	18.68°/s	Fastest pace (Sprint)
Steeplechasers' women time of 11 minutes and 53.53 seconds (manual) with average velocity of 4.41m/s						
Starting/finishing line	31.38°	36.5m	12.2m	2.77s	11.33°/s	Fast pace
Bend between steeplechase 1st& 2nd hurdle	125.52°	36.5m	80m	18.14s	6.92°/s	Sharp bend (work on balance)
Start of 200m&100m sprint	42.52°	36.5m	13.3m	3.02s	14.08°/s	Fast pace
Start &end of water-jump straight	47.45°	16.0m	13.6m	3.08s	15.41°/s	Fastest pace (Sprint)

The results in Table 17 showed that the steeplechasers' angular velocity was lowest at the zone between the first and the second steeplechase hurdle (average of 8.24°/s) and the highest at the zone near the water-jump straight ($18.33^\circ/s$). These results also showed that barriers could slow down steeplechasers making the race spectacular and interesting to watch. In zones with lower pace, the steeplechasers had opportunities to overtake or improve their time by ensuring optimum balance while zones for fast pace were meant to help athletes maintain their pace except at the finishing dash where the winner was determined by maintaining balance, being in the front pack then sprinting throughout the last 200 meters of steeplechase. These observations and description were necessary for modeling of mechanics problems.

Mechanics students in steeplechase had lower pace (4.11m/s for men and 3.34m/s for women) than the guest steeplechasers (6m/s). Hence, the angular velocities of students were lower than those of guest steeplechasers. These results suggested that steeplechase activities had the capacity to involve students in measuring time, angles, and arc distance to determine the angular velocity. Students in small-group discussions could use the IAAF (2008) Edition of the Marking Plan of 400m Standard Track. These observations and description were necessary for modeling of mechanics problems. Figure 4 showed a diagrammatic presentation of the projectile motion by Group E on the maneuvers made by steeplechasers at the water-jump.

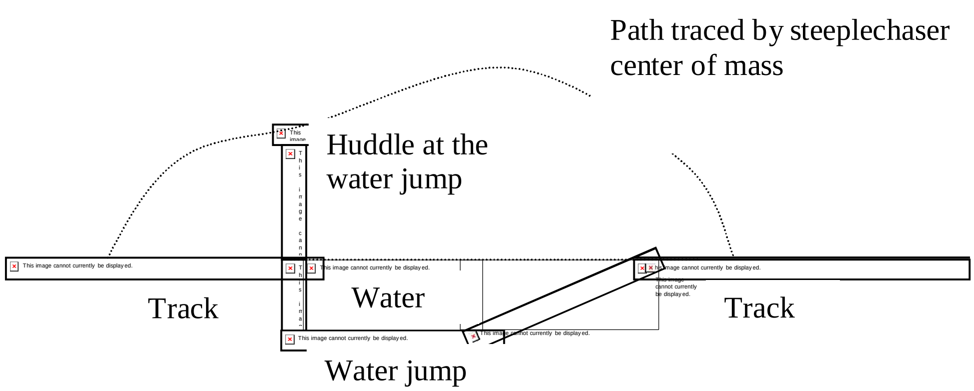


Figure 4: **Group E's Presentation of Projectile Motion at Water-Jump**

Figure 4 showed that students in Group E were able to make a diagrammatic presentation of maneuvers made by steeplechasers at the water-jump. Students' responses on the projectile motion at the water-jump were reported as shown here. The optimum initial velocity at which steeplechasers were expected to move pushed hard against the rail to be able to step almost at the end of the water jump at between 5m/s to 6m/s. The initial velocity for novice steeplechasers was almost zero (0.5m/s) because the hurdle at the water was a barrier that almost stopped the athletes. Since it was hard to attain a high initial velocity, say of 6m/s, the ideal initial velocity was estimated as 5.857m/s. If a steeplechaser took off from the rail at a velocity of 5.857m/s and an angle of 45^0, the athlete shall landed at about 0.1m away from the end of the water jump before proceeding on to sprint again on the track. The optimum take off velocity was estimated at between 40^0 and 45^0. Where possible, an athlete aimed at stepping on the rail with the trail leg then stepping out onto the track on the lead leg. If the initial velocity was low, say 5.5m/s or below and the take-off angle was 40^0 or below, the athlete would need to get into the water with both legs then push through turbulent waves of water. Passing through the water consumed a lot of energy apart from slowing down the athlete due to water pushing back against the forward motion.

In calculation of the range (the horizontal distance travelled by the center of mass of the steeplechase) in projectile motion was given by the equation:

$$Range = 0.10417(s^2m^{-1})v_0^2\sin(2 \propto)$$

Mechanics students in Group E considered that $\sin(2\theta)$ was a unit (1) if $\theta = 45°$, optimum initial velocity of $5.93m/s$ and the length of the water jump pit was 3.66m. The students divided the value: $3.66m$ by $(5.93m/s)^2$, to obtain $0.10417(s^2m^{-1})$ which was found to be a constant connecting range and the initial velocity. The equation above was similar to what had been developed by Mathematics in Sports (2012).

Table 18 presented the pedagogical technique lessons from the discussion with the steeplechasers on their training techniques and programs to provide insight into specific activities that were useful in simulation of mechanics problems.

Table 18: **Pedagogical Lessons from STA Training Techniques and Programs**

Areas developed through Training programs	f (%)
Doing water jump	39 (32.5%)
Hurdling	38 (31.7%)
Economy of energy to have reserve for sprint finish	24 (20.0%)
Role of hurdling drills and circuit training	
Speed	24 (20.0%)
Hurdling experience	43 (35.8%)
Efficient breaking and acceleration	45 (37.5%)
Stamina	43 (35.8%)
Endurance	30 (25.0%)
Ability to kick back at the hurdle at the water jump	30 (25.0%)
Purpose of interval training	
Endurance	30 (25.0%)
Stamina	37 (30.8%)
Sprint finish	46 (38.3%)
Balance in jumps	53 (44.2%)
Training in spreading ones energy throughout the race	30 (25.0%)

Key: STA-steeplechase activities $(n = 60)$

The results in Table 18 showed that areas which needed specialized training programs and techniques were found to include: 33% water jump, 32% hurdling and 20% running economy of energy reserve. The role of hurdling drills techniques and circuit training includes: 20% improvement of speed, 36% efficiency in breaking and acceleration. Students' understanding of the training program for steeplechasers had the capacity to understand the reason behind their spectacular performance in world competitions. The Table 19 presented pedagogical lessons from hurdling strategies used at the water jump.

Table 19: **Pedagogical Lessons from Hurdling Strategies at the Water-Jump**

Techniques for doing hurdle at water jump involve:	f (%)
Maintaining low hip	42 (35.0%)
The leg on the hurdle is bent	55 (45.8%)
The push from the barrier is delayed until the body is well beyond it	87 (72.5%)
The athlete propel himself or herself to maximize the drive	71 (59.2%)
Landing is done with the lead leg in the water while the trail leg steps outside the water	82(68.3%)

(n = 120)

Table 19 showed that techniques for hurdling at the water jump include: 35% maintaining low hip; 73% the push from the barrier was delayed until the body was well beyond it, 60% the athlete propel himself or herself to maximize drive and 68% landing was done with the lead leg in the water while the trail leg steps outside the water.

Table 20 showed the reliability statistics based on alpha model.

Table 20: Reliability Statistics

Group	Cronbach's Alpha	N of Items	n
Traditional Methods of Teaching (TMT)	0.673	2	96
Lecturer’s Demonstration (LD)	0.631	2	96
Steeplechase Activities (STA)	0.624	2	96
STA-Female	0.414	2	20
STA-Male	0.649	2	76

Model: Alpha; Items compared: pre-test and post-test results

Results in Table 20 showed that use of pre-test and post-test results to make inferences on students’ learning gains (as predictors of performance in mechanics) was relatively high in all groups (except for the STA-Female group of students) since the expected Cronbach's Alpha was 0.700 (Thompson, et al., 2005).

Results on the test of a normal curve were presented as shown here. Results on pre-test (n = 384) was skewed to the lower performance or positively skewed (+0.622; $std.error$ = 0.125) as well as being less peaked (+0.805; $std.error$ = 0.248). Results on post-test for traditional method of teaching (n = 192) was skewed to the lower performance or positively skewed (+0.534; $std.error$ = 0.175) as well as being less peaked or platykurtic (1.33; $std.error$ = 0.349). Results on post-test for lecturer's demonstration (n = 96) was near normally distributed (3.034; $std.error$ = 0.246) as well as being mesokurtic (-0.122; $std.error$ = 0.488). Results on post-test for steeplechase activities as a method of teaching (n = 96) was skewed to the upper performance or negatively skewed (−0.282; $std.error$ = 0.246) as well as being more peaked or leptokurtic (3.30; $std.error$ = 0.488). Lack of symmetry on the distribution of students' scores led to use of students' normalized learning gain in mechanics. Table 21 presented the students' learning gains in mechanics (descriptive statistics) for the treatment and the control groups.

Table 21: **Students' Learning Gains in Mechanics for Teaching Groups**

Group	Mean		n	Std. Dev.	Gain	Normalized Gain
	*Pre-Test	Post-Test				
Steeplechase Activities	31.68	63.71	96	12.376	32%	47%
Lecturer's Demonstration	31.68	46.72	96	9.383	15%	22%
Traditional Methods of Teaching (TMT)-Lecture method)	31.68	42.02	96	10.480	10%	15%
TMT- use of examples and Q&A	31.68	41.84	96	9.223	10%	15%

*Pre-Test (Sample Mean)

Results in Table 21 showed that the treatment (steeplechase activities) group of students had a gain of 32% which translates to normalized gain of 47% ($std.dev.$ = 12.376). The work by Wells (1987) on modeling showed that the normalized gain of 48% was significant at 5% level. The normalized gain of 47% showed that the treatment group. The lecturer's demonstration had a gain of 15% which translates to a normalized gain of 22% ($std.dev.$ = 9.383). Traditional methods of teaching had a gain of 10% which translates to a normalized gain 15% ($std.dev.$ = 10.480) for CG_1 and ($std.dev.$ = 9.223) for CG_2. The difference in the standard deviation between control groups CG_1 and CG_2 suggested that more interactive expository strategies might reduce the learning difficulties in mechanics. These results also suggested that the lecturer's demonstration had greater capacity to improve students' learning gain (as a suitable predictor of students' performance in curriculum-based examination) in mechanics than alternative methods (expository strategies and lecturer's demonstration). The test of hypothesis on the difference between the students' gains when students were taught using steeplechase activities and traditional methods of teaching was done here. The first hypothesis H_{O1} was stated as:

H_{O1} –**There is no significant difference in performance in mechanics when learners are taught using steeplechase activities and traditional methods of teaching.**

Table 22 presents the z-test statistics which were used to test the first and the second hypotheses (H_{O1} and H_{O2}).

Table 22: **Paired Samples Z-Test Statistics**

		Paired Differences			z	df	Sig.
		Mean	Std. Dev.	Std. Error Mean			(2-tailed)
Pair 1	STA - TMT	21.69	17.386	1.774	12.222	95	0.000
Pair 2	STA - LD	16.99	14.520	1.482	11.464	95	0.000

p = 0.05; df = 95

STA-Steeplechase Activities; LD- Lecturer's Demonstration; and TMT-Traditional Methods of Teaching

Since the table value of significance (2-tailed test) is less than 0.05 for df = 95 (0.000 < 0.05), the study rejects the null hypothesis H_{01}. The paired difference between students' learning gains in mechanics when students were taught using participation in steeplechase activities and traditional methods is 22% (normalized gain of 32% ($std.dev.$ = 17.386) also reflected in which is significant at 5% level. The difference between normalized students' learning gains in mechanics when students were taught using steeplechase activities and lecturer's demonstration was 17% (normalized gain of 25% ($std.dev.$ = 14.520) also in Table 26) which was significant at 5% level. The above results of normalized students gain in mechanics for students when students were taught using steeplechase activities had greater capacity to improve performance in mechanics than the alternative teaching strategies. The difference in variability in the normalized learning gains suggested that using lecturer's demonstration and steeplechase activities for teaching might had greater capacity to reduce learning difficulties than expository methods of teaching. These results of students' learning normalized gain suggested that using interactive engagement methods for teaching mechanics had greater capacity to improve students' performance in mechanics than alternative methods of teaching.

4.3.1 Learning Gains for Steeplechase Activities and Traditional Methods

The results discussed in this section were in response to the first (a) objective of the study on the difference in students' learning gains (as predictor of performance) in mechanics when students were taught using steeplechase activities and traditional methods.

The factors which influence students' performance in mechanics were discussed as shown here. The results showed that the factors which could influence students' performance in mechanics include: 79% teaching strategies and 67% mechanics is abstract in nature. The current study concurred with what Amuka, Olel & Gravenir (2011) and Nzama (2000) asserted those lecturers' related characteristics which contribute to poor performance in mechanics which included putting more emphasis on theoretical teaching while neglecting to provide for adequate practical experiences. The current study concurred with what Butunyi (2009), Muthaa (2009) and Nzama (2000) asserted that poor performance in mechanics in South Africa and Kenya was associated with teaching strategies. The solution to poor performance in mechanics might be based on using a combination of teaching strategies (interactive methods of teaching) to meet all students' needs in terms of their interest and learning styles.

In response to the first (a) objective of the study on the students' learning gain (as predictor in students' performance) in mechanics, this section also interrogated item analysis of the pre-test scripts as a useful tool for planning for instructional design. The study found that data obtained from item analysis was useful for designing the instructional processes to deal with the short falls identified. The study also found that the data obtained was also useful in providing an impetus for improved teaching and learning processes, class activities, formative evaluation and research in teaching, learning and training processes. The current study concurred with what Jackson (2009) observed that analysis of pre-test items had the capacity to guide lecturers in determining students' entry behavior, diagnose learning difficulties and choose appropriate teaching and learning strategies. The current study concurred with what Baldwin & Yun (2012) and Inghan (2008) asserted that item analysis of pre-test scripts was an integral part of planning tool for effective instructional process in mechanics because it played an important role in diagnosing students' learning difficulties. Therefore, item analysis of pretest was conducted and the results discussed as shown below.

The results showed that in 5-point items, 3% ($n = 10$) of the students got more than half of the average expected scores while 10% ($n = 40$) got less than half. In 4-point questions, 5% ($n = 20$) got more than half of expected average scores while 13% ($n = 50$) got less than half. In a 3-point items, 10% ($n = 40$) got more than half while 13% ($n = 50$) got less than half. In 2-point questions, 29% ($n = 112$) got more than half while 31% ($n = 50$) got less than half of the expected average scores. In 1-point items, less than 1% ($n = 3$) got more half. These observations from study results suggested that 18% of the students got more than half of the average expected scores in questions dealing with low cognitive level while 32% got less than half in high cognitive items. These observations in the study results also suggested that majority (over 50%) of the students got correct questions that were less demanding in terms of cognitive ability. Therefore, the study found that majority (over 50%) of the students lacked the required pre-requisite knowledge and skills for effectively learning of mechanics concepts.

The results also showed about a third (38%) of students mistakes were concentrated in questions which required higher cognitive levels such as conceptual understanding of mechanics while two third (62%) of the mistakes were concentrated on questions which required lower level cognitive level. The current study concurs with what Goldfinch, Carew and McCarthy (2009) suggested that globally, students' mastery of higher order cognitive skills in mechanics was limited. Hence, the current study concurred with what Goldfinch, Carew and McCarthy (2009) observed that students had the highest number of mistakes associated with conceptual understanding, critical and analytical skills. The current study concurred with what Fang (2014) and Wells (1987) asserted that problem of limited conceptual understanding in teaching and learning mechanics could be addressed through using interactive engagement methods. Therefore, teaching mechanics for conceptual understanding could have been needed.

Students taking mechanics were found to have common errors in content areas such as: coefficient of friction and work done against gravity. Specifically, the misconceptions demonstrated lack of understanding of equilibrium attained by sliding objects on a floor or a rough surface. Students were also unable to appropriate frictional force which remains constant and it is equal to limiting friction. In coefficient of kinetic friction, students confused limiting frictional force and normal reaction. Students were also unable to identify the information provided and what information was needed in solving related problems. In the question related to work efficiency and gear system, the misconceptions involved a mix-up of velocity ratio and mechanical advantage. Working suggested that students made mistakes related to premature approximation. Other common errors included: inability to work out resolution of forces; wrong substitution; misconception related to decimal fractions and inability to represent information diagrammatically. In solving problems related to linear motion, students confused equations related to projectile motion with linear motion equations when solving problems related to free fall. In calculations related to linear motion, students were observed to calculate the range. Students demonstrated mistakes related to trigonometric ratios; calculation on inclined planes and work done by effort in a machine. Other students had misconception related to machine efficiency since some students found efficiency of 110% which was unrealistic. The content related to momentum, inertia and circular motion, students' misconception include: inability to work out square roots and mistakes in premature rounding-off. Other misconceptions were related to momentum as a product of velocity and mass because students were unable to compute the average force. Students were unable to work out linear speed of a point which is a product of angular speed and radius. All those observed mistakes, errors and misconceptions in students' examination pre-test scripts suggested that there was limited conceptual understanding of pre-instructional concepts in the introductory mechanics offered at diploma level. The same observations related to students' examination pre-test scripts also suggested that interactive engagement methods of teaching might need to be interrogated further to identify what pedagogical techniques could be used to improve students' conceptual understanding of mechanics. The current study was different from Goldfinch, Carew and McCarthy (2009) who asserted that poor performance in mechanics was associated with teaching and learning based on linear procedural knowledge, memorization of facts, principles, laws and the theorems instead of aiming at developing conceptual understanding and analytical skills. The current study concurred with what Amuka, Olel & Gravenir (2011) asserted that in diploma technical institutions there was overemphasis of theoretical teaching of the practical oriented course such as mechanics. The current study concurred with what Kerre (2010); Henderson & Broadbridge (2007) observed that interactive teaching strategies had capacity to post better performance in mechanics compared to expository approaches. Specifically, the current study concurred with what Cockcroft (1982) observed that combination of teaching strategies could tap from different students' learning styles. An alternative teaching strategy which could solve the problem of misconception was best understood when the existing strategies were interrogated (Fang, 2014; Huang, 2011). Once the existing strategies were interrogated, their influence was compared to steeplechase activities as for teaching which might be the panacea for students' poor performance in mechanics.

Results showed that 72% ($n = 55$) of all the lessons depended on traditional methods of teaching while 28% depended on interactive methods of teaching. The results from lesson observation were different from the lecturers' responses. Lesson observations showed that 85% of all lessons in the study depended on traditional methods of teaching (chalk and talk) while 15% of the lessons depend on the lecturer's demonstration. The current study concurred with what Muthoni (2012), Bukhala (2009) and Muthaa (2009) found out that expository teaching and learning approaches were 80% frequently used while interactive teaching approaches were 20% frequently used. Similarly, the current study concurred with what Khakala (2009) found in secondary schools, that 77% of all the mathematics lessons in secondary schools in Nairobi and Western Regions in Kenya depended on teacher-centered teaching strategies while 23% advocated for the use of problem-solving strategies. Similarly, a study by Mwenda, et al., (2013) in Tharaka South District in Kenya mathematics lessons in secondary schools, teacher demonstration (teacher-centered teaching strategy) was used in over 70% ($n = 248$) of the lessons while class discussion (interactive teaching strategies) accounted for less than 30% of the lessons taught. The current study agreed with observations by Mwenda, et al., (2013), Muthoni (2012) and Khakala (2009) that expository teaching strategies were more frequently (in 80%) used than interactive teaching strategies (in 20%) in both secondary schools and in diploma technical institutions in Kenya. The current study was different from what Government of Kenya (2010b) argued that there was a similarity between mathematics and science teaching in secondary schools and tertiary colleges because of the teachers' and lecturers' similarity in training in the university and other teacher training institutions. Hence, theoretical teaching might need a lasting solution to the problem through steeplechase activities as an interactive teaching strategy.

The results showed that the factors which affected performance in mechanics included: 71% opportunities for practical application of mechanics in real life situations; 81% contextualizing mechanics learning through games and simulations; and 76% industrial attachment. The current study concurred with what Mwinzi (2012), Abdullar & Sharrif (2008) and asserted that involving students in instructional activities could post higher scores than expository teaching strategies. Alternative teaching strategies which could better meet students' needs involve interactive teaching strategies. Interactive teaching strategies were found to be missing in the lessons observed during the study. Therefore, teaching using steeplechase activities might had the capacity to improve students' performance in mechanics. The current study concurred with what Jackson (2009) and Meltzer (2002) observed that interactive learning in practical lessons could develop students' critical and analytical thinking skills as well as encourage life-long training. Students taking mechanics could engage in scientific inquiry through steeplechase activities by making and using mathematical models used to describe, explain, predict, design and control physical phenomenon (Billington, et al., 2014). Mathematical modeling instruction could make it possible for students to use scientific tools for collecting, organizing, analyzing, visualizing and modeling real data to justify and support their predictions. The studies by Abdullar and Sharrif (2008) did not discuss the influence of using steeplechase activities for modeling mechanics problems a gap filled by the current study. However, the ideas in modeling instruction in Abdullar and Sharrif (2008) were used in the theoretical framework of this study.

The current found that 83% lecturers' characteristics affect students' performance in mechanics. Lecturers' inability to create link between what had already been learnt and what had not been learnt could lead to misconceptions. The current study concurred with what Absi, et al., (2009) Abdullar & Sharriff (2008) asserted that new experiences needed to be interpreted in the light of the existing experiences. Hence, establishing what trainees already knew could play an important role in laying a firm foundation for development of network of ideas and facilitate development of new concepts. These observations pointed to the need to use pedagogical techniques (such as steeplechase activities) which promoted the use of modeling instruction for teaching mechanics in diploma technical institutions.

The results in the current study showed that using steeplechase activities for teaching involve: 18% participation in actual race and data collection; 13% carry out mathematical calculations. Forty percent (40%) of the lecturers felt that students could hold discussion with the steeplechaser and 32% make group presentations of the findings and results to the whole class. These observations suggested that steeplechase activities had the capacity to encourage modeling instruction in mechanics and encourage interactive learning which could be the key to development of scientists and physicists (Hestenes & Wells, 1999). Hence, steeplechase activities have the capacity to develop scientific methods.

The results showed that areas which need specialized training programs and techniques include: 31% water jump, 39% hurdling and 25% running economy of energy reserve. The role of hurdling drills techniques and circuit training include: 44% improvement of speed, 47% efficiency in breaking and acceleration. Steeplechase activities could enrich simulation of mechanics problems. The current study concurred with what Francois and Kerkhove (2010) that socio-cultural activities which were rich in mathematics can be a source of content, teaching and learning strategies which could contextualize learning. The current study concurred with Beis, et al., (2011) and Onywera (2006) who asserted that unique characteristics of the elite steeplechasers in Kenya included their sense of discipline in training; intelligence in doing the water jump; running in a pack in the race (Beis, et al., 2011; Onywera, 2006). The mathematical calculations from the spectacular record held by Saif Saaeed Shaheen (formerly named Stephen Cherono) of 7:53.63 suggested that the hurdlers spent about 5.25 seconds for water jumps, 14 seconds for ordinary barriers and 11.719 seconds for each of the 80m straight with an average speed of 6.82m/s. The average speed of about 7m/s suggested that the predominant activities in the race were running accompanied by explosive activities such as: sprinting, changing pace, jumping, kicking back at the water jump hurdle to propel one-self over the water barrier landing and accelerating again. The current study concurred with what Beis, et al., (2011) and Onywera (2006) pointed to the fact that steeplechase activities could be a source of content such as: displacement and velocity; force and acceleration; work and energy; and momentum and impulse which might need to employ pedagogical techniques in interactive approaches such as steeplechase activities. These observations were consistent with what was in the data which showed that content areas in which steeplechase activities could be used for simulation of mechanics problems included: friction, speed, time spent, projectile motion, linear motion, force, work energy and power. Therefore, steeplechase activities as a teaching strategy might provide learning stimulation needed in mechanics lessons.

The current study found that understanding of mechanics content in areas in steeplechase activities which include; angular velocity, time of flight, angle of projection, projection velocity, height of center of mass, trajectories, equations of linear and projectile motion, friction, force, work, energy and power among others could be encouraged. The current study concurred with the ideas in Billington, et al., (2014) and Francois & Kerkhove (2010) who observed that pedagogical techniques had a combination similar to what was in steeplechase activities: collaborative learning, experiential learning, problem-based learning, and interactive learning as well as out-door activities and computer-based learning. The current study concurred with what Abdullar and Shariff (2008) observed that consolidation of ideas could involve individual or group assignment, small-group discussions, individual or group report writing, in-class presentation of group findings and Socratic probing to assess deep understanding of concepts in steeplechase activities. The current study concurred with what Jones (2008) suggested that interactive strategies of teaching such as steeplechase activities could motivate students to experiment with new skills during data collection, analysis, interpretation, mathematical modeling, and application of the model in problem solving as well as developing ability to communicate results to non-technical audience. The current study concurred with what Tammet (2012) observed that steeplechase activities could encourage students' understanding of fundamental concepts, ability to communicate results accurately and concisely as well as mastery of content for brainstorming and problem-solving. Therefore, steeplechase activities had a combination of pedagogical techniques desired in mechanics learning.

The current study found that steeplechase activities could encourage simulation of mechanics problems in areas such as: maximum vertical height one jumps, maximum horizontal distance, the time taken and the angle that could offer optimum results. The current study concurred with what Wells and Hestenes (1994) and Wells (1987) summarized the Hestenes (1987) model of instruction in mechanics to take place through three necessary processes effective in inducing meaningful learning as steeplechase activities were carried out. Using steeplechase activities for teaching might provide concrete experiences necessary for placing valid interpretation of sensory inputs. That process involved collection of data through measurements from steeplechase race in the track as well as watching a video in steeplechase as well as on resources (hurdles, spikes and water-jump, track, water and guest steeplechasers) used. The next important process was related to identification of reconcilable conceptual conflict between conceptual matrices constructed from sensory input and preexisting mental structures. That process constituted the simulation of mechanics problems which needed to be solved. Modeling process last step was related to process for developing cuing mechanism. That process involved procedural knowledge characterized by the techniques and tactics necessary for the utilization of the factual knowledge.

The current study found that simulation of mechanics problems through steeplechase activities included: work done to raise the steeplechaser's center of mass, mathematical advantages of doing water jump in a certain way in terms of energy spent and time taken from take-off to landing, angle of take-off. The current study concur with what Wells (1987) combined the three above learning cycles with the Hestenes (1987) model of instruction for teaching mechanics in three (3) stages. In exploration combined with description, students were involved in directed but unstructured laboratory activities. In this case, steeplechase activities were directed but unstructured. In this stage, the student was involved in identification and description of variables relevant to the phenomenon being considered. It involves first step in problem solving in linear and non-linear motion as well as in content areas: static, dynamics, friction, stress and strain as well as fluids. The students involved in steeplechase activities in mechanics could collect data useful in modeling problems on work, energy and power, friction, the angle of projection and projection velocity and make generalizations useful in understanding the concepts needed. In the concept introduction with formulation stage, the students might evaluate the data presentations; develop mathematical relationships between relevant variables before physical interpretation of the relationships. In the discovery with ramification evaluation stage, tactics and techniques necessary for utilization of the laws and relationships developed are deployed and utilized.

Results showed that areas which need specialized training programs and techniques include: 33% water jump, 32% hurdling and 20% running economy of energy reserve. The role of hurdling drills techniques and circuit training include: 20% improvement of speed, 36% efficiency in breaking and acceleration. The results of the current study, the work by Boslaugh and Watters (2008), Kong and Heer (2008) and Cometti (2001) concurred on the need to collect data related to training in athletics, use statistical tools to analyze the outcomes and apply the interpretations in problem solving in training programs. Such activities would involve approaches of increasing angular velocity on acceleration of athletes. The current study was different from what Cheung, Smith & Wong (2012), Kong & Heer (2008) and Holcomb, Rubley, Lee, and Guadagnoli (2007) asserted that the functional H:Q ratio increased as angular velocity increased Eccentric Hamstring Torque which remained relatively constant while the quadriceps torque decreased as angular velocity increased a relation supported by classical force-velocity relationship. The current study was different from what Cheung et al., (2012) and Holcomb, et al., (2007) observed that a functional optimum H:Q of 1.0 was proposed for training in distance running although a higher value would be better, but 1.0 provided necessary condition during training that reduced chances of anterior cruciate ligament injuries. Soccer players were expected to have H:Q ratio of an average of 0.96±.09 to 1.08±0.11. Kenyan distance runners H:Q ratio was found to be higher than 1.0 at all angular velocities. Systematic resistance training among South Eastern athletes distance runners at higher H:Q ratio than 1.0 and absence of injuries was uncommon among personnel in other track, fields events and other sporting disciplines from other parts of the world. Hence, the high H:Q ratio among Kenyans steeplechasers required a systematic study as carried out in the current study to bridge and mathematically illustrate the reasons in the required H:Q ratio. The current study was different from what Staiger (1999) observed that mathematical calculations carried out in steeplechase could involve quantities such as average speed, acceleration and force Students could identify the distribution of the time over the race. The details of the explosive activities were described here. The current study was different from what IAAF (2013) observed that the race started by steeplechaser doing the first 90m bend and a 110m straight without barriers.

The results showed that the steeplechasers' angular velocity was lowest at the zone between the first and the second steeplechase hurdle (average of $8.24°/s$) and it was highest at the zone near the water-jump straight ($18.33°/s$). The results also showed that barriers slowed down steeplechasers making the race spectacular and interesting to watch. In zones with lower pace, the steeplechasers had opportunities to overtake or to improve on time by ensuring optimum balance while zones for fast pace were meant to help athletes maintain their pace except at the finishing dash where the winner was determined by maintaining their balance being in the front pack then sprinting throughout the last 200m of steeplechase. Mechanics students in steeplechase had lower pace (4.11m/s for men and 3.34m/s for women) than the guest steeplechasers (6m/s). Hence, the angular velocities of students were lower than those of guest steeplechasers. Those results suggested the current study concurred with what Billington, et al., (2014) asserted that sports and games such as had the capacity to involve students in measuring time, angles, and arc distance to determine the angular velocity. Therefore, steeplechase activities had the capacity to develop conceptual understanding of mechanics.

Students in small-group discussions could use the IAAF (2008) Edition of the Marking Plan of 400m Standard Track. The current study was different from what Staiger (1999) observed that steeplechase activities could revolve around areas discussed here. The bend had an approximate radius of 14.31m. If the athletes' take off in a fast pace, they were likely to attain an average speed of 7m/s in the direction towards the center of the circular bend suggesting that the time taken for the bend was thirteen(12.85s) seconds. The steeplechasers' angular velocity was 25.21^0/s. The current study was different from what Kong and Heer (2008) observed that the steeplechasers' average speed of 7m/s and was higher than that of long distance athletes whose run at between 3.5m/s and 5.4m/s. The current study was different from what Commetti, Maffiuletti, Pousson, Chartard & Maffuli (2001) observed that the angular velocity of 25.21^0/s was lower than that of soccer players for peak performance whose angular velocity was between 60^0/s and 90^0/s.

The current study observed that mathematical skills developed through using steeplechase activities for teaching included: critical and creative thinking skills, problem-solving skills, coping with stress, information handling skills, effective communication skills, 55.5% conflict resolution skills, assertiveness, and team-work skills. The current study concurred with what Billington, et al., (2014), Gayondato (2011) and Jafaar (2011) who asserted that teaching and learning of STEM courses required the ability to think logically, comprehend abstract ideas and communicate effectively; abilities to responsibly manage information and communication (ICT) resources that include ICT wastes, interpersonal skills, green skills, effective communication of ideas and information; higher order skills such as application of learning, evaluation and analysis; social skills, creative problem-solving, innovative scientific skills, leadership, team-workmanship, entrepreneurship, making informed decisions and flexibility and life-long learning. Similarly, the current study concurred with what Billington, et al., (2014) and Kuppe & Loring (2006) asserted that performance in technical and vocational careers comprise of personnel's ability to: perform tasks autonomously, cooperate with others, take responsibility and perform tasks efficiently and effectively. Hence, steeplechase activities played an important role in developing students' mathematical skills.

Steeplechase activities could create an environment for thinking clearly, paying attention to details, manipulating specific and complex ideas, following complex reasoning and constructing logical arguments and exposing illogical ones through what Government of Kenya (2010a) referred to as analytical skills. The current study concurred with what Government of Kenya (2010a) observed that mathematical skills involved the use of symbols with specific meaning and context to represent information through symbolization skills. Symbolization skills were useful in modeling mathematical relationships in mechanics. Symbolization skills enabled individuals to communicate briefly, precisely and effectively. The current study concurred with what Wilber & Pitsiladis (2012) and Enomoto, et al., (2011) observed that in steeplechase activities, students were able to identify factors that influence performance of steeplechasers which included exceptional biomechanical efficiency, chronic exposure to altitude training, high intensity training and strong psychological motivation to succeed. The current study concurred with what

Barreau (2011) observed that in their groups, students' capacity to identify the most efficient approach to the hurdle at the water jump, strategies used to keep steeplechasers' stability, save time, energy and increase chances of winning the competition. In collaborative learning students could determine students' ability to discuss and identify optimum conditions necessary for steeplechasers to clear the ordinary barriers.

Optimum take-off in steeplechase activities was observed to be done at an angle of 37^0 and launch vertical velocity of 3.89m/s and horizontal velocity of 5m/s to ensure that the steeplechasers lands with the trail leg in the water and the lead leg on the track to be able to sprint again. The current study concurs with what Bostock and Chandler (1996) observed that calculations could be used to identify that 0.5 seconds was needed for optimum jump of the ordinary hurdle, an athlete take off angle was 20^0 and land 1.26m away from the hurdle. The current study concurred with what Jones (2008) and Wells (1987) observed that students could collect data, predict conditions for optimized take off and efficient landing through mathematical modeling. The current study concurred with what Barreau (2011) observed that the steeplechasers were encouraged to take off from track at an angle of 20^0 ensuring that the hurdle was still 1.26m away from the point of take off and land on the rail with the lead leg. The current study concurs with what Mackenzie (2007) observed that while on the rail, steeplechasers were expected to maintain a low hip, delay take off until the whole body was past the hurdle then push the rail as hard as possible. Hence, steeplechase activities had the capacity to stimulate simulation of mechanics problems.

The current study concurred with what Jones (2008) observed students' experiential learning cycle in steeplechase activities could have dimensions such as: concrete experience, active experimentation, abstract conceptualization and reflection. The current study concurred with what Huang (2011) and Johnson (2000) observed that in steeplechase activities, concrete experiences could form the basis for active experimentation and application of learnt concepts and theories. The current study concurred with what Abdullar and Shariff (2008) observed that consolidation of ideas could involve individual or group assignment, small-group discussions, individual or group report writing, in-class presentation of group findings and Socratic probing to assess deep understanding of concepts in steeplechase activities. The current study concurred with what Jones (2008) games and sports can motivate students to experiment with new skills during data collection, analysis, interpretation, mathematical modeling, and application of the model in problem solving. The current study concurred with what Tammet (2012) observed that games and sports could encourage understanding of fundamental concepts, ability to communicate results accurately and concisely as well as mastery of content for brainstorming and problem-solving. Therefore, steeplechase activities had combination of pedagogical techniques needed in learning mechanics.

The results showed that steeplechase activities could encourage students to: 47% carry out investigational experiments; 14% develop motor skills and 36% develop ability to describe situations and make notes. These results showed that teaching using steeplechase activities could encourage constructivists' strategies of learning mechanics. The current study concurred with what Tammet (2012), Khakala (2009), Serway and Jewett (2004), Millennium Mathematics Project (MMP) (2002) observed that sports and games had been used to make learning meaningful in STEM courses in Britain and United States of America and Canada, among other countries. The current study concurred with what MMP (2002) scholars observed that students were able to review simulation of mechanics problems related to linear motion, projectiles, use of force and energy as well as forms of energy such as sound through activities in field and track athletics. The MMP (2002) project suggests that there are other games and sports in field and track athletics activities that can provide opportunities for simulation of mechanics problems. The current study concurs with what (Tammet, 2012 and Khakala, 2009) who observed that other games and sports (field and track athletics) can be used to contextualize mechanics problems include steeplechase, swimming, rugby, cricket, hammer, lawn tennis, hockey, long jump, triple jump, high jump, pole vault, golf, cricket, and lawn tennis, among others. Similarly, the current study concurs with what Serway and Jewett (2004) who observed that used long jump and high jump for simulation of mechanics problems. Sporting activities such as rugby, cross-country, long jump, triple jump and high jump can be rich in content such as: linear and projectile motion; work energy and power; friction and breaking; mathematical calculations done by trial and error; precision; estimations as well as mental calculation also found in steeplechase activities. The current study is different from what Enomoto, et al., (2011) pointed out that biomechanics can be useful in distance running studies for simulation of mechanics problems. Biomechanics involves application of mechanics and physics to human movement and performance to understand athletics. Mechanics on the other hand could participation in sports could be used to create models for understanding concepts in mathematics and physics as used in the current study. Similarly, steeplechase activities could be used for simulation of mechanics problems. Therefore, the study in what steeplechase activities could offer in mechanics instruction was urgent and necessary.

Results showed that the pre-test sample mean ($n = 384$) was 32%. The value of the pre-test sample mean was used for calculation of ordinary and normalized gain made by the treatment as well as control groups. The treatment group (steeplechase activities) group was found to have learning gain of 32% which translated to a normalized gain of 47% ($std.dev. = 12.376$). The lecturer’s demonstration had learning gain of 15% which translated to a normalized gain of 22% ($std.dev. = 9.383$). Traditional methods of teaching (chalk and talk) had learning gain of 10% which translated to a normalized gain of 15% ($std.dev. = 10.480$). These results showed that steeplechase activities had the capacity to improve students’ performance in mechanics compared to alternative methods of teaching. The current study concurred with what Jackson, Dukerich and Hestenes, (2008) in a study of 14 courses observed that when students were taught by an inexperienced modeler using instructor-centered strategies posted normalized learning gain of 23%. The current study concurred with what Jackson, Dukerich and Hestenes (2008) observed that when students were taught using interactive engagement methods (hands-on usually and minds-on always), their learning normalized gain was 48%. The current study was different from what Jackson, Dukerich and Hestenes (2008) observed that when an experienced modeler was involved, learning normalized gain of 59% was registered. Similarly, the current study concurred with what Modig and Roxa (2009) asserted that collaborative learning and activity-based teaching posted better results for the 21st century learners in overall satisfaction, relevance, feedback from lecturers enthusiasm, clear goals, problem solving, and ability to work in groups, the program was by far the most important determinant of the total variance in the scales (three times better results for experimental group than control groups). Steeplechase activities method of teaching with collaborative learning activities had the capacity to help lecturers shift from over-reliance on textbooks question-and-answer to instructional processes to experiment on instructional alternatives. Steeplechase activities could arouse and maintain curiosity among the students, encourage meaningful experiences that raise questions in the students' mind thus encouraging construction of knowledge. Therefore, investigative experiments could contribute to students' construction of meaning and develop manipulative and experimental skills in steeplechase activities.

In calculating the range (the horizontal distance travelled by the center of mass of the steeplechase) in projectile motion was given by the equation:

$$Range = 0.10417(s^2m^{-1})v_0^2\sin(2\theta)$$

Mechanics students considered that $\sin(2\theta)$ is a unit (1) if $\theta = 45°$, optimum initial velocity of $5.93m/s$ and the length of the water jump pit. The students divide $3.66m$ by $(5.93m/s)^2$, to obtain $0.10417(s^2m^{-1})$ which was a constant connecting range and the initial velocity. The current study showed that steeplechase activities as a teaching method had the capacity to help students learn mechanics by: attempting mathematical questions on their own; discuss their thought processes with peers to build consensus or differences; refer to textbooks, journals, periodicals for comparison; discuss their findings with their lecturers; use various tools including computer for brainstorming. Students could proceed to model mechanics problems through use of various strategies; solve problems which require mathematical calculations; and provide brief explanations of the mathematical results obtained. The students could then manage to present group findings to the whole class; have opportunity for Socratic probing which could deepen understanding of concepts; and pass curriculum-based examinations. Steeplechase activities could encourage: creative problem solving; critical thinking and modeling mathematical relations; use of mathematical thought processes to discuss and explain reasoning, use mathematical and numeracy skills to provide evidence for informed decisions as well as answer questions from clients and assessors. All the above skills were developed through training in mechanics. Therefore, steeplechase activities could be having the capacity to deal with lack of basic pre-requisite knowledge and skills identified through item analysis of the pre-test.

The results in the current study showed that success of steeplechase activities depended on: 78% organization of the learning environment; 83% effective instructions; 64% effective facilitation; 74% group dynamics; 39% lecturers ability to build a bridge between activities and the concept learnt; and 90 % safety precaution. These results showed that the success of steeplechase activities depended on the capacity of the learning facilitators to create a link between the activities and the concept being learnt. The current study concurred with Jackson, Dukerich and Hestense (2008) who asserted that an experienced modeler was likely to achieve higher gains in mechanics compared to a novice modeler. However, the Jackson, Dukerich and Hestense (2008) did not investigate the strength of the interaction between steeplechase activities and other variables which affect students’ performance in mechanics a gap filled by the current study.

The test of hypothesis on the difference in students' learning gains n mechanics when students were taught using steeplechase activities and traditional methods was done here.

H_{O1} –**There is no significant difference in performance in mechanics when learners are taught using steeplechase activities and when learners are taught using traditional methods.**

Since table value of significance was less than 0.05 with $df = 95$ the study rejects the null hypothesis, H_{01}. These results suggested that involving students in interactive engagement (for example steeplechase activities) in mechanics had the capacity to improve students' learning gains compared to alternative teaching strategies. Similarly, the students' learning gains in mechanics showed that when students were taught using steeplechase activities was 32% while the gains made when the traditional methods of teaching are used was 10%. The normalized gains made when students were taught using steeplechase activities was 47% ($std.dev. = 12.376$) while the normalized gains made when the traditional methods of teaching are used was 15% ($std.dev. = 10.480$). Those observations suggested that interactive engagement methods of teaching mechanics (for example steeplechase activities) had the capacity to improve students' learning gains compared to alternative teaching strategies. The current study concurred with what Jones (2008) asserted that interactive teaching strategies had the capacity to motivate students to experiment with new skills during data collection, analysis, interpretation, mathematical modeling, and application of model in problem solving as well as developing ability to communicate results to non-technical audience. Similarly, steeplechase activities as pedagogical techniques had the capacity to motivate students to explore new skills, practice data handling activities such as: data collection, analysis, interpretation, mathematical modeling, application of the mathematical model developed in problem solving as well as developing ability to communicate results to non-technical audience. Those learning practices had the capacity to improve students' performance in mechanics. Therefore, steeplechase activities as a combination of pedagogical techniques could be adopted as a suitable teaching strategy for mechanics lessons.

4.4.0 Steeplechase Activities, Lecturer's Demonstration and Performance in Mechanics

Results in this section were useful in responding to second (b) objective on the students' learning gains (as predictor of students' performance) in mechanics when they were taught using steeplechase activities and use of lecturer's demonstration. Table 23 represents lecturers' responses on resources which could be used in lecturer's demonstration in mechanics lessons.

Table 23: **Resources used for Lecturer's Demonstration in Mechanics Lesson**

Resource used in lecturer's demonstrations	Frequency	%
Colored charts	33	34.4%
Tennis ball and feather	3	3.1%
Marble balls and open pipes	11	11.4%
Toys with flywheel system	5	5.2%
Demonstration models	6	6.3%
Running engines	10	10.4%
Gear boxes & Brake-systems	9	9.4%
Engineering drawing models	7	7.3%
Computers and other ICT tools such as: TV, radio, CD player	9	9.4%
Bicycle and bicycle parts	3	3.1%
Total	96	100.0%

(n = 96)

Results in Table 23 showed that 34% ($n = 33$) of the lecturers used graphic materials while 35% ($n = 34$) of the lecturers used three dimensional (3-D) resources as well as concrete materials in lecturer's demonstration. The same results also showed that 10% ($n = 10$) of the lecturers used running engines; 7% of the lecturers used drawing models for technical drawing; and 13% ($n = 12$) lecturers use of electrical equipment and electrical resources which included ICT tools in lecturer's demonstration. Table 24 showed the details on lecturers' demonstration.

Table 24: **Responses on use of Lecturers' Demonstration for Teaching Mechanics**

Statement about lecturer's demonstration:	Frequency	%
Demonstration involves oral presentation and practical demonstration	15	15.6%
Oral presentation involves use of sketches, drawings, photos, and pictures among other resources	9	9.4%
A certain amount of information or theory supports students in understanding what is being done and why	9	9.4%
Stages of carry out a lecturers demonstration lesson: preparation, performing of the demonstration and discussion	6	6.3%
Situations where lecturers demonstration is preferred:		
There is shortage of materials and facilities	7	7.3%
Safety of students is a major consideration	1	1.0%
Experiment involves a sophisticated or expensive apparatus	6	6.3%
Time for students' experiment is limited	15	15.6%
In experiments certain specific skills are to be learnt	2	2.1%
Conditions necessary for lecturers demonstration to be successful include:		
Demonstration should be visible to the whole class	9	9.4%
Demonstration must be followed by practice by students in which they begin to imitate the skills observed	10	10.4%
There should be adequate time to critically evaluate the demonstration observations	7	7.3%
Total	96	100.3%

The results in Table 24 showed that 16% of the lecturers said that lecturer's demonstration involved oral presentation and practical demonstration. That meant that practical demonstration could be carried out in class, laboratory, in workshops and in the out of class activities. Nine percent (9%) of the lecturers said that lecturer's demonstration was meant to provide certain amount of information or theory meant to supports students in understanding what was being done and the reason of providing the information or theory needed for learning. Nine percent (9%) of the lecturers said that oral presentation involved use of sketches, drawings, photos, and pictures among other resources to encourage visualization. That meant that visualization was likely to encourage conceptualization. Six percent (6%) of the lecturers said that the stages of carrying out lecturer's demonstration lesson included: preparation, performing of the demonstration and discussion. Those observations suggested that lecturer's demonstration was lecturer-centered but it was more interactive in nature than lecture and questioning methods.

The test of hypothesis on the difference between students' learning gains when students were taught using steeplechase activities and when students were taught using lecturer's demonstration was done here. The second hypothesis H_{O2} was stated as:

H_{O2} –**There is no significant difference between students' performance in mechanics when learners are taught using steeplechase activities and lecturer's demonstration.**

Table 22 presents the z-test statistics which were used to test the second hypotheses (H_{O2}). Since the table value of significance (2-tailed test) is less than 0.05 for $df = 47$ ($0.000 < 0.05$), the study reject the null hypothesis H_{02}. Therefore, the difference in students' learning gain (as a predictor of performance) in mechanics between students taught using steeplechase activities and when students were taught using lecturers' demonstration was significant at 5% level. Those results suggested that students' gain was higher when students were taught using interactive engagement methods compared to alternative strategies. These results were in concurrence with the findings on students' gain in mechanics. The mean difference between students' learning gain in mechanics when students were taught using steeplechase activities and when they were taught using lecturer's demonstration in Table 22 was 17% (normalized students' learning gain difference was 25% ($std.dev. = 14.520$) same as what was in Table 21). These results of normalized students' learning gain suggest that interactive engagement methods have capacity to improve students' performance in mechanics. The results also illustrated that lecturer's demonstration could forms an important step in modeling problems in mechanics when introducing a task or project. These results also suggested that the students taught using lecturer's demonstration were likely to put more effort in studying in mechanics compared to students taught using alternative methods. Table 25 presents Group E's responses on the mechanics lessons from the pictures taken during steeplechase competitions.

Table 25: **Lessons from Pictures Taken during Steeplechase Competitions**

Observation	Model/Content	Methodological implications
Walking through water	Constraints, reduced speed Direction of force of water	Factor all constraints in the model, Mathematical model
Athlete almost covered by water	Constraints, reduced speed,	constraints in the model
Struggle to get out of water	Impact of force of water	constraints in the model
Athlete lands in water with the lead leg and the trail leg on the tract	Projectile motion Effective hurdling, balance, mental calculation on take-off	Estimation of angle of launch, launch velocity and constraints
Four students doing water jump: Two in water;	Constraints, reduced speed Direction of force of water Projectile motion	constraints in the model
One successfully jump; and	Effective hurdling, balance, mental calculation on take-off	Estimation of angle of launch, launch velocity and constraints
One straining to run after water jump	Strain on the muscles, fatigue	Strain and stress
Effective hurdling	Maintain balance with the hands/ Moments	Model the situation on balance and model the moments
Stability of the water and ordinary hurdle	Center of mass and moments	model the Center of mass and moments

The results in Table 25 showed that the students make appropriate observations before they could model mechanics problems in mechanics. Those results suggested that steeplechase activities include the following actions shown here. First, plenary session during the introduction of the tasks ahead involved: giving instruction verbally, form groups, provide materials and resources (stop-watch, work-sheets), and seeking for clarification. Second track running involved: running on the track as colleagues taking measurements, identification, and tabulations as well as taking pictures for analysis. Third, students were involved in watching a video of best practice in steeplechase to: make measurements, identify the concept, compare with what was observed, describe and identify mathematical relations in steeplechase, make observations on content, laws, theorems and principles in mechanics. Actions in first and third have characteristics of lecturer's demonstrations. However, steeplechase activities considered that lecturer's demonstrations was a fair start for the group activities and experimentations. Fourth, in small-group discussions, students come up with patterns observed; identify relationships between variables, model expressions, equations, develop concept maps, concept networks, motion maps and application of procedures and processes and techniques in problems solving. Fifth, presentation of students' group-work in plenary session forms the highest stage of learning mechanics through: Socratic probing, questions are paused to non-presenting group members, major findings in models formed, checklist use to assess individual students' performance in class-based assessment and feed-back was provided.

4.4.1 Learning Gains for Steeplechase Activities and Lecturer's Demonstration

Results in this section were useful in discussing the results related to the second (b) objective related to the difference in the students' learning gains in mechanics between groups taught using steeplechase activities and lecturer's demonstration.

The results showed that 16% of the lecturers said that lecturer's demonstration involves oral presentation and practical demonstration. Nine percent (9%) said that a reasonable amount of information or theory was necessary to support students in understanding what was being done and why. Nine percent (9%) oral presentation involved use of sketches, drawings, photos and pictures among other resources. The current study concurred with what Billington, et al., (2014) asserted that ICT tools had capacity to encourage students to manipulate sketches and drawings as well as get immediate feedback. Six percent (6%) of the lecturers said that lecturer's demonstration had three distinct stages which include: preparation, performing of the demonstration and discussion. The current study concurred with what Obengo (2011) and Twoli (2006) who asserted that preparation for a lecturer's demonstration involved checking availability and accessibility of materials and apparatus, preview of experiment, consider safety precautions and give instructions. The current study concurred with what Twoli (2006) and Nzama (2000) asserted that performing of the actual demonstration experiment involved: introducing the purpose and objective, checking the students' sitting or standing arrangement, perform the demonstrations, require students to record their observations (data collection). Therefore, use of a combination of resources which include ICT in lecturer's demonstration could encourage students' visualization of the concept.

Lecturer's demonstration was preferred in situations where materials and facilities were limited, safety of students might be at risk, experiment involved a sophisticated or expensive apparatus, time for students' experiment was limited and in demonstration experiments certain specific skills were learnt. The current study concurred with what Bukhala (2009), Jones (2008) and Twoli (2006) observed that lecturer's demonstration was most appropriate when students' experiments cannot be conducted due to logistical reasons. The current study was different from what Jackson (2009) observed that lecturers' demonstration had a weakness when examples were used for illustration in mechanics based on the 'correct procedures' only without leaving room for creative mathematics, critical thinking and analytical skills among students. Hence, there was need to explore the contribution of both the lecturer's demonstration and steeplechase activities on students' performance in mechanics. Therefore, more flexibility in leading students in whole class discussion could be needed to prepare scientific thinking among students.

The study results showed that information communication and technology (ICT) tools in a lectures' demonstration played an important role in introducing pictorial and process experiences in mechanics. The current study concurred with what Gunga, et al., (2013) asserted that electronic media could provide a suitable environment for class based and out-of-class activities as well as self-assessment needed for instant feedback as a follow-up to lecturers' demonstration in virtual lab situations. The current study was different from what Omufwoko (2009) observed that the most commonly used type of ICT by students in technical institutions include 91.8% mobile phones and 36.9% internet outside colleges. However, the study by Gunga, et al (2013), Zachary (2009), Omufwoko (2009), Jones (2008) and Nzama (2000) did not suggest what role could be played by ICT in steeplechase activities for concept learning. There was also needed to seek for opportunities for concrete experiences to complement pictorial and symbolic experiences through steeplechase activities. Therefore, more investigation on the role of ICT tools in steeplechase activities was necessary.

The study results showed that conditions necessary for lecturer's demonstration to be successful included: demonstration should be visible to the whole class, demonstration must be followed by students' practice in which they begin to imitate the skills observed and there should be adequate time to critically evaluate the demonstration observations. The opportunities were provided through what the results showed that 34% ($n = 33$) of the lecturers used 2-D resources while 35% ($n = 34$) of the lecturers used 3-D resources. Those results showed that 2-D resources (such as pictures, carts, posters, cartoons, motion pictures) and 3-D resources (for example toys, models which could be manipulated, simulated cartoons) could be used for lecturer's demonstration in mechanics. The same results showed that 10% ($n = 10$) of the lecturers used running engines; 7% of the lecturers used drawing models for technical drawing; and 13% ($n = 12$) of lecturers used electrical resources such as ICT tools in lecturer's demonstration. The current study concurred with what Nzama (2000) asserted that in South Africa, poor performance in mechanics was associated with lack of demonstration models such as running engines, gear boxes and brake-systems in motor mechanics workshops. Similarly, the current study concurred with what Nzama (2000) asserted that poor performance was due to lack of engineering drawing models as well as lack of electronics or electrical equipment. These results in the study concurred what Twoli (2006) observed that visibility played an important role in concept learning. the current study also concurred with what Jones (2008) observed that use of ICT tools made it possible for both steeplechase activities and lecturers' demonstration for teaching as well as self-assessment needed for instant feedback for follow-up.

The discussion on the test of the second (b) hypothesis on the difference in students learning gains in mechanics between groups when students were taught using steeplechase activities and lecturer's demonstration was done here.

H_{O2} –**There is no significant difference in performance in mechanics when learners are taught using steeplechase activities and lecturer's demonstration.**

Since the table value of significance (2-tailed test) was less than 0.05 with $df = 47$, the study rejects the null hypothesis, H_{02}. These results suggested that when students were taught using steeplechase activities, their learning gains in mechanics were higher than when alternative methods of teaching were used. Similarly, the normalized gain made when students were taught using steeplechase activities was 22% ($std.dev. = 9.383$) compared to 15% ($std.dev. = 10.480$) when lecturer's demonstration was used. These results suggest that involving students in interactive techniques for example steeplechase activities had capacity to post higher performance in mechanics for treatment (experimental) group compared to control group. The current study concurred with what Francois and Kerkhove (2010), Jones (2008) and Johnson (2000), observed that interactive teaching strategies which include steeplechase activities had the capacity to post higher performance than lecturer's demonstration because students were involved in experiments in practical work, library research, small-group discussions involving collaborative learning and presentation of group results. Therefore, steeplechase activities had the capacity to encourage learning of mechanics.

Lecturer's demonstration could use resources in steeplechase activities as a race; a computer simulation, a video session or watching a film which included: 400m standard athletics track, hurdles, water-jump, gunny bags filled with sand, lines, lanes, starting gun, spiked shoes, sleeveless t-shirts, pairs of short, electronic or manual stop watches, ICT tool such as video cameras, tablets for recording events, taking photographs for photo finish and recording still pictures. Those resources were useful for understanding projectile motion calculations. The current rules and regulations provided by International Athletics Amateur Federation (IAAF, 2011) stipulated that steeplechase involves hurdlers clearing 28 ordinary barriers and 7 water jumps by the end of the 3000m event. The same document advised that hurdles were to be heavy enough and almost impossible to knock down or displace. The document by IAAF (2011) illustrated that heights of hurdles are 914mm and 762mm for men and ladies respectively. The 2000m steeplechasers for under-18 (junior) were expected to jump 5 water barriers and 20 ordinary hurdles with a height of 762mm. The same document also stipulated that the water-jump was 3.66m wide with a downward slope ending in a depth of 0.70m and ensuring that the water-jump barrier was filled with water. The rules and regulations by IAAF (2011) showed that athletes must jump or go over or through the water barrier such that they pass the complete 3.66m length at the obstacle. The current study was different from what IAAF (2011) observed that when an athlete left the water jump barrier before getting to the end, they were disqualified. IAAF (2011) pointed to the need for structured games which form an important part of visualization for concept learning in mechanics when students were taught using steeplechase activities.

The mathematical distribution of 7 minutes and 53.63 seconds was explained as shown here. Time spent for tactfully doing seven (7) hurdles and water jumps was 8.89 seconds such that the steeplechaser spent exactly 1.27 seconds for each hurdle and water barrier. The steeplechaser also spent 14 seconds to do 28 ordinary barriers suggesting that each hurdle requires 0.5 seconds. The steeplechaser also spent approximately 450.8 seconds for thirty five (35) 80m straight sprint suggesting that the average speed was 6.83 m/s.

The optimum initial velocity at which steeplechasers moved with when they pushed hard against the rail to be able to step almost at the end of the water jump was estimated as between 5m/s to 6m/s. The initial velocity for novice steeplechasers was almost at zero (0.5m/s) because the hurdle at the water was a barrier that almost stops athletes. Since it was hard to attain a high initial velocity, say of 6m/s, the ideal initial velocity was estimated at 5.857m/s. If a steeplechaser takes off from the rail at a velocity of 5.857m/s and an angle of 45^0, the athlete landed about 0.1m away from the end of the water jump before proceeding on to sprint again on the track. The optimum take-off velocity was estimated at between 40^0 and 45^0. Where possible, an athlete aimed at stepping on the trail leg then step out onto the track on the lead leg. If the initial velocity was low say 5.5m/s or below and the takeoff angle was 40^0 or below, the athlete will had to get into the water with both legs then push through it. Passing through the water consumed a lot of energy apart from slowing down the athlete due to the water pushing back against the forward motion of the athlete. When students made the above observations, used them in discussions and made appropriate conclusions their learning was enhanced. The current study concurred with what Billington et al., (2014) and Huang (2011) asserted that teaching climate and learning environment included: collaborative learning, link learners' experiences with new experiences learnt, involvement of students in learning processes, grading of assignments including group work, relating mechanics to real life situations, use of ICT access learning materials and remedial work for low achievers. Hence, interactive teaching strategies such as steeplechase activities could post higher performance in mechanics compared to alternative teaching strategies.

Results showed that techniques for hurdling at the water-jump included: 52% maintaining low hip; 90% the push from the barrier was delayed until the body was well beyond it, 74% the athletes propel themselves to maximize drive and 85% landing was done with the lead leg in the water while the trail leg steps outside the water. These results suggested that superior approximation strategies were needed to achieve precision in the above activities. The simulation of mechanics problems related to doing ordinary jumps and speed sprint consider the steeplechaser desire to minimize amount of time to take on the race. Similarly, the current study concurred with what by Serway and Jewet (2004) and MMP (2002) asserted that simulation of mechanics problems had mathematical calculations related to maximum distance, time of flight and the highest vertical distance covered by a long jumper in track and field athletics. The current study concurred with what Serway and Jewet (2004) and MMP (2002) asserted that students' needed to develop understanding on the principles of projectile motion, force, work energy, optimum friction and power to improve their performance in mechanics. Other areas where mathematical calculations were needed included what the current study and Beckman (1991) and Staiger (1999) observed that concept such as matrix was applied when preparing entry of the players' statistics into the computer for analysis. Therefore, steeplechase activities as interactive teaching strategies had capacity to foster modeling of mechanics problems.

The results in the current study found that steeplechasers carry out explosive activities, while fellow students made observations, collect data, analyze and interpret include: accelerating, changing pace after every 5-6 seconds, jumping, ordinary and water barriers and sprinting. Calculation related to steeplechasers' attainment of an acceleration of $3.81 m/s^2$ before changing the pace again caused by start of doing the ordinary barriers. The current study was different from what Tammet (2012) asserted that steeplechasers could attain a net force of 215.65N. Other calculation that could be carried out included the net force of 215.65N is relatively low compared to that of 87kg soccer player at the same acceleration and time because they could attain a net force of 331.47N. The current study concurred with what Staiger (1999) observed that students could determine observe that relatively low net force suggested that steeplechasers needed less effort to stay on course and avoid being disqualified. In steeplechase activities involving various quantities, students could develop problem-solving techniques and strategies. Similarly, the concepts in inferential statistics and calculus find application in tennis when an integral estimator was used to determine the players' performance in a series of matches over a certain period of time and betting in games and sports. Therefore, interactive pedagogical techniques in steeplechase activities could improve students' performance in mechanics.

4.5.0 Steeplechase Activities, Ability Groups and Performance in Mechanics

Results in this section were useful in responding to the third (c) objective on the difference in students' learning gains (as predictor of students' performance) in mechanics when were taught using steeplechase activities for high and low ability groups. Table 26 represents lecturers' responses on the influence of using steeplechase activities for teaching on students' students' learning gains (performance) in mechanics by ability.

Table 26: **Using Steeplechase Activities Teach Different Ability Groups**

Statement on Ability Grouping in Teaching and Learning of Mechanics	f (%)
The purposes of pre-test is identify students' learning abilities	45 (46.9%)
Ability grouping can improve students' performance in mechanics	66 (68.8%)
Students' ability can be expanded through hard work	23 (23.9%)
Gifted students benefit if grouping aims at meeting their academic needs	73 (76.0%)
Mixed ability grouping is preferred in small-group discussions	40 (41.7%)
Ability grouping in steeplechase activities is done for purposes of:	
Acceleration in learning in mechanics	22 (22.9%)
Curriculum compacting in learning in mechanics	32 (33.3%)
Enrichment in learning in mechanics	48 (50.0%)
Cluster grouping in learning in mechanics	45 (46.9%)
Differentiation in instruction	26 (27.1%)
Negative Impact of Ability Grouping in Mechanics	**f (%)**
Ability grouping is part of students labeling	36 (37.5%)
View that technical courses are meant for low academic achieving students	46 (47.9%)
Average ability students experience diminished self-concept	68 (70.8%)
Low ability students rebel against lecturers' effort in helping them to learn	32 (33.3%)

The results in Table 26 suggest that 70% of the lecturers said that that ability grouping was useful for improving students' learning gains in mechanics for example by giving more work to the high ability for in-depth studies, provide remedial for low ability group. Twenty four percent 24% of the lecturers felt that students' ability could be expanded by hard work for example students who develop positive attitude towards mechanics and decide to study, carry out research, carry out experiments and investigate more on what they observed in nature. Forty one percent 41% of the lectures felt that mixed-ability grouping was useful in small-group discussion while 45% of the lecturers felt that pre-test was meant to help establish the students' ability in learning mechanics. The analysis of quantitative data on the third (c) objective on the difference between students' learning gain for high and low ability group was presented here.

Results in Table 27 showed students' learning gain (descriptive statistics) of the high and the low ability groups when students were taught using steeplechase activities.

Table 27: **Descriptive Samples Statistics for High and Low Ability Groups**

Steeplechase group	Mean		N	Std. Dev.	Gain	Normalized Gain
	Pre-Test	Post-Test				
High Ability	31.68	68.79	48	10.25205	37%	54%
Low Ability	31.68	58.63	48	12.31609	27%	40%

The results in Table 27 showed that when students were taught using steeplechase activities, the high ability group of students had better (37%) learning gain (as predictor of performance) in than low ability group (27%) of students. The difference between students' learning gains for high ability and low ability groups in Table 27 was 10% ($std.dev.$ = 13.569). The normalized gain made by the high and low ability group of student were 54% ($std.dev.$ = 10.252) and 40% ($std.dev.$ = 12.316). The difference between the highly motivated and less motivated groups of students in Table 28 was 14% ($std.dev.$ = 13.569). These results on the difference in the variability showed that low ability group had greater diversity in learning disposition compared to high ability group. These results suggests teaching using steeplechase activities had the capacity to inspire both highly motivated and less motivated groups of students in to work hard and improve their performance in mechanics. The third (iii) hypothesis on the difference between students' learning gains (as predictor of students' performance) in between high and low ability groups was tested as shown here.

H_{O3} –**There is no significant difference in students' performance in mechanics between high and low ability groups when they are taught using steeplechase activities.**

The hypothesis H_{O3} was tested as shown in the results in the Table 28.

Table 28: **Paired Samples z-Test Statistics for High and low Ability Groups**

Steeplechase Activities Group	Paired Differences			z	df	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean			
High - Low	10.17	13.569	1.958	5.191	47	0.000

p = 0.05; df = 47

Since the table value of significance (2-tailed test) was less than 0.05 with $df = 47$ the study rejects the null hypothesis H_{03}. Therefore, the difference in students' learning gain in mechanics between high and low ability groups was 10% ($std. dev. = 13.569$) (same as what was in Table 27) when they were taught using steeplechase activities was significant at 5% level. The difference in students' normalized gain in mechanics between high and low ability groups when they were taught using steeplechase activities (14% ($std. dev. = 13.569$). These observations suggested that interactive engagement methods of teaching such as steeplechase activities had greater capacity to improve students' learning gains for high ability students than for low ability group. However, the these observations suggest from showed that the students' learning gains of 40% in mechanics when they were taught using interactive engagement methods was significant at 5% level.

4.5.1 Learning Gains for High and Low Ability Groups in Steeplechase Activities

Results in this section were useful in responding to the third (c) objective on the difference in students' learning gains (as predictor of students' performance) in mechanics between high and low ability groups when students were taught using steeplechase activities were discussed as shown. Forty one percent 41% of the lectures felt that mixed-ability grouping was useful in small-group discussion while 45% of the lecturers felt that pre-test was meant to help establish the students' ability in learning mechanics. The current study concurred with what Dweck (2006) observed that ability grouping referred to forms of placement of students into homogeneous classroom based on students' performance. The results showed that about 69% of the lecturers observed that ability grouping was useful for improving students' performance in mechanics. The current study concurred with what Davis (2012) and Steel (2005) observed that ability grouping could be used as an intervention strategy to improve students' performance in various disciplines such as mechanics. Similarly, the current study was different from what Borovik and Gardiner (2006), Steel (2005) and Johnson (2000) asserted that ability grouping was done for purposes of acceleration, curriculum compacting, enrichment, cluster grouping or differentiation in terms of curricular, resources, assessment, use of different approaches in teaching and learning processes. The current study concurred with what Siegle and Reis (1998) observed that if gifted students work on activities that were less challenging in mathematics and science, they tended to get bored and lose interest in the discipline. These observations were different from what Johnson (2000) suggested that although ability grouping was meant to provide for differentiation, observed that in 84% of the instruction time, lecturers of mathematics tended to ask high performing students to do the same activities as average performing students. Twenty four percent 24% of the lecturers felt that students' ability could be expanded by hard work. The current study concurred with what Davis (2012) and Steel (2005) ability grouping could encourage provision of material for self-instruction; enrichment; special projects; individual projects; acceleration (or completion of standard curriculum in shorter time). The current study Kerre (2010) and Bukhala (2009) asserted that acceleration (completion of standard curriculum in shorter time) in technical and vocation courses through the module system in technical institutions. The current study was different from Davis (2012) who asserted that grouping for acceleration was done to encourage high ability students to experience rapid and proficient learning. The current study was different from Steel (2005) who asserted ability grouping for enrichment was meant to provide time for breadth and in-depth learning alongside standard curriculum to: improve gains in general performance, encourage critical thinking and creativity. The results also show that 24% of the lecturers felt that students' ability could be expanded by hard work. The current study, Steel (2005) and Davis (2012) concurred that there were two views on ability in mathematics: the view that mathematics ability was a gift (in-born) and the view that ability could be expanded by hard work. The view that mathematical ability could be expended was preferred because it encouraged students to work hard even if they experience failure while those with the view of ability was a gift excuse their failure to lack of mathematical ability.

The results showed that when students were taught using steeplechase activities, the high ability group of students had higher (37%) learning gain (as a predictor of performance) than low ability group (27%) of students. The difference between high ability and low ability groups of students is 10%. The normalized gain made for high ability group was higher (54%) than the low ability group (40%). These results suggested that the difference between their normalized gains was 14%. These results suggested that teaching using steeplechase activities had the capacity to inspire both highly motivated and less motivated groups of students to work hard and improve their performance in mechanics. The current study was different from what Amelink (2012), Davis (2012), Steel (2005) and Johnson (2000) who asserted that students could be grouped into high performance (highly motivated or gifted and talented) group, moderate performance (moderately motivated or middle ability or average achieving students) group and poor performance (students with less motivation to learn or low ability or low achieving students) group. Identifying students' level of performance was an effective instructional strategy to provide for within-class grouping for differentiation as well as fostering mathematical creative thinking. The negative impact of ability grouping in teaching and learning include: 70% average ability students experience diminished self-concept while 33% low ability students rebel against lecturers efforts to contribute to learning. Those observations on the negative impact of grouping students in terms of their ability justified the use of casual-comparative research design.

The test of hypothesis on the difference in performance in mechanics between ability groups when students were involved in steeplechase activities.

H_{O3} –**There is no significant difference in performance in mechanics between ability groups when learners are involved in steeplechase activities.**

Since the value of significance (2-tailed test) was less than 0.05, the study rejected the null hypothesis H_{03}. Therefore, the study could state with 95% confidence that the difference between the means (10%) of the high and low ability students' performance in mechanics when students were taught using steeplechase activities was significant. When students were taught using steeplechase activities, the gain for the high ability group was 37% ($std. dev. = 10.252$) while that of low ability group was 27% ($std. dev. = 12.376$). The value of normalized gain confirms that the mean difference in performance in mechanics between ability groups when students are involved in steeplechase activities is 10% ($std. dev. = 9.918$). The results suggested that steeplechase activities had the capacity to encourage both high and low ability students to improve their performance in mechanics. The current study concurred with Jackson, Dukerich and Hestenes (2008) that involving students in activities rich in modeling improves students' gains in mechanics. Those observations suggested that the current study was different from that of Davis (2012) and Johnson (2000) who asserted that gifted students showed significant to moderate gains in performance when grouping for accelerated learning was used while the current study determined the gains made when high and low ability students groups were taught using steeplechase activities. However, study by Jackson, Dukerich and Hestenes (2008) did not study the normalized gains made by high and low ability groups of students; a gap filled by the current study. Therefore, steeplechase activities as pedagogical techniques had the capacity to improve students' performance in mechanics.

The results in showed that success of steeplechase activities depended on: 74% group dynamics; 78% organization of the learning environment; 83% effective instructions; 64% effective facilitation; 39% lecturers ability to build a bridge between activities and the concept learnt; and 90 % safety precaution. These results showed that the success of steeplechase activities depended on the capacity of the learning facilitators to create a link between the activities and the concept being learnt. The current study concurred with what Jackson, Dukerich and Hestense (2008) asserted that an experienced modeler was likely to achieve higher gains in mechanics compared to a novice modeler. However, the Jackson, Dukerich and Hestense (2008) did not investigate the strength of the interaction between steeplechase activities and other variables which affect students' performance in mechanics a gap filled by the current study.

The current study found that students in mixed ability groups identify relationships between quantities obtained, model mechanics equations which they discussed to check their concurrence or difference in opinion. The current study concurred with what Johnson (2000) observed that students could compare their equations with the relevant literature values and explain the difference or concurrence. The current study concurred with what Staiger (1999) and Beckmann (1991) observed that students could derive equations in small-group discussions or those obtained from textbooks could act as a recipe for algebraic problem-solving. Students' capacity to handle algebraic problem solving was useful in finding unknown quantities in word problems or in real-world situations. Therefore, mixed ability grouping was preferred when steeplechase activities were used for teaching mechanics.

4.6.0 Steeplechase Activities, Gender and Performance in Mechanics

Results in this section were useful in responding to second (d) objective of the study on the difference in students' learning gain in mechanics between male and female groups when they were taught using steeplechase activities. Table 29 represents lecturers' responses on the difference in students' learning gain in mechanics between male and female groups when they were taught using steeplechase activities.

Table 29: **Responses on Difference between Male and Female Group of Students**

Statement on the effect of steeplechase activities on Students Performance in Mechanics by gender:	Male f (%)	Female f (%)	Total f (%)
Steeplechase activities have the same influence on male and female students' learning gains in mechanics	17(22.4%)	15(75.0%)	32(33.3%)
Female students achieve higher than men in lower cognitive problems in mechanics	58(76.2%)	16(80.0%)	74(77.1%)
Men students have higher spatial ability than women	55(72.4%)	4(20.0%)	59(61.5%)
Factors attributed to gender difference in performance in Mechanics include:	**Male f (%)**	**Female f (%)**	**Total f (%)**
Lack of interest on the part of female students	64(84.2%)	5(25.0%)	71(73.9%)
Mechanics is abstract in nature	42(55.3%)	13(65.0%)	53(55.2%)
Socio-cultural influence	58(76.2%)	14(70.0%)	72(75.0%)
Male students get more opportunities to respond to higher level problems than female students	16(21.1%)	16(80.0%)	32(33.3%)
Lecturers interact more with male than female students	14(18.4%)	18(90.0%)	32(33.3%)
Fewer female lecturers	56(73.7%)	14(70.0%)	70(72.9%)

n = 96 ($female$ = 21; $male$ = 75)

The results in Table 29 show that 34% of the lecturers felt that both male and female had the same mental ability in mechanics. In situations where there was gender disparity; 62% of the lecturers felt that male had higher spatial ability than female students. Seventy six percent (76%) of the lecturers felt that female students achieve higher than male students in lower cognitive problems in mechanics. Other factors which affected gender disparity in students' performance in mechanics include: 33% classroom interactions; 69% more male than female lecturers of mechanics; 51% physical facilities; and 76% socio-cultural influence.

The analysis of quantitative data in response to the fourth (d) objective was presented here. Table 30 presents the descriptive statistics of the male and the female steeplechase groups.

Table 30: **Descriptive Statistics for Male and Female Group of Students**

Steeplechase activities Group	Mean		n	Std. Dev.	Gain	Normalized Gain
	Pre-Test	Post-Test				
Male	31.68	60.50	20	13.89244	29%	42%
Female	31.68	57.50	20	9.91809	26%	38%

The results in Table 30 showed that when students were involved in steeplechase activities, the students learning gains were higher for male (29% ($std.dev.$ = 13.892) than female students (26%) ($std.dev.$ = 9.918). The gender difference between male and female students' means was 3%. The normalized gain for male students is 42% while that of female students was 38%. The gender difference of 4% in Table 30 was almost the same in the normalized gain of 4% ($std.dev.$ = 16.428). Although male students had higher mean score compared to female students, variability in performance of male students in mechanics was higher (($std.dev.$ = 13.892) than female students ($std.dev.$ =9.918). These results showed that men who had higher learning gains in mechanics very scores ('very good') while those with lower learning gain in mechanics had very low scores ('very poor'). These results suggested that teaching using steeplechase activities had the capacity to reduce gender difference in performance in mechanics while female students had average scores in learning gains in mechanics. The fourth hypothesis was tested here.

H_{O4} –**There is no significant difference in performance in mechanics when students are taught using steeplechase activities between gender groups.**

The results for test of the fourth hypothesis H_{O4} on the difference in learning gains for male and female groups when students were taught using steeplechase activities were shown in Table 31.

Table 31: **Paired Samples t-Test Statistics for Male and Female Group of Students**

Steeplechase Activities Groups	Paired Differences Mean	Std. Dev.	Std. Error Mean	t	df	Sig. (2-tailed)
Male – Female	3.00	16.428	3.674	0.817	19	0.424

p = 0.05; df = 19

Since the table significance value (2-tailed test) was greater than 0.05 with $df = 19$ the study did not reject the null hypothesis $H_{04.}$ Therefore, the difference in performance between gender groups was not significant at 5% level. The difference between the gain made by male (29%) and female (26%) groups of students was 3%. The difference between the normalized gain made by male (42%) and female (38%) groups of students was 4%. The results when students were taught using interactive engagement (for example steeplechase activities), their learning gains in mechanics were likely to improve (hence, improved students' performance).

4.6.1 Learning Gains for Gender Groups when Taught Using Steeplechase Activities

Results in this section were useful in responding to fourth (d) objective of the study on the difference in students' learning gains (as a predictor of students' performance) in mechanics between male and female group of students were discussed here. The results in Table 33 showed that 34% of the lecturers felt that both male and female have the same mental ability in mechanics. The current study concurred with what Davis (2012), Niederle and Vesterlund (2010), Wai, et al., (2010) and Benbow, et al., (2000) who asserted that gender disparity in overall mathematical ability was negligible or non-existent. Gender difference in preference to certain course had been found in the current study. The results showed that more male 304 (79.17%) took engineering courses than females 80 (20.83%). The results showed that majority of the female 32 (40%) students involved in the study took diploma in electrical and electronic engineering. The current study was different from Amelink (2012) and Johnson (2000) who observed that in spatial visualization abilities were related to performance in mathematics differently for females than for males. Similarly, the current study was different from what Davis (2012) observed that females tended to achieve higher than males on lower level cognitive level problems in mathematics while males tended to achieve higher than females on more complex cognitive problems. The current study was different from Spelke (2005) who observed that since male students were more focused on objects throughout their lives, they were likely to perform better in learning about mechanical systems. Therefore, a study on reasons behind the gender disparity in mechanics was necessary and urgent.

In situations where there was gender disparity; 62% of the lecturers felt that male had higher spatial ability than female students. The current study concurs with what Akala (2010) asserted that secondary schools in Kakamega District in Kenya asserted that in a group (boys, $n_1 = 206$ and girls, $n_2 = 180$) boys had higher mean (4.45 out of 8 points) and (4.39 out of 8 points) than girls (3.34) and (3.83) in mathematics and spatial ability respectively. The results in the current study and Johnson (2000) observed that females tended to achieve higher than males on lower level cognitive problems in mathematics. The current study was also different from the work by Amelink (2012) and Dweck (2006) who asserted that the difference in overall mathematical ability of male and female student' has been reducing over decades 1981-2010. Although Amelink (2012), Akala (2010), Dweck (2006) and Johnson (2000) had carried out studies in mathematics, the current study had studied the difference in learning gains as predictor of performance in mechanics between male and female students when taught using steeplechase activities.

The normalized gain for male students was 42% while that of female students is 38%. The gender difference of 4% was recorded. Although male students have higher mean score compared to female students, variability in performance of male students in mechanics was higher ($std. dev. = 13.892$) than female students ($std. dev. = 9.918$). Those results suggested that that men who have good performance in mechanics were ‘very good’ while those who have poor performance in mechanics were ‘very poor’. The current study concurred with what Wai, et al., (2010) asserted that men were ‘over-represented’ in mathematics-based fields like engineering, physics and technology because they have more natural variability in mathematics. The current study concur with what Amelink (2012), Davis (2012) and Benbow, et al., (2000) and who observed that variability in mathematics meant that women were ‘average’ in mathematics ability while men were either ‘very good’ or ‘very bad’ in mathematics. Therefore, the gender gap in students’ performance in mechanics was worth the effort in this study.

Seventy six percent (76%) of the lecturers felt that female students achieve higher than male students in lower cognitive problems in mechanics. When students were taught using steeplechase activities, male students had higher (29%) learning gain than female students (26%). The normalized gains for male and female students were 42% ($std.dev.$ = 13.892) and 38% ($std.dev.$ = 9.918) respectively. The gender difference between male and female in the normalized gain was of 4%. These results suggest that teaching using steeplechase activities had the capacity to reduce the gender disparity among students in mechanics. The current study concurred with what Akala (2010) and Spelke (2005) who observed that male had better performance in mathematics than female students. Similarly, the current study concurred with what Meltzer (2002) found that male students’ performance in mechanics was better than that of female students. The current study was different from what Akala (2010) and Spelke (2005) gender difference was due to the fact that men’s performance was encouraged by their better ability in spatial and numerical abilities that produce greater aptitude in mechanics.

Other factors which affect gender disparity in students’ performance in mechanics include: 33% classroom interactions; 51% physical facilities; and 76% socio-cultural influence. The current study was different from what Johnson (2000) observed that teachers of mathematics tended to give male students more opportunities to respond to higher-level cognitive questions than females. More aggressive nature of male students if pampered in a two gender classroom setting could lead to female students shying off from participating in the lesson. The current study concurred with what Johnson (2000) observed that more mathematics teachers interact more with male students than with female students. The current study concurred with what Amuka, Olel and Gravenir (2011) who asserted that in Kenya, there were no female students enrolled for engineering courses in technical institutions because by the second year the majority of the female students either had dropped out or they were not there at all. Sixty nine per cent (69%) of the lecturers felt that other factors which affect gender disparity in performance in mechanics was that there were more male lecturers than female in mechanics. The current study was different from Mwenda, et al., (2013) who observed that although gender mainstreaming could play an important role in encouraging development of positive opinion as well as attitude in mechanics, girls in certain institutions in Kenya lack role model to emulate their learning of mathematics and physics. Knowledge and skills in Mathematics and Physics were needed for understanding of mechanics (Fang, 2014). Hence, the effort in studying the gender difference in mechanics was urgent and necessary.

Gender disparity in students' performance in mechanics might be associated with 21% ($n = 80$) female enrollment compared to 79% ($n = 304$) enrollment of their male counterparts in mechanics. These results showed gender difference of 58% in students' enrollment. The current study concurs with what Odhiambo (2009) observed that female instructors were fewer 180 (45%) than male instructors 220 (55%) in technical training institutes in Nairobi Province. The current study concurred with what Mwenda, et al., (2013) and Akala (2010) who asserted that having more male lecturers in lessons could reinforce the notion that the discipline was a man dominated discipline. The current study concurs with what Dweck (2006) and Johnson (2000) who observed that classroom interaction affect students' performance in mechanics. The current study found that gender disparity in performance is reinforced by presence of fewer female lecturers (21%) than male lecturers (79%) ($n = 96$). The current study concurred with what Amelink (2012) and Wells (1987) observed that gender disparity in mathematical ability is closely correlated with women participation in science, technology, engineering and mathematics (STEM) course and especially in mechanics. Similarly, the current study concurred with what Obengo (2009) found that in Machakos technical institute the enrollment of male students taking engineering courses was more (95.53%, $n = 771$) male students than female students ((4.46%, $n = 36$). The current study was different from Obengo (2011) observed that in the overall enrollment of male and female students' population of 1359 and 1111 respectively, majority (over 60%) of the female students had enrolled in tourism, hospitality among other 'soft' sciences compared to male students who are enrolled for 'hard' sciences like engineering courses. Similarly, Bukhala (2009) carried out a study in the former Western Province technical institutes observed that the enrollment of male students taking engineering related courses had higher 89 (83.96%) male than female students 17 (14.65%). Similarly, Odhiambo (2009) who carried out her study in Nairobi technical institutes observed that more male students 2279 (66%) were enrolled in technical and vocational courses than female students 1416 (34%).

The test of hypothesis on the difference in students' learning gain in mechanics between male and female when they were taught using steeplechase activities was discussed as shown below.

H_{O4} –**There is no significant difference in performance in mechanics when learners are taught using steeplechase activities for between male and female groups.**

Since the table value of significance (2-tailed test) in is greater than 0.05 at $df = 19$, the study did not reject the null hypothesis H_{04}. These resulted suggest that the difference in performance in mechanics between male and female groups when students were taught using steeplechase activities was not significant. The results also suggest that steeplechase activities had the capacity to reduce the gender disparity in performance compared by motivating both male and female students to work hard. Motivation to work hard had the capacity to improve students' performance in mechanics. The current study concurred with what Muriithi, et al., (2013) observed that involving students in a project had capacity to improve teaching and learning of physics. Improved teaching and learning could translate to improved performance in mechanics. Specifically, the current study concurred with what Muriithi et al., (2013) and Well (1987) observed that involving students in project such as steeplechase activities had capacity to model problems as well as encourage students to work hard in physics. The current study was doing a follow-up on Wells (2013) recommendation for further research to find out the perceived differences between initial knowledge status in physics for male and female; the reasons for these differences and the necessary modeling techniques needed to accommodate differences if any a gap filled by the current study.

4.7.0 Pedagogical Techniques in the Teaching of Mechanics

The results in this section addressed the pedagogical techniques when steeplechase activities are used for teaching mechanics.

Table 32: **Lecturers' Responses on Pedagogical Techniques in Steeplechase Activities**

Statement	f (%)
Steeplechase activities can help students test their understanding of mechanics	34 (35.4%)
Steeplechase activities can help students collect data, organize and analyze data, interpret data and make conclusions	18 (18.8%)
Steeplechase activities can help students make graphical and diagrammatic representations of phenomena then carry out mathematical calculations	36 (36.5%)
Steeplechase activities can help students form algebraic expressions, equations and use them in problem-solving	25 (25.0%)
Steeplechase activities can encourage improvisation of teaching and learning resources	32 (33.3%)
Steeplechase activities and use of audio-visual resources, charts diagrams, models can improve students' performance in mechanics	39 (40.6%)
Steeplechase activities can help students to develop ability to read instruments accurately and correct use of apparatus and equipment can help students get the best out of activities	39 (40.6%)
Steeplechase activities can help demystify learning of mechanics	34 (35.4%)

(n = 96)

Results in Table 32 showed that steeplechase activities could encourage students 37% to make diagrammatic representations and carry out mathematical calculations after 25% forming algebraic expressions and 25% form equations useful for problem-solving. Thirty five percent (35%) felt that steeplechase activities could demystify learning mechanics. Table 33 represents lecturers' responses on the role of students in steeplechase activities.

Table 33**: Responses on the Role of Students in Steeplechase Activities**

Statement	f (%)
Plan, carry out investigations and make observations	45 (46.9%)
Describe situations and make notes	35 (36.5%)
Discuss with peers, express themselves (communication skills)	62 (64.6%)
Exercise for development of motor skills and refreshment	14 (14.6%)

(n = 96)

The results in Table 33 showed that the role of students in steeplechase activities includes: 47% carry out investigational experiments as well as make observations; 14% get involved in physical exercise to develop motor skills; and 36% describe situations and make notes. Table 34 represented lecturers' responses on factors that influence success of steeplechase activities.

Table 34: **Lecturers' Responses on what Affects Success of Steeplechase Activities**

Statement	f (%)
Clarity of instructions	80 (83.3%)
Effective guidance and supervision	60 (62.5%)
Group size and composition	71 (73.9%)
Lecturers' ability to establish link between the activities and the concept	38 (39.6%)
Maintain safety precautions	87 (90.6%)

(n = 96)

The results in Table 34 showed that success of steeplechase activities depends on: 78% organization of the learning environment; 83% effective instructions; 64% effective facilitation; 74% group dynamics; 39% lecturers ability to build a bridge between activities and the concept learnt; and 90 % safety precaution. Table 35 presents lecturers' responses on the components of steeplechase activities.

Table 35: **Lecturers' Responses on Components of Steeplechase Activities**

In Steeplechase Activities students can:	f (%)
Participate in actual race, collect data, analyze and interpret data and make conclusions	18 (18.75)
Make graphical and diagrammatic representations of phenomena and carry out mathematical calculations	13 (13.54)
Form algebraic expressions, equations and use them in problem-solving	31 (32.29)
Interrogate the training programs and techniques	39 (40.63)
Make group presentations of the findings and results	31 (32.29)

(n = 96)

The data in Table 35 showed that lecturers felt that in steeplechase activities, students could: 18% participate in actual race and collect data; 13% carry out mathematical calculations. Forty percent (40%) of the lecturers felt that students could hold discussion with the steeplechaser and 32% make group presentations of the findings and results to the whole class.

Other benefits of teaching mechanics using steeplechase activities were summarized here. Explaining ones thinking develops effective communication skills. The lecturers' responses also showed that participation in steeplechase activities develops estimation skills. The lecturers' responses also showed that developing and using mathematical expressions and equations in steeplechase activities develop problem-solving skills. The lecturers' responses also showed that simulation of mechanics problems develops analytical and critical thinking skills.

The study also found that teaching using steeplechase activities with Socratic probing posted higher mean score (67%; $std.dev.$ = 11.80) in mechanics compared to teaching using steeplechase activities without Socratic probing (61%; $std.dev.$ = 11.63). The gains students' learning gain (a predictor of performance) in mechanics when students were taught using steeplechase activities with Socratic probing was higher (35%) compared to teaching using steeplechase activities without Socratic probing (29%). These results also suggested that teaching using Socratic probing in steeplechase activities had the capacity to encourage deeper understanding of mechanics concepts, encourage correction of misconceptions and commons errors as well as encourage informed construction of knowledge. The results also suggested that Socratic probing have the capacity to fortify the benefits of teaching using steeplechase activities. These results also suggested that Socratic probing used in steeplechase activities had the capacity to improve students' performance in mechanics.

4.7.1 Discussion on Pedagogical Techniques Used in Teaching Mechanics

The lecturers' responses show that explaining ones thinking in steeplechase activities have capacity to develop effective communication skills. The lecturers' responses also showed that developing and using mathematical expressions and equations in steeplechase activities had capacity to develop problem-solving skills. The lecturers' responses also showed that simulation of mechanics problems in steeplechase activities had capacity to develop analytical and critical thinking skills. The current study concurred with what Dasmani (2011) and Modig and Roxa (2009) asserted that using steeplechase activities for teaching had the capacity to provide opportunities for reflection, practice, consolidation of ideas and connect students' experiences with techniques of mathematical analysis. The current study concurred with what Bellington, et al., (2014) and Jackson (2009) observed that students write assignment questions meant for discussion with peers, reflection on concepts learnt in out-of-college activities. The current study was different from what Molenda and Pershing (2008) asserted that selection of appropriate problems encourages transfer of training needed in learning of mechanics concepts. The current study concurred with what Jones (2008) observed that students' understanding of what was presented in class, what they read from books, observations made from scientific and physical happenings can be encouraged by conceptualization of abstract ideas that was facilitated though small-group discussions. The current study concurred with what Jackson, Dukerich and Hestenes (2008) observed that involving students in small group discussion facilitated by attempting assignments individually then discussing results with peers to deepen understanding of concepts in mechanics.

When students are taught using steeplechase activities, their mean score posted was higher (63.71%; $std.dev. = 12.376$) in mechanics compared to alternative teaching strategies (43.53%; $std.dev. = 12.376$). These results suggested using students in steeplechase activities for teaching had the capacity to improve students' performance in mechanics compared to alternative teaching strategies such as traditional methods of teaching-chalk and talk and lecturer's demonstration. The study also found that when students were taught steeplechase activities with Socratic probing posted higher mean score (67.08%; $std.dev. =$11.800) in mechanics compared to using steeplechase activities for teaching without Socratic probing (60.79%; $std.dev. =$11.630). The gains made when students were taught using steeplechase activities with Socratic probing is higher (35%) compared to students who were taught using steeplechase activities without Socratic probing (29%). The normalized gain made when students were taught using steeplechase activities with Socratic probing was higher (51%) compared to using steeplechase activities for teaching without Socratic probing (42%). These results suggested that the gain attributed to Socratic probing was 9%. These results also suggested that when students were taught using Socratic probing in steeplechase activities had the capacity to encourage deeper understanding of mechanics concepts, encourage correction of misconceptions and commons errors as well as encourage informed construction of knowledge for students involved in steeplechase activities. The results also suggested that Socratic probing had the capacity to fortify the benefits of using steeplechase activities for teaching. These results also suggested that Socratic probing used in steeplechase activities had the capacity to improve students' performance in mechanics. The current study concurred with what Jackson (2009) found out that engaging students in cooperative learning and Socratic probing during group presentations posts 17% higher scores among experimental group compared to the control groups (where expository strategies were used). The current study concurred with what Jackson (2009) that students in steeplechase activities can be engaged in learning together and are exposed to Socratic probing during group presentation. Steeplechase activities had the capacity to encourage cooperative learning and Socratic probing during group report presentations.

The lecturers felt that simulation of mechanics problems develops analytical and critical thinking skills. The lecturers also felt that mathematical skills developed thorough steeplechase activities revolve around physical and mental well-being (cognitive skills), healthy interpersonal relations skills, capacity to make informed decisions and capacity for handling data. The current study concurred with what Serway and Jewett (2004) and MMP (2002) asserted that the related areas include time of flight, distance from the ground to the hurdle, angle of projection, projection velocity and optimum friction. The current study concurred with what Barreau (2011), Beis, et al., (2011), Janusz and Walaszczyk (2011) observed that leaping from water jump rail involves staying as low as possible and pushing as hard against the rail. The current study concurs with what Serway and Jewett (2004) and MMP (2002) asserted that the mathematical calculations were related to: time of flight; projection velocity, force for pushing against the rail, work done and power needed during takeoff; height of the center of mass from the ground; projection velocity and optimum friction. Similarly, the current study concurs with what Modig and Roxa (2009) that in interactive teaching strategies such as steeplechase activities, students' presentations and Socratic probing by lecturers could provide opportunities for reflection, practice, consolidation of ideas and connect students' experiences with techniques of mathematical analysis.

The results showed that mechanics can be applied in games and sports in attaining precision, timing of runners' movement, techniques of reducing air resistance, elimination of skin friction, use of ultrasound for routine checks for ensuring health and safety of athletes and use of modern starting blocks integrated with high-tech starting gun system which can automatically detect athlete's false start. The current study was different from what Wilson (2013), and Tammet (2012) observed that mathematics can also be applied in players' statistics, coaches' formula for drafting certain players, judges' scores for a particular athlete and ranking of players to determine play-off scenario. The current study was different from what Wilson (2013) observed that probability can also be used to determine the chances of a particular athlete or team winning. The current study was different from what Tammet (2012) and Staiger (1999) observed that mechanics concepts can also be used in calculation related to launch velocity, shooting angle and appropriate range (distance between player and basket) needed to make a basket could be done using equations in projectile motion. The current study is different from what Wilson (2013) and Staiger (1999) observed that mathematics concepts in mechanics can be useful in throwing and hitting a baseball to determine the height from which the ball was thrown, launch angle, speed of the ball, the distance the ball will travel require and the equation for finding the projectile of motion that the baseball would travel. Hence, simulation of problems in mechanics might involve long jump, catapult, football, and lawn tennis among others.

The study results showed that the simulation of mechanics problems can be done in form of exploratory and open-ended questions which are both thought provoking and has a high level of difficulty that requires collaborative learning to solve. The current study concurred with what MMP (2002) that simulation problem in mechanics can involve long jump in areas such as: work done to raise the center of gravity, mathematical advantages of the various high jump approaches in terms of energy spent, a suggestion of another track or field event in which the same principles are used to maximize performance in the race. In sprints, mechanics has been used in determine the distance of the starter from the athlete implying that the starter's position should be equidistant from all the athletes to ensure that they get the signal to start at the same time. Mechanics has also been used in wind assistance to determine the force needed to generate maximum acceleration and rate at which energy is spent (power). Mechanics concepts are applied in long jump in calculation of time taken from take-off to landing, angle of take-off, the value of acceleration due to gravity depending on the position on the surface of the earth. The current study concurred with what Billington, et al., (2014) that the simulation of mechanics problems is offered in form of personal projects where the individual results are discussed in small-groups for consolidation of ideas. The group results are compared with the corrected responses offered on a different material to ensure instant feedback is provided. That means that students can be involved in steeplechase activities in mechanics to collect data useful in modeling problems on work, energy and power, friction, the angle of projection and projection velocity. The current study concurred with what Serway and Jewett (2004) that students can make generalizations useful in understanding the principles for problem solving in linear and non-linear motion. The current study concurred with what Tammet (2012) that other sports and games rich in providing opportunities for simulation of mechanics problems include shot put, discuss, 110m hurdles and throwing a javelin. Therefore, steeplechase activities can be used for simulation of mechanics problems as an intervention strategy for improving students' performance in the discipline in Kenya.

The study results showed that simulation of mechanics problems through track and field athletics (which in this case involves steeplechase activities) included: work done to raise the steeplechaser's center of mass, mathematical advantages of doing water jump in certain way in terms of energy spent and time taken from take-off to landing and the angle of take-off. The areas discussed here applied the same principles found in mechanics in static, dynamics, friction, stress and strain, and fluids. The current study concurred with what Fang (2014), Tammet

(2012), Serway and Jewett (2004) and MMP (2002) observed that students taught using steeplechase activities in mechanics could collect data useful in modeling problems on work, energy and power, friction, the angle of projection and projection velocity and make generalizations useful in understanding the principles for problem solving in linear and non-linear motion. The current study was different from what MMP (2002) observed that simulation problem in mechanics could be done in long jump in areas such as: work done to raise the center of gravity, mathematical advantages of the various high jump approaches in terms of energy spent. In sprints, mechanics was used in determining the distance of the starter from the athlete. Mechanics was also used in wind assistance to determine the force needed to generate maximum acceleration, rate at which energy is spent. Mechanics concepts were applied in long jump in calculation of time taken from takeoff to landing, angle of takeoff, the value of acceleration due to gravity depending on the position on the surface of the earth. The current study benefited from MMP (2002) who suggested that there are other track and field events in which modeling of mechanics problems can take place, a gap filled by the current study. Therefore, steeplechase activities could be used for teaching mechanics.

The current study concurred with what Government of Kenya (2010b) that in steeplechase activities, effective instructional processes might take place if lecturers play their encouraging, facilitator, management and leadership roles. The current study concurred with what Muthoni (2012) that the lecturer is a learning facilitator, a guide, a manager of the learning resources and an encourager. The current study concurred with what Muthoni (2012) and Kombo (2005) outlined nine possible functions of lecturers in collaborative learning which include the following. In preparation, the lecturers are involved in group formation by: first, initiating group work; second, presenting guidelines for small-group operations; third, fostering group norms of cooperation and mutual helpfulness; and fourth forming groups. Then, the lecturers are involved in equipping the groups with the necessary instructions and materials needed by: fifth, preparing and introducing new materials; sixth, interacting with the groups; and seventh, providing avenues for tying the ideas together. The lecturers are also involved in students' project or assignment or individual or group work by: eighth, making assignment of homework or in-class collaborative learning activities; and ninth, facilitating positive and objective evaluation of students' performance in group or individual setting. The current study concurred with what Muthoni (2007) that the lecturers provide groups with reasonable autonomy as well as visit the groups from time to time and ensure that the students prepare for group presentation. The current study concurred with what Jackson (2009) that during group presentations, Socratic probing is used to deepen understanding

The results in Table 32 showed that 33% of the respondents felt that steeplechase activities can help students test their understanding of mechanics. Nineteen percent (19%) of the respondents felt that steeplechase activities can help students collect data, organize and analyze data, interpret data and make conclusions. Thirty seven percent (37%) of the respondents felt that steeplechase activities can help students make graphical and diagrammatic representations of phenomena then carry out mathematical calculations. Twenty five (25%) of the respondents felt that steeplechase activities can help students form algebraic expressions, equations and use them in problem-solving. Thirty three percent (33%) of the respondents felt that steeplechase activities can encourage improvisation of teaching and learning resources. Forty one percent (41%) of the respondents felt that steeplechase activities and use of audio-visual resources, charts diagrams, models can improve students' conceptualization of ideas in mechanics. Forty one percent (41%) of the respondents felt that steeplechase activities can help students to develop ability to read instruments accurately. Correct use of apparatus and equipment can help students get the best out of activities. Thirty five percent (36%) of the respondents felt that steeplechase activities could demystify learning of mechanics. The current study concurred with what Tammet (2012) that steeplechase activities can encourage students' understanding of fundamental concepts, ability to communicate results accurately and concisely as well as mastery of content for brainstorming and problem-solving. The current study concurred with what Jones (2008) that students' experiential learning cycle in steeplechase activities can have dimensions such as: concrete experience, active experimentation, abstract conceptualization and reflection which are found in steeplechase activities. The current study concurred with what Huang (2011) that in steeplechase activities, concrete experiences can form the basis for active experimentation and application of learnt concepts and theories. The current study concurred with what Abdullar and Shariff (2008) that consolidation of ideas can involve individual or group assignment, small-group discussions, individual or group report writing, in-class presentation of group findings and Socratic probing to assess deep understanding of concepts in steeplechase activities. Hence, steeplechase activities can be a source of content, learning methods and pedagogical strategies.

The results in Table 33 showed that 47% of the respondents felt that in steeplechase activities, students can plan, carry out investigations and make observations. Thirty seven percent (37%) of the respondents felt that in steeplechase activities, students can describe situations and make notes. Sixty five percent (65%) of the respondents felt that in steeplechase activities, students can discuss with peers, express themselves (communication skills). Fifteen percent (15%) of the respondents felt that in steeplechase activities, students can exercise for development of motor skills and refreshment. The study results showed that as steeplechasers' carry out explosive activities; students can be assessed in their participation in making observations, collecting data, analysis and interpreting the data which include: accelerating, changing pace after specific time, jumping, ordinary and water barriers can be determined. The study results also showed that the that calculation related to steeplechasers' attainment of an acceleration of $3.81 m/s^2$ before changing the pace again caused by start of doing the ordinary barriers. The study results also showed that steeplechasers can attain a net force of 215.65N. The current study concur with what Tammet (2012), Onywera (2006) and Staiger (1999) asserted that other calculations that can be carried out include the net force of 215.65N which is relatively low compared to that of 87kg of a soccer player at the same acceleration and time because one can attain a net force of 331.47N. Students can observe that the relatively low net force suggests that steeplechasers need less effort to stay on course and avoid being disqualified. Similarly, in steeplechase activities involving various quantities, students can develop problem-solving techniques and strategies.

The study results showed that in steeplechase activities, students are able to identify factors that influence performance of steeplechasers which include exceptional bio-mechanical efficiency, high intensity training and strong psychological motivation to succeed. The study results also showed that in their groups, students' capacity to identify the most efficient approach to the hurdle at the water jump, strategies used to keep steeplechasers' stability, save time, energy and increase chances of winning the competition. The study results show that Wilber & Pitsiladis (2012), Barreau (2011), Enomoto, et al., (2011) and Jones (2008) that in collaborative learning class-based assessment can be used to determine students' ability to discuss and identify optimum conditions necessary for steeplechasers to clear the ordinary barriers. Therefore, students can collect data to predict conditions for optimized take off and efficient landing through mathematical modeling.

The current study concurred with what Tammet (2012) that understanding of mechanics concepts in areas in steeplechase activities which include; angular velocity, time of flight, angle of projection, projection velocity, height of center of mass, trajectories, equations of linear and projectile motion, friction, force, work, energy and power among others can be encouraged. These observations are consistent with the fact that the Kenyan excellent performance in steeplechase is associated with athletes' use of intelligence in world competitions, great sense of discipline in training and running in a pack. The current study concurred with what IAAF (2013) that the world record in steeplechase is held by Saif Saaeed Shaheen of Qatar (formerly named

Stephen Cherono of Kenya) that the record is 7 minutes, and 53.63 seconds. Mathematical distribution of 7 minutes and 53.63 seconds is explained as shown here. Time spent for tactfully doing seven (7) hurdles and water jumps is 8.89 seconds such that the steeplechaser spends exactly 1.27 seconds for each hurdle and water barrier. The steeplechaser also spends 14 seconds to do 28 ordinary barriers suggesting that each hurdle requires 0.5 seconds. The steeplechaser also spends approximately 450.8 seconds for thirty five (35) 80m straight sprint suggesting that the average speed is 6.83 m/s. The current study concurred with what Beis, et al., (2011), MMP (2002), Staiger (1999) and Beckmann (1991) that the mathematical calculations related to each of the part of the steeplechase in the competition can be rich in both experimental and investigation that can be practiced by students in the steeplechase activities in the teaching experiment. The current study also concurred with what Francois & Kerkhove (2010) that instructional strategies in steeplechase activities can include: collaborative learning, experiential learning, problem-based learning, small-group discussion and out-door activities.

Mathematical calculations which can be carried out in steeplechase can involve quantities such as average speed, acceleration and force. Students can identify the distribution of the time over the race. The details of the explosive activities in steeplechase as a race start by the steeplechaser doing the first 90m bend and a 110m straight without barriers. Students taking mechanics can carry out observations from data obtained through measurements and carry out calculations. The bend has an approximate radius of 14.31m. If the athletes' take off in a fast pace, they are likely to attain an average speed of 7m/s in the direction towards the center of the circular bend suggesting that the time taken for the bend is thirteen seconds (precisely 12.85s). The steeplechasers' angular velocity is 25.21^0/s. The current study concurred with what Kong and Heer (2008) and Staiger (1999) that the steeplechasers' average speed of 7m/s and is higher than that of long distance athletes who run at between 3.5m/s and 5.4m/s. The current study is different from what Commetti, et al., (2001) that the angular velocity of 25.21^0/s is lower than that of soccer players for peak performance whose angular velocity is between 60^0/s and 90^0/s Therefore, steeplechase activities have the capacity to develop students' experimental and investigations for simulation of mechanics problems.

The study results showed that students can identify relationships between quantities obtained, model mechanics equations which they can discuss to check their concurrence or difference in opinions. Students can compare the equations with the relevant literature values and explain the difference or concurrence. The current study concurred with what Johnson (2000) and Staiger (1999) that students can derive equations in small-group discussions or those obtained from textbooks which can act as a recipe for algebraic problem-solving. The current study concurred with what Beckmann (1991) that students' capacity to handle algebraic problem solving is useful in finding unknown quantities in word problems or in real-world situations. Therefore, steeplechase activities have the capacity to model linear and non-linear equations in mechanics.

The current study found that cooperative learning or collaborative learning in activities-based teaching might post better results in overall satisfaction, relevance, feedback from lecturers, enthusiasm, clear goals, problem solving and ability to work in groups. The current study concur with what Tammet (2012) observed that incorporation of instructional activities rich in sports and games can develop inter-personal and social abilities such as: negotiations skills, effective communication, conflict resolution, develop critical thinking, psychological health; creative problem-solving; synthesis of knowledge and promote self-esteem and positive attitude to Mechanics among other generic skills. Therefore, steeplechase activities can be used for developing inter-personal and social abilities such as: critical thinking, psychological health; creative problem-solving; synthesis of knowledge and promote self-esteem negotiations skills, effective communication and conflict resolution development and positive attitude to Mechanics among other mathematical and process skills.

The results in Table 34 showed that 83% of the respondents felt that the success of steeplechase activities is affected by clarity of instructions. Sixty three percent (63%) of the respondents felt that the success of steeplechase activities is affected by effective guidance and supervision. Seventy four percent (74%) of the respondents felt that the success of steeplechase activities is affected by group size and composition. Ninety one percent (91%) of the respondents felt that the success of steeplechase activities is affected by lecturers' ability to establish link between the activities and the concept. Sixty three percent (74%) of the respondents felt that the success of steeplechase activities is affected by ability to maintain safety precautions. Hence, the results showed that stages of carrying out a steeplechase activities could include: preparation, performing of the demonstration and discussion. Specifically, discussion involves: analysis, interpretation of data, finding of patterns, making generalizations and writing assignments on procedure and further practice. The current study results concurred with what Arthur, et al., (2013), Twoli (2006) and Nzama (2000) suggested that in in-class-activities and out-door-activities students could be involved in lecturer's demonstration at the start and the end of the students' experiments for purposes of setting the pace, giving instructions, facilitation of the students' experiments and correcting common errors. The current study concurred with what Serway and Jewett (2004) observed that students could make generalizations useful in understanding the principles for problem solving in linear and non-linear motion. The current study was different from what Tammet (2012) observed that other games and sports that could be rich in providing opportunities for simulation of mechanics problems include shot put, discuss, 110m hurdles and throwing a javelin. Therefore, steeplechase activities could be used for simulation of mechanics problems as an intervention strategy for improving students' performance in the discipline in Kenya.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This study aimed at establishing the influence of steeplechase activities on students' performance in mechanics in selected diploma technical institutions in Kenya. This chapter contained the summary of the study, conclusion, recommendations and suggestions for further research.

5.1 Summary

In response to the first **(a) objective** on the difference in students' learning gain (as a predictor of students' performance) in mechanics when students were taught using steeplechase activities and traditional methods, the study found the following:

Results from questionnaires showed that 70% of all the lessons depended on traditional (expository) teaching strategies; 12% depended on heuristic strategies while 18% depend on other teaching strategies. Other teaching strategies used by lecturers included: field trips and educational visits; industrial-related training; and use of ICT for collaborative learning through the internet. Results from lesson observation show that 85% of all the mechanics lessons depend on traditional teaching strategies while 15% of the lessons observed depend of interactive teaching strategies. Steeplechase activities were not listed as one of the most commonly used teaching strategies.

Teaching of mechanics depended on: 19% lecture method, 17% dictation of notes, 16% question and answer method, 10% use of examples and illustrations and lecturers' demonstration. Those results show that 70% of the lessons depend on traditional methods of teaching. Similarly, lesson observations showed that traditional methods of teaching accounted for 85% of all the lessons while lecturer's demonstration accounted for 15%.

From the analysis of students' responses in pre-test scripts showed the prevalence of misconceptions. The most common misconceptions are related to: calculations on time in linear motion; confusion of motion under free-fall with potential energy; inability to form and solve quadratic equations; and using linear motion for problem solving. Other misconceptions were related to: inability to derive and use projectile motion equations; efficiency of machine which is greater than 100%; inability to work out resolution of forces; wrong substitution; misconception related to decimal fractions; and inability to represent information diagrammatically.

Misconceptions in mechanics were associated with inadequate preparation in mathematics and physics as well as use of over-reliance on traditional methods of teaching at the expense of using discovery learning. The study results gave an assurance that steeplechase activities had the capacity to deal with the above misconceptions.

Poor performance in mechanics was associated with teaching and learning based on linear procedural knowledge, memorization of facts, principles, laws and theorems instead of aiming at developing conceptual understanding and analytical skills. Poor performance in mechanics was also associated with decrease in mathematics and physics preparation leading to propagation of misconceptions.

The study also showed that steeplechase activities had the capacity to develop understanding of mechanics content areas which include; angular velocity, time of flight, angle of projection, projection velocity, height of center of mass, trajectories, equations of linear and projectile motion, friction, force, work, energy and power among others can be encouraged. Since the study results showed misconceptions in mechanics in these areas, steeplechase activities had the capacity to improve understanding of mechanics.

The results showed that steeplechase activities were rich sources of content, learning methods and pedagogical strategies. The study showed that steeplechase activities include: collaborative learning, experiential learning, problem-based learning, and heuristic teaching as well as out-door activities.

Since the table value of significance was less than 0.05, at $df = 95$, the study rejects the null hypothesis, H_{01} and accepts the alternative. These observations suggested that when students' learning gains in mechanics were higher when they were taught using interactive teaching strategies such as steeplechase activities compared to alternative teaching strategies (traditional methods of teaching which involves chalk and talk). The students' learning gain in mechanics when students were taught using steeplechase activities was 32% while the gain made when the traditional methods of teaching was 10%. The normalized gain made when students were taught using steeplechase activities was 47% while the normalized gain made when the traditional methods of teaching were used was 15%. These results suggested using steeplechase activities had the capacity to improvement students' learning gains by 32%. These results give the assurance that using steeplechase activities for teaching had the capacity to improve students' performance in mechanics compared to the alternative teaching strategies (traditional methods of teaching).

These results suggested that lack of practical applications of introductory mechanics concepts in real-life situation through the process of modeling instruction lead to the disciplines being abstract and misconceptions. Misconceptions which were not dealt with interfere with effective ability to relate concepts to problem solving in real life situations. Therefore, the study results gave the assurance that using steeplechase activities for teaching could provide application opportunities for improving performance in mechanics.

In response to the second **(b) objective** on the difference in students' learning gains (as a predictor of students' performance) in mechanics between group of students taught using steeplechase activities and lecturers' demonstration, the study found the following.

Lecturer's demonstration referred to a process of showing something such as a specimen, a model, an experiment, or a skill that need to be acquired while students watched.

When a lecturer was involved in the "showing" as students make observations was referred to as lecturer's demonstration.

Lecturer's demonstration involved oral explanation as well as a practical demonstration of content. That meant that lecturer's demonstration take place in controlled environment such as in mechanical or electrical workshops, laboratories or classrooms or real life environment. The lecturers used sketches, drawings, photos, models and pictures to support their oral explanations.

Lecturer's demonstration takes through three distinct stages: preparation, performing of the demonstration and discussion. The same stages were considered appropriate for conducting steeplechase activities

Resources which are used in steeplechase activities included: 400m standard athletics track, hurdles, water-jump, gunny bags filled with sand, lines, lanes, starting gun, spiked shoes, sleeveless t-shirts, pairs of short, electronic or manual stop watches, ICT tool such as video cameras, tablets for recording events, taking photographs for photo finish and recording stationery. These resources in steeplechase activities have the capacity to encourage understanding projectile motion concepts and application in problem-solving.

In lecturer's demonstration, resources were used for set induction, stimulus variation, motivation, and attempt to initiate discussion and help students identify the relationship between variables. Hence resources in steeplechase activities have the capacity to encourage conceptualization during lecturers' demonstration.

Steeplechase activities are interactive teaching strategies where instructional resources were used in sports and games are carried out for teaching of mathematics. Results show that electronic media could provide a suitable environment for in-class and out-of-class activities as well as self-assessment needed for instant feedback. Instant feedback could contribute to students' construction of meaning and encourage a systematic study discipline in hard work and positive reinforcement. The use of modern technology-based teaching could provide opportunities for students to explore concepts through activities provided in the virtual laboratory.

ICT for e-learning was useful in technical training as a catalysts for intensified application of science, technology and innovation, provide resources for scientific research, enhance technical capabilities of the work force and raise quality of TIVET instruction. These ICT-based tools had the capacity to provide the much needed opportunity to develop visualization useful in conceptualization process in the modeling instruction in mechanics.

A virtual lab provides opportunities for modeling mathematical situations which could promote effective diagrammatic and graphical presentation of information before coming up with the algebraic expression or equation for problem-solving. A virtual lab could provide opportunity for instant feedback, receive benefit of learning together, provide warmth, provide help during learning and develop professionalism as well as practical skills. The involvement of students in investigative activities such as steeplechase activities has higher chances of developing an all-round person than chalk and talk. Therefore, steeplechase activities could benefit from use of

ICT to record events, process results and model equations, use equations in problem solving, provide net-working for collaborative learning as well as provide simulation of steeplechase activities maneuvers.

Since the significance table was less than 0.05, the study rejects the null hypothesis, H_{02}. The study results suggested that students' learning gains in mechanics were higher when students were taught using interactive strategies such as steeplechase activities compared to the alternative strategies such as lecturer's demonstration. The gain made when students were taught using steeplechase activities was 32% while the gain made when resources were not used in lecturer's demonstration was 15%. The normalized gain made when students were taught using steeplechase activities was 47% while the normalized gain made when students are taught using lecturer's demonstration was 22%. These results suggest that lecturer's demonstration had greater capacity in improving students' performance in mechanics than using expository teaching strategies.

In response to third **(c) objective** on the difference in students' learning gains (as a predictor of performance) in mechanics between high and low groups when students were taught using steeplechase activities, the study found the following.

The results showed that 24% of the lecturers felt that students' ability could be expanded by hard work. The view that mathematical ability in mechanics could be expanded was preferred because it encourages students to work hard even if they experienced failure while those with the view of ability was a gift excuse their failure to lack of mathematical ability.

The results showed that 70% of the lecturers felt that ability grouping was useful for improving students' performance in mechanics. The results also showed that 41% of the lectures felt that mixed-ability grouping was useful in small-group discussion while 45% of the lecturers felt that pre-test was meant to help establish the students' ability in learning mechanics.

The negative impact of ability grouping in teaching and learning were summarized here. Seventy percent (70%) of the lecturers felt average ability students experience diminished self-concept while 33% of the lecturers felt low ability students rebelled against lecturers' efforts to contribute to learning.

When students were taught using steeplechase activities, the high ability group of students had higher (37%) learning gain in mechanics than low ability group of students (27%). The difference between highly motivated and less motivated groups of students was 10%. The normalized gain made by the motivated and less motivated student groups were 54% and 40%. The difference between the highly motivated and less motivated groups of students was 14%. These results suggests that involving students in interactive teaching strategies such as steeplechase activities had the capacity to inspire both high ability and low ability groups of students to work hard and improve their performance in mechanics.

Since the table value of significance (2-tailed test) was less than 0.05 at $df = 47$, the study rejects the null hypothesis H_{03} and accept the alternative. These results suggested that the difference (of 14%) between the means of the high and low ability students' performance in mechanics when students were taught using steeplechase activities is significant at 5% level of significance. The difference between the learning gains made by high ability students was 3% higher than that of the low ability students (37% and 27% respectively). The normalized gains a difference of 14% (54% and 40%). These results gave the assurance that using steeplechase activities for teaching have the capacity to encourage the high ability students to work harder as well as spurring the low ability to work hard and improve their performance in mechanics.

Results also give the assurance that when low ability group of students are allowed to manipulate resources in steeplechase activities, their performance in mechanics could improve.

In response to fourth **(d) objective** on the difference in students' learning gains (as predictor of performance) in mechanics between groups of students when taught using steeplechase activities, the study found the following.

The results showed that 34% of the lecturers felt that both male and female had the same mental ability in mechanics. In situations where there was gender disparity; 62% of the lecturers felt that male have higher spatial ability than female students. The results also showed that 76% of the lecturers felt that female students achieve higher than male students in lower cognitive problems in mechanics.

The results also showed that other factors which affect gender disparity in students' performance in mechanics included: 33% classroom interactions; 69% more male than female lecturers of mechanics; 51% physical facilities; and 76% socio-cultural influence. Those factors were referred to as the "hidden variable" in influencing the gender disparity in learning gains in mechanics. The "hidden variables" might need further research to determine their effect on performance in mechanics.

The results showed that when students were taught using steeplechase activities, the male group of students had better (29%) learning gains in mechanics than female students (26%). The gender difference between male and female students' means was 3%. The normalized gain for male students was 42% while that of female students was 38%. The gender difference of 3% was almost the same in the normalized gain of 4%. Although male students have higher mean score compared to female students, variability in performance of male students in mechanics was higher (standard deviation of 13.892) than female students (standard deviation of 9.918). Those results showed that men who had good performance in mechanics were ‘very good’ while those who have poor performance in mechanics were ‘very poor’. These results suggested that using steeplechase activities for teaching have the capacity to reduce gender difference in performance in mechanics.

Since the value of significance (2-tailed test) was greater than 0.05 at $df = 19$, the study did not reject the fourth null hypothesis H_{04} on the difference in learning gain as predictor of students’ performance in mechanics between male and female group of students. Those results suggested that the difference between the means (of 3%) between the gender groups of students in performance in mechanics when students were taught using steeplechase activities was not significant at 5% level of significance. The difference between the learning gains made by male (29%) and female (26%) groups of students was 3%. The difference between the normalized learning gains made by male (42%) and female (38%) groups of students was 4%. Those results also suggested that steeplechase activities had the capacity to reduce the gender difference in performance. Using steeplechase activities for teaching had the capacity to motivate both male and female to work hard thus improve performance in mechanics.

General gender difference in students’ performance in mechanics was associated with 21% (80) female enrollment compared to 79% (304) enrollment of their male counterparts in mechanics. These results showed a gender disparity of 58% in enrollment which was more than half of the total enrollment. Therefore, there was need to address gender disparity among students taking mechanics in Kenyan technical institutions a gap addressed by the current study. The results showed that male and female students’ performance in mechanics was improved through steeplechase activities.

Classroom interactions were likely to encourage gender disparity in performance in mechanics because lecturers were observed to ask male students more questions than female students. Lecturers of mechanics gave male students more opportunities to respond to higher-level cognitive questions than female students. More mechanics lecturers interact more with male students than female students especially relative to blame or praise interactions. The solution to gender disparity was associated with providing equity in classroom interactions.

The study results on steeplechase activities were summarized as shown here. When students were taught using steeplechase activities estimation skills were developed. Explaining ones thinking develops effective communication skills were also developed. Mathematical expressions and equations were developed and used through steeplechase activities which also encouraged problem-solving skills development. Simulation of mechanics problems developed analytical and critical thinking skills.

The results showed that the role of students in steeplechase activities included: 47% carrying out investigative experiments as well as making observations; 14% getting involved in physical exercise to develop motor skills; and 36% describe situations and make notes.

The study showed that the mathematical skills developed through using steeplechase activities for teaching included: critical and creative thinking skills, problem-solving skills, coping with stress, information handling skills, effective communication skills, conflict resolution skills, assertiveness, team work skills. The study showed that students and graduates in mechanics needed to develop personnel's attribute which included: perform tasks autonomously, cooperate with others, own responsibility and perform tasks efficiently and effectively.

The results showed that the success of steeplechase activities depended on: 78% organization of the learning environment; 83% effective instructions; 64% effective facilitation; 74% group dynamics; 39% lecturers ability to build a bridge between activities and the concept learnt; and 90 % safety precaution.

Angular velocity problems could be simulated using steeplechase activities. The results showed that the steeplechasers' angular velocity was lowest at the zone between the first and the second steeplechase hurdle (average of $8°/s$) and the highest at the zone near the water-jump straight ($18°/s$). These results also showed that barriers slowed down steeplechasers making the race spectacular and interesting to watch. In zones with lower pace, the steeplechasers had opportunities to overtake or improve on time by ensuring optimum balance while zones for fat pace were meant to help athletes maintain their pace except at the finishing dash where the winner was determined by maintaining being in the front pack then sprinting throughout the last 200m of steeplechase.

Results showed that mechanics students in steeplechase had lower pace (4.11m/s for men and 3.34m/s for women) than the guest steeplechasers (6m/s). Hence, the angular velocities of students were lower than those of guest steeplechasers. These results suggested that steeplechase activities had the capacity to involve students in measuring time, angles, and arc distance to determine the angular velocity. Students in small-group discussions could use the IAAF (2008) Edition of the Marking Plan of 400m Standard Track.

Results showed that the optimum initial velocity at which steeplechasers moved with when they push hard against the rail to be able to step almost at the end of the water jump was estimated as between 5m/s to 6m/s. The initial velocity for novice steeplechasers was almost at zero (0.5m/s) because the hurdle at the water was a barrier that almost stops the athletes. Since it was hard to attain a high initial velocity, say of 6m/s, the ideal initial velocity was estimated at 5.857m/s.

Results show that if a steeplechaser takes off from the rail at a velocity of 5.857m/s and an angle of 45^0, the athlete shall land at about 0.1m away from the end of the water jump before proceeding on to sprint again on the track.

Results showed that the optimum take off velocity was estimated at between 40^0 and 45^0. Where possible, an athlete aimed at stepping on the rail with the trail leg then step out onto the track on the lead leg. If the initial velocity was low say 5.5m/s or below and the takeoff angle was 40^0 or below, the athlete had to get into the water with both legs then push through it. Passing through the water consumes a lot of energy apart from slowing down the athlete due to water pushing back against the forward motion.

In calculation of the range (the horizontal distance travelled by the center of mass of the steeplechase) in projectile motion is given by the equation:

$$Range = 0.10417(s^2m^{-1})v_0^2\sin(2 \propto)$$

Mechanics students consider that $\sin(2\theta)$ is a unit (1) if$\theta = 45°$, optimum initial velocity of $5.93m/s$ and the length of the water jump pit. The students divide$3.66m$ by $(5.93m/s)^2$, to obtain 0.10417(s^2m^{-1}) which was a constant linking range to the initial velocity. The equation above was similar to what had been developed by Mathematics in Sports as used in rugby.

The study shows that steeplechase activities had the capacity to be a source of content, learning methods and pedagogical strategies. The study showed that steeplechase activities include: collaborative learning, experiential learning, problem-based learning, heuristic teaching and learning and out-door activities.

The study showed that steeplechase activities could encourage simulation of mechanics problems in areas such as: maximum vertical height one jumps, maximum horizontal distance, the time taken and the angle that could offer optimum results in steeplechase as a spectacular race world over. These results showed that mechanics had the capacity to improve performance in steeplechase as a race.

Students have opportunities to gain experiential learning cycle in steeplechase activities which were rich in dimensions such as: concrete experience, active experimentation, abstract conceptualization and reflection. In steeplechase activities, concrete experiences had capacity to form the basis for active experimentation and application of learnt concepts and theories.

Steeplechase activities had capacity to encourage lecturers to guide students in consolidation of ideas through involving individual or group assignment, small-group discussions, individual or group report writing, in-class presentation of group findings and Socratic probing to assess deep understanding of concepts in steeplechase activities.

The study showed that steeplechase activities have the capacity motivate students to experiment with new skills during data collection, analysis, interpretation, mathematical modeling and application of the model in problem solving as well as developing ability to communicate results to non-technical audience. The study showed that steeplechase activities had the capacity to encourage understanding of fundamental concepts, ability to communicate results accurately and concisely as well as mastery of content for brainstorming and problem-solving.

The study showed that in steeplechase activities, students can observe steeplechasers make explosive activities, collect analyze and interpret data include: accelerating, changing pace after every 5-6 seconds, jumping, ordinary and water barriers and sprinting. Calculation related to steeplechasers' attainment of an acceleration of $3.81 m/s^2$ before changing the pace again caused by start of doing the ordinary barriers.

The study showed that steeplechasers had capacity to attain a net force of 215.65N which was relatively low compared to that of 87kg soccer player at the same acceleration and time because soccer player could attain a net force of 331.47N. Hence, simulation of mechanics problems involving net force in steeplechase activities could improve the understanding of the same especially when compared to net force in other games and sports such as rugby, cross-country, cricket and basketball among others.

Steeplechase activities have capacity to encourage growth of ethno-mathematics as a source of mathematical practices which include symbolic systems, spatial design, practical constructions techniques, calculation methods, measurement in time and space specific ways of reasoning and inferring and other cognitive and material activities which can be translated to formal mathematical representation

The results show that areas which needed specialized training programs and techniques included: 33%water jump, 32% hurdling and 20% running economy of energy reserve. The role of hurdling drills techniques and circuit training include: 20% improvement of speed, 36% efficiency in breaking and acceleration.

Results showed that the techniques for hurdling at the water jump include: 35% maintaining low hip; 73% the push from the barrier was delayed until the body was well beyond it, 60% the athlete propel himself or herself to maximize drive and 68% landing was done with the lead leg in the water while the trail leg steps outside the water.

The lecturers' responses showed that explaining ones thinking developed effective communication skills. The lecturers' responses also showed that using steeplechase activities for teaching could develop estimation skills. The lecturers' responses also showed that developing and using mathematical expressions and equations in steeplechase activities developed problem-solving skills. The lecturers' responses also showed that simulation of mechanics problems developed analytical and critical thinking skills.

Using steeplechase activities for teaching posted higher mean score (63.71%) in mechanics compared to alternative teaching strategies which posted 43.53%. Those results suggested that using steeplechase activities for teaching had the capacity to improve students' performance in mechanics compared to alternative teaching strategies (traditional methods of teaching-chalk and talk and lecturer's demonstration).

The study also found that using steeplechase activities for teaching with Socratic probing posted higher mean score (67.08% ($std.dev. = 11.80$) in mechanics compared to using steeplechase activities for teaching without Socratic probing (60.79%; $std.dev. = 11.63$). The gains made when students were involved in steeplechase activities with Socratic probing was higher (35%) compared to using steeplechase activities for teaching without Socratic probing (29%). The normalized gain made when students were involved in steeplechase activities with Socratic probing is higher (51%) compared to using steeplechase activities for teaching without Socratic probing (42%).

These results suggested that the gain attributed to Socratic probing was 9%. These results also suggested that involving students in Socratic probing in steeplechase activities had the capacity to encourage deeper understanding of mechanics concepts, encourage correction of misconceptions and commons errors as well as encourage informed construction of knowledge for students involved in steeplechase activities. The results also suggested that Socratic probing had the capacity to fortify the benefits of teaching using steeplechase activities. These results also suggested that Socratic probing used in steeplechase activities had the capacity to improve students' performance in mechanics.

5.2 Conclusion

The purpose of the study was to explore the influence of pedagogical techniques in using steeplechase activities as a teaching strategy on students' performance in Mechanics in selected diploma technical institutions in Kenya. Therefore, the study made the following conclusions:

a) The study showed that if students were taught using steeplechase activities, the experimental group had higher gains in performance than control groups where traditional methods of teaching (chalk and talk) were used. Therefore, using steeplechase activities for teaching had greater influence on students' performance in mechanics than traditional methods of teachings.

b) The study showed that if students were taught using steeplechase activities, the experimental group had higher gains in performance than control group where students were taught using lecturer's demonstrations. Therefore, using steeplechase activities for teaching had greater influence on students' performance in mechanics than lecturer's demonstration.

c) Steeplechase activities had greater influence on high ability group of students' performance in mechanics compared to the influence on low ability group of students. Therefore, steeplechase activities had the capacity to improve performance in mechanics. The low group of students was encouraged to successes in physical exercises and gets fresh air needed for improved learning. Steeplechase activities had the capacity to encourage high ability group of students to work harder.

d) Steeplechase activities had the capacity to reduce the gender difference in performance in mechanics. Steeplechase activities had the capacity to motivate male and female students to excel in mechanics and encourage greater participation among female students in mathematics-based technical courses.

e) The study showed that steeplechase activities had the capacity to develop data handling skills, mathematical modeling and application of the model in problem-solving as well as developing ability to communicate results to non-technical audience.

f) Therefore, steeplechase activities had the capacity to encourage understanding of fundamental concepts, ability to communicate results accurately and concisely as well as mastery of content for brainstorming and problem-solving

g) Therefore, steeplechase activities had the capacity to encourage the use of modeling instruction in mechanics as a pedagogical technique useful in developing competent personnel in mechanics.

h) Therefore, Socratic probing had the capacity to fortify the benefits of using steeplechase activities for teaching mechanics.

i) Therefore, Socratic probing used in steeplechase activities had the capacity to improve students' performance in mechanics.

j) Therefore, a combination of various pedagogical techniques in a single lesson was available in steeplechase activities compared to use of alternative teaching strategies.

5.3 Recommendations for Policy

Based on the research findings, the study recommended that:

- There was need to carry out awareness campaigns to sensitize all stakeholders on the need to teach using steeplechase activities in order to improve performance in mechanics.
- There was need for mathematics education and INSET courses to be offered using simulation of mechanics problems through sports and games especially using the pedagogical techniques in steeplechase activities for training of technical lecturers. There was need for quality assurance and standard officers (QASO) to be trained by use of the pedagogical techniques in steeplechase activities for simulation of mechanics problems.
- There was need for policy guidelines that promotes the use of steeplechase activities in mechanics teaching. There was need for QASO officers to visit lecturers in technical

institutions to advice and encourage lecturers to use the pedagogical techniques in steeplechase activities for improving students' performance in mechanics.

- There was need for lecturers to use the pedagogical techniques in steeplechase activities for practice of recreational mathematics to encourage learning of mechanics.
- There was need to use data handling tools such as computers for helping students to collect data, organize the data, analyze the data and use the results obtained for mathematical modeling in mechanics
- There was need for lecturers, educators, administrators, consumers of scientific and mathematical knowledge and skills among other stakeholders to involve students in the pedagogical techniques in steeplechase activities for improving students' performance in mechanics.

5.4 Recommendations for Further Research

The study was basically limited in terms of scope in the sense that it confines itself to technical institutions in Kenya. Hence, the study could be replicated in other countries of Eastern and Central Africa, in Africa and world over.

The study confined itself to students at diploma level in technical institutions. Mechanics was offered as an introductory course pre-university, in first year at undergraduate in university and post graduate. Hence, the study results could be generalized to other levels of learning.

Mechanics was a branch of mathematics. Hence, the results could be generalized to other branches of mathematics. Hence, the study could be replicated to other branches of mathematics.

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APPENDIX 1: COVERING LETTER

David Mutahi

P.O. Box 1978-010100
NYERI
12th November 2011

Dear Madam/Sir,

REF: DATA COLLECTION

I am a post-graduate student of the University of Nairobi pursuing the degree of Doctor of Philosophy (PhD) in Mathematics Education in the Department of Educational Communication and Technology. My research title is "***influence of pedagogical techniques Students' performance in Mechanics in Selected Diploma Technical Institutions in Kenya***" This study is expected to offer a basis for academic investigation into areas teaching and learning strategies that can encourage learning of mechanical science as an introductory course in mechanical and automotive engineering as well as other science based courses. The research outcomes will serve as a basis for policy decision making as well as fill the knowledge gaps.

The results of the study will be beneficial to the government, technical and vocational institutions administrators, educators and consumers of technical and scientific knowledge and skills in adopting appropriate mechanical science teaching strategies to prepare students who are life-long learners, develop positive attitude towards mechanical and automotive engineering, improve graduates performance in curriculum based examinations as well as guarantee ability to acquire, maintain, operate and repair industrial systems with the view of sustaining scholarly and industrial competence. Please feel free to answer all the questions in the questionnaire. You are assured that the information provided will be treated with uttermost confidentiality and will only be used for research purposes.

Sincerely

David Mutahi

APPENDIX 2: PRE-TEST OF PRE-REQUISITE SKILLS

Gender (Tick one) F ( ) M ( )

2 Hours
100 marks

Instructions to Candidates

i. $Take g = 9.81 ms^{-2}$

ii. *Attempt all the questions in this paper.*

QUESTIONS

1. A bus accelerates from $76 m/s$ to $7 km/min$ in four (4) $seconds$. What is its acceleration? (3 marks)
2. A child throws a ball vertically upward with initial velocity at $12 km/h$. The ball thrown rises and then hits the roof $8m$ high. How long did the ball take to reach the roof? (4 marks)

3. A ball on a high building is allowed to fall freely. If air resistance is assumed to be negligible:
   (a) How far will it fall after 4 seconds? (2 marks)
   (b) What velocity is attained after the 4 seconds? (2 marks)
   (c) If the height of the building from the ground was $150m$, what was the ball's velocity before hitting the ground? (2 marks)
4.
   a) A bullet shot up vertically rises to a maximum height of $100m$:
      i. What was the initial velocity of the bullet? (2 marks)
      ii. How long after firing will the bullet come back to the place it was fired from? (4 marks)

   (b) A man pushes a lawn mower with a force of $86N$. The handle of the mower is at $38°$ to the horizontal. If the mower moved a distance s and the work done was estimated to be $9.65\ x 10^{-1} kJ$, determine the distance moved (4 marks)

   (c) Explain the terms: kinetic energy and power. A bullet of mass $40g$ is fired at a velocity of $280 m/s$.
      i. Determine the kinetic energy of the bullet. (2 marks)
      ii. If it takes the bullet 5 seconds to hit the target, what is its power at the point of impact? (5 marks)
5.
   a) A horizontal force of $40N$ is used to pull a piece of metal along a distance of $25m$. Calculate the work done (3 marks)
   b) If in a particular machine the effort of $10N$ moving $8m$ raised a load of $30N$to a height of $2m$, what was the machine's efficiency? (4 marks)

   c) A certain gear has 32 teeth and drives another gear with 74 teeth. Calculate the ratio of the gear system (2 marks)
   d) A train accelerates uniformly from rest to 54km/h in 200s after which the speed remains constant for 300s then decelerates to rest in 150s. Determine the: acceleration over the first 200s; deceleration at 150s and total distance covered by the train (5 marks)

6. A river flows over a waterfall which is 80m high. If the rate of the river is 1.0×10^6 liters per minute and it is assumed that there are no energy losses, what power would be available from the falling water at the base of the waterfall? Some of the energy from the falling water would be lost. Explain what other forms of energy through which water is lost (5 marks)
7. A drop forging die is lifted vertically to a height of 3m and allowed to fall into a work piece. Determine:
   a) the velocity of the top die at impact (3 marks)
   b) the time taken to fall the distance of 3m (3 marks)

8.

a) Calculate the amount of work done in when a constant force of 20N acts through a distance of 30m in its own direction (2 marks)

b) Calculate the amount of work done in when a body is moved 10m horizontally by a force 1.8kN inclined at 60^0 upwards from the horizontal (3 marks)

c) An engine drives a car against a total resistance of 1.2kN over a distance of 250m in 30 seconds. What is power developed by the crankshaft? (2 marks)

9.

a) A building is 72m high.

i. How long will a tennis ball dropped from the top of the building take to fall to the ground? (2 marks)

ii. What will be its velocity be just before it hits the ground? (2 marks)

b) A rocket in level flight ejects 100kg of burnt fuel in 8s at velocity of 500m/s relative to the rocket. Calculate:

i. change in momentum of burnt fuel (2 marks)

ii. the average force on the rocket due to the ejection (2 marks)

c) A car has a wheel diameter of 80cm. Calculate the linear speed at a point on the wheel when the wheel rotate at 600 per min and the wheel radius is: 40cm; 20cm and 60cm (3 mark)

i. Determine the maximum linear speed of the point on the wheel (1 mark)

10.

a) A pendulum of a large block takes 2 seconds to make one complete swing. A girl walks 160m in a straight line while the pendulum makes 15 complete swings. What is the average velocity of the girl? (3 marks)

(b) A metallic bar of mass 2kg is dropped vertically down from a window and hits the ground after 25 seconds. i. How high is the window from which the metal bar is dropped? (3 marks)

ii. How much kinetic energy does the metal bar posse slightly before it hits the ground? (4 marks)

11.

a) A block of wood having a mass of 2kg requires a horizontal force of 5N to drag it with uniform velocity along a surface. Calculate the coefficient of friction between the block and the surface (3 marks)

(a) A motor vehicle of mass 0.8 tones is propelled up a hill of gradient 1 in 15 at a steady speed of 63km/h. find the work done against gravity per minute. Neglect frictional resistance (4 marks)

12. An effort of 135N is used to lift a load of 876N through a height of 1.82m in a pulley system. If the distance moved by the effort is 15m, calculate:

a) the work done in lifting the load (2 mark)

b) the work done by the effort and (1 mark)

c) the efficiency (1 marks)

d) Explain why the efficiency is not 100% (1 marks)

APPENDIX 3: INSTRUCTIONAL DESIGN

Appendix 3.1A: Lesson Plan for Control Group-Treatment D_1

(Traditional Methods of Teaching)

Topic: Dynamics
Sub-topic: Linear motion
Lesson objectives
By the end of the lesson, the learner should be able to:

i. Define the terms: displacement, speed, velocity and acceleration
ii. Distinguish between speed and velocity
iii. Determine velocity given displacement and time taken
iv. Determine acceleration given velocity and time taken
v. Sketch velocity-time graph
vi. Use velocity-time graph to determine distance covered
vii. State laws of motion
viii. Derive the three equations of linear motion under uniform acceleration
ix. Use equations to solve problems in real life situations

Teaching/learning resources: Lecturers' hand-out of the notes
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 12-18.

Lesson Development

Step/ Time	Teaching Activities	Learning activities
I (7 min)	**Introduction** Lecturer to review the definitions of distance, displacement, speed, velocity and acceleration	Students answer lecturers' question on: displacement, speed, velocity and acceleration students write notes
II (8 min)	Lecturer illustrate working of velocity and acceleration on chalk board	Students answer lecturers' questions used in the illustration working out velocity acceleration
III (10 min)	Lecturer illustrate working of velocity and acceleration on chalk board	Students answer lecturers' questions used in the illustration working out velocity acceleration
IV (10 min)	Lecturer illustrate sketching of velocity-time graph and working of displacement	Students note down the sketch of velocity-time graph and working of displacement
VI (10 min)	Lecturer states laws of motion and derive equation of linear motion under uniform acceleration $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$	Students note down the laws of motion and related equations of linear motion under uniform acceleration $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$
VI (8 min)	Lecturer write questions on equations of linear motion under uniform acceleration on chalkboard	Students answer questions on equations of linear motion under uniform acceleration on exercise books
VII (7 min)	**Conclusion** Lecturer give an assignment on equations of linear motion	Students note down assignment on equations of linear motion

Self-evaluation..

Exercise and Assignment questions One

1. A drop forging die is lifted vertically to a height of 3m and allowed to fall freely into a work piece. Determine:
   a) the velocity of the top die at impact
   b) the time taken to fall the distance of 3m let g = 9.81m/s^2
2. A train accelerates uniformly from rest to 54km/h in 200s after which the speed remain constant from 300s then decelerate to rest in 150s. Determine the:
   a. Acceleration over the first 200s
   b. Deceleration at 600s and
   c. Total distance covered by the train
3. An athlete accelerates from the starting block to attain a velocity of 8m/s in 5 seconds. Determine:
   a. The acceleration in the first three seconds
   b. The velocity after 4 seconds
   c. The final velocity if it takes the athlete 9 seconds to finish a 100m race.
4. A steeplechaser takes off from the starting point to attain a constant speed of 5m/s after 10 seconds. Determine:
   a. The speed after 5 seconds
   b. The acceleration after 9 seconds
   c. The time taken to attain a speed of 4m/s.

Appendix 3.1B: Lesson Plan for Control Group-Treatment D_1

(Traditional Methods of Teaching)

Topic: Dynamics
Sub-topic: Relationship between Linear and Angular Motion
Lesson objectives
By the end of the lesson, the learner should be able to:

i. Define the angular motion
ii. Describe the relationship between the laws of motion and the angular motion
iii. Sketch diagrams of angular motion
iv. Represent vector motion diagrammatically
v. Determine centripetal acceleration
vi. Determine tangential acceleration
vii. Derive angular motion equations
viii. Determine angular momentum
ix. Describe the effect of the second law of motion on direction of torque
x. State the third law of motion
xi. Determine kinetic energy associated with angular motion

Teaching/learning resources: Lecturers' hand-out of the notes

Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	Teaching Activities	Learning activities
I (7 min)	**Introduction** Lecturer to review velocity and acceleration	Students answer lecturers' question on: velocity and acceleration and write notes
II (8 min)	Lecturer describe relationship between linear motion and angular motion	Students answer lecturers' questions on relationship between linear and angular motion

III (10 min)	Lecturer illustrate working of angular motion	Students answer lecturers' questions on angular motion
IV (10 min)	Lecturer illustrate sketching of diagrams on vector motion	Students note down the sketch of velocity-time graph and working of displacement
VI (10 min)	Lecturer illustrate working out centripetal and tangential acceleration, angular motion and angular momentum	Students write notes on illustrations of centripetal and tangential acceleration, angular motion and angular momentum
VI (8 min)	Lecturer to state second and third laws of motion and explain direction of torque	Students notes down second and third laws of motion and explain direction of torque
VII (7 min)	**Conclusion** Lecturer give an assignment on equations of linear motion	Students note down assignment on equations of linear motion

Self-evaluation...

Exercise and Assignment Two

1. A flywheel 1.2 in diameter is uniformly accelerated from rest and revolves completely sixty times in reaching a speed of 120 revolution/min. determine:
    i) Angular acceleration
    ii) The maximum radical acceleration of a point on the rim
    iii) The time taken
    iv) The linear acceleration

2. A 56.6-kg steeplechaser moving at 5m/s takes a turn around the circular bend with radius 15.9m. Determine:
    i. speed
    ii. Acceleration
    iii. The net force acting up on him

3. A 95-kg halfback makes a turn on the football field. The half-back sweeps out a path that is a portion of a circle with a radius of 12-meters. The half-back makes a quarter of a turn around the circle in 2.1 seconds. Determine:
    i. Speed
    ii. Acceleration
    iii. Force acting upon the half-back

4. A disc of diameter 28cm and length of 0.25m revolves at 420rpm about its axis. If the density of the disc is 7.8mg/m^3, determine the braking force required to bring the disc to rest in 10s. The radius of gyration for disc is given by $k = \frac{r}{\sqrt{2}}$ where r is the disc radius

Appendix 3.1C: Lesson Plan for Control Group-Treatment D_1

(Traditional Methods of Teaching)

Topic: Dynamics
Sub-topic: Introduction to Projectile Motion
Lesson objectives
By the end of the lesson, the learner should be able to:
i. Describe the motion of an object thrown vertically upward
ii. Define the terms: projectile motion and range
iii. Describe the theory of projectile motion in terms of:
Air resistance, vertical and horizontal components

iv. Sketch path traced by an object projected
v. Describe time of flight
vi. Describe range of flight
vii. Describe angle of elevation
viii. Work out problems related to maximum vertical height
ix. Work out problems related to maximum horizontal distance travelled

Teaching/learning resources: Lecturers' hand-out of the notes
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	**Teaching Activities**	**Learning activities**
I (7 min)	**Introduction** Lecturer to review motion under gravity (under free fall) on areas such as: Maximum height reached Total time taken Velocity just before the object hits the ground Force at which it hits the ground	Students answer lecturers' question on: motion under gravity (under free fall) on areas such as: Maximum height reached Total time taken Velocity just before the object hits the ground Force at which it hits the ground
II (8 min)	Lecturer defines new terms: projectile, range Lecturer introduce the theory of projectile motion and path of projectile motion	Students answer lecturers' question on: new terms: projectile, range Students answer lecturers' questions on the theory of projectile motion and path of projectile motion
III (10 min)	Lecturer describe projectile motion	Students answer lecturers' questions on projectile motion
IV (10 min)	Lecturer illustrate sketching of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building	Students note down the sketch of sketching of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building
VI (18 min)	Lecturer illustrate working related to: Time of flight; Range of flight and Angle of elevation	Students make notes of illustrations on: Time of flight; Range of flight and Angle of elevation
VII (7 min)	**Conclusion** Lecturer give an assignment on object thrown vertically upward	Students note down assignment on object thrown vertically upward

Self-evaluation...

Exercise and assignment Three

1. A 5kg mass is fired vertically upward with an initial velocity of 100m/s and during its fall back it hits another object which has just been fixed at mid height between the ground firing point and the max point reached by the object making a 0.55mm indentation onto the stationary object and comes to rest. Determine:

a) The max height risen by the object
b) The time taken to reach the max height
c) The total time taken before impact with the stationary object
d) The velocity at which it would have struck the ground if the stationary object were not introduced in its path
e) The force with which it strikes the stationary object

2. A 50-kg athlete accelerates up to 10m/s, how much kinetic energy is acquired? If this occurs in 3 seconds, how much power is required? What is the average acceleration? Is this power part of what an athlete must produce for sprinting? Explain you reasoning.
3. A body is thrown vertically upward with an initial velocity of 100m/s. calculate the time taken to pass a point 120m above the ground
4. A shell is fired at 30^0 to the horizontal with a velocity of 20m/s from the top of a cliff 50m high calculate the distance from the foot of the cliff to the point where the shell strikes the ground
5. Determine the elevation angle of a gun to fire 60km with a nozzle velocity of 1000m/s

Appendix 3.1D: Lesson Plan for Control Group-Treatment D_1

(Traditional Methods of Teaching)

Topic: Dynamics
Sub-topic: Problem-Solving in Projectile Motion
Lesson objectives
By the end of the lesson, the learner should be able to:

i. Differentiate between motion when an object is thrown vertically upward and projectile motion
ii. Describe projectile motion
iii. State the assumption made in projectile motion
iv. Derive the equations of projectile motion
v. Sketch path traced by a projected object
vi. Work out problems related to time of flight
vii. Work out problems related to range of flight
viii. Work out problems related to angle of elevation
ix. Work out problems related to maximum vertical height
x. Work out problems related to maximum horizontal distance travelled

Teaching/learning resources: Lecturers' hand-out of the notes
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/Time	Teaching Activities	Learning activities
I (7 min)	**Introduction** Lecturer to review motion of an object thrown vertically upward	Students answer lecturers' question on: motion of an object thrown vertically upward
II (8 min)	Lecturer describe assumptions of projectile motion	Students answer lecturers' questions on assumptions of projectile motion
III (10 min)	Lecturer derives the equations of projectile motion	Students answer lecturers' questions on the equations of projectile motion
IV (10 min)	Lecturer illustrate sketching of diagrams on projectile motion	Students note down the sketching of diagrams on projectile motion
VI (10 min)	Lecturer illustrate working of time of flight, angle of elevation, maximum vertical height, maximum horizontal distance	Students write notes on illustrations time of flight, angle of elevation, maximum vertical height, maximum horizontal distance

VI (8 min)	Lecturer to state questions on time of flight, angle of elevation, maximum vertical height, maximum horizontal distance	Students answer lecturers questions on time of flight, angle of elevation, maximum vertical height, maximum horizontal distance
VII (7 min)	**Conclusion** Lecturer give an assignment on projectile motion	Students note down assignment on projectile motion

Self-evaluation..

Exercise and assignment Four

1. A body is thrown vertically upward with an initial velocity of 100m/s. calculate the time taken to pass a point 120m above the ground
2. A shell is fired at 30^0 to the horizontal with a velocity of 20m/s from the top of a cliff 50m high calculate the distance from the foot of the cliff to the point where the shell strikes the ground
3. Determine the elevation angle of a gun to fire 60km with a nozzle velocity of 1000m/s

Appendix 3.2A: Lesson Plan for Experimental Group-Treatment

(Steeplechase Activities without Socratic Probing)

Topic: Dynamics
Sub-topic: Linear motion
Lesson objectives (refer to appendix 3.1A)
Teaching/learning resources: Steeplechase track, water jump, hurdles, stops watch, work-sheets and pencils
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2^{nd} ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/Time	Teaching Activities	Learning activities
I (7 min)	**Introduction** Lecturer focuses students' attention to linear motion as the content to be learnt. Lecturer hands in working sheets with questions on review of distance, displacement, speed, velocity and acceleration	Students respond to questions posed by the lecturer on linear motion In groups of six (6) members apart, students use worksheet to discuss questions on: displacement, speed, velocity and acceleration students write notes
II (8 min)	**Plenary session** Lecturer introduce steeplechase activities, hand in the work-sheets on the order of events, what is to be done and measurements for discussion	Students make short notes, ask questions on the worksheet provided on steeplechase activities: order of events, what is to be done and measurements for discussion
III (30 min)	**Steeplechase activities** Lecturer works a learning facilitator to ensure that all activities are carried out by students	Students participate in steeplechase activities: Steeplechaser (guests and students) run on the track. Non-steeplechasers make measurements All students join in the track after steeplechasers are through to make one lap around the track

VI (20 min)	**Preparation for group work** Lecturer facilitates students groups to consolidate ideas on statement of the laws of motion. Lecturer hands in the work-sheet used to guide students to derive equation of linear motion under uniform acceleration: $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$	Students respond to questions in a whole class discussion to consolidate the ideas statement of the laws of motion. Students work in their discussion groups to follow the work-sheet to state laws of motion and derive the equations of linear motion under uniform acceleration: $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$
VI (15 min)	**Plenary session** Lecturer guide students to report their findings to the whole class	Lecturer guide students to report their findings to the whole class
VII (7 min)	**Conclusion** Lecturer give an assignment on equations of linear motion	Students note down assignment on equations of linear motion

Self-evaluation...

Exercise and Assignment questions One (Refer to appendix 3.1A)

Appendix 3.2B: Lesson Plan for Experimental Group-Treatment

(Steeplechase Activities without Socratic Probing)

Topic: Dynamics
Sub-topic: Relationship between Linear and Angular Motion
Lesson objectives (refer to Appendix 3.1B)
Teaching/learning resources: Pictures, steeplechase track, water jump, hurdles, stops watch, work-sheets and pencils
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	**Teaching Activities**	**Learning activities**
I (8 min)	**Introduction** Lecturer to hand in pictures to students Lecturer to guide students to review velocity and acceleration	Students studies pictures in groups of two or three. Making reference to their observations, students respond to lecturers' question on velocity and acceleration
II (14 min)	**Steeplechase activities** Lecturer hands in worksheet related to angular motion to students. Students are invited to participate in group discussions on relationship between linear motion and angular motion	Students identify angular motion in steeplechase as a race. Students participate in discussions on relationship between linear motion and angular motion in steeplechase. In small groups, students attempt questions related to angular motion in steeplechase activities
III (13 min)	**Consolidation of ideas** The lecturer facilitates two groups selected at random to present their	Two groups selected at random present their findings to the whole class on angular motion found in steeplechase activities

	findings to the whole class	Students ask their colleagues follow up questions
IV (10 min)	**Sketching of Diagrams** Lecturer hands in worksheets for illustration of diagrams on vector motion	Students identify vectors in steeplechase activities. Students work in groups to sketch of diagrams to represent vector motion.
VI (10 min)	**Group work on problem-solving** Lecturer hands in work sheet for problem solving on centripetal acceleration, tangential acceleration, angular motion and angular momentum	In groups, students use work sheets to solve problem on centripetal acceleration, tangential acceleration, angular motion and angular momentum
VI (8 min)	**Consolidation of ideas** Students are guided to present their findings to the whole class. Lecturer guide students to state second and third laws of motion and explain direction of torque	Students are guided to present their findings to the whole class. Students respond to questions asked by colleagues on their presentations Lecturer guide students to state second and third laws of motion and explain direction of torque
VII (7 min)	**Conclusion** Lecturer give an assignment on angular motion	Lecturer give an assignment on angular motion

Self-evaluation..

Exercise and Assignment Two (refer to appendix 3.1B)

Appendix 3.2C: Lesson Plan for experimental Group-Treatment T_1

(Steeplechase Activities without Socratic Probing)

Topic: Dynamics
Sub-topic: Projectile Motion
Lesson objectives (refer to appendix 3.1C)
Teaching/learning resources: pictures, Steeplechase track, water jump, hurdles, stops watch, work-sheets and pencils
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	Teaching Activities	Learning activities
I (8 min)	**Introduction** The lecturer guide students to review motion under gravity from their experiences from steeplechase activities on: Maximum height reached; total time taken; Velocity just before the object hits the ground; Force at which it hits the ground	Students answer question on: motion under gravity (under free fall) on areas such as: Maximum height reached; Total time taken Velocity just before the object hits the ground Force at which it hits the ground

II (8 min)	**Plenary session** Lecturer hands in pictures to guide students to define new terms: projectile, range; Lecturer introduces the theory of projectile motion and path of projectile motion	Lecturer hands in pictures to guide students to define new terms: projectile, range; students make observations related to theory of projectile motion and path of projectile motion. Students summarize assumptions in projectile motion
III (20 min)	**Steeplechase activities** Lecturer illustrate sketching of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building Work out: maximum vertical height, maximum horizontal distance angle of elevation	Students make sketch of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building Work out: maximum vertical height, maximum horizontal distance angle of elevation
VI (15 min)	**Consolidation of ideas** Lecturer guide students to work out problems on chalkboard related to: Time of flight; Range of flight and Angle of elevation	Students make presentation of working of problems on: Time of flight; Range of flight and Angle of elevation
VII (7 min)	**Conclusion** Lecturer give an assignment on projectile motion	Lecturer give an assignment on projectile motion

Self-evaluation...

Exercise and assignment three (refer to appendix 3C)

Appendix 3.3A: Lesson Plan for Control Group-Treatment D_2

(Use of Resources in lecturers' Demonstration)

Topic: Dynamics
Sub-topic: Linear motion
Lesson objectives (refer to appendix 3.1A)
Teaching/learning resources: Pictures, Lecturers' hand-out of the notes
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill; Pp. 12-18.

Lesson Development

Step/ Time	Teaching Activities	Learning activities
I (7 min)	**Introduction** Lecturer to hand in pictures to facilitate review of displacement, speed, velocity and acceleration	Based on the pictures, Students answer lecturers' question on: displacement, speed, velocity and acceleration students make notes
II (8 min)	Lecturer illustrate working of velocity and acceleration on chalk board	Students answer lecturers' questions used in the illustration working out velocity

		acceleration
III (10 min)	Lecturer involve students in whole class discussion on working of velocity and acceleration and Lecturer notes main points on chalk board	Students participate in the whole class discussion answer on working out velocity and acceleration questions
IV (10 min)	Lecturer hand in hand-outs with diagrams for illustration of sketch velocity-time graph and working on displacement	Students use hand-out illustration of a sketch velocity-time graph and working on displacement
VI (10 min)	Lecturer states laws of motion and derive equation of linear motion under uniform acceleration $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$	Students note down the laws of motion and related equations of linear motion under uniform acceleration $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$
VI (8 min)	Lecturer write questions on equations of linear motion under uniform acceleration on chalkboard	Students answer questions on equations of linear motion under uniform acceleration on exercise books
VII (7 min)	**Conclusion** Lecturer give an assignment on equations of linear motion	Students note down assignment on equations of linear motion

Self-evaluation...
Exercise and Assignment two (refer to appendix 3.1A)

Appendix 3.3B: Lesson Plan for Control Group-Treatment D_2

(Use of Resources in lecturers' Demonstration)

Topic: Dynamics
Sub-topic: Relationship between Linear and Angular Motion
Lesson objectives (refer to appendix 3.1B)
Teaching/learning resources: Pictures on vehicles around a bend, Lecturers' hand-out of the notes, picture of a footballer making a turn
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	**Teaching Activities**	**Learning activities**
I (7 min)	**Introduction** Lecturer to hand in pictures on vehicles around a bend, picture of a footballer making a turn review to facilitate the concept of angular velocity and acceleration	Students use pictures on vehicles around a bend, picture of a footballer making a turn review to facilitate the concept of angular velocity and acceleration
II (8 min)	Lecturer to hand in pictures on vehicles around a bend, picture of a footballer making a turn review to facilitate whole class discussion on relationship between linear and angular motion	Students use pictures on vehicles around a bend, picture of a footballer to facilitate whole class discussion on relationship between linear and angular motion
III	Lecturer illustrate working of angular	Students answer lecturers' questions on

(10 min)	motion	angular motion
IV (10 min)	Lecturer illustrate sketching of diagrams on vector motion	Students note down the sketch of velocity-time graph and working of displacement
VI (10 min)	Lecturer illustrate working out centripetal and tangential acceleration, angular motion and angular momentum	Students write notes on illustrations of centripetal and tangential acceleration, angular motion and angular momentum
VI (8 min)	Lecturer to state second and third laws of motion Lecturer explain direction of torque	Students notes down second and third laws of motion Students write notes on direction of torque
VII (7 min)	**Conclusion** Lecturer give an assignment on equations of linear motion	Students note down assignment on equations of linear motion

Self-evaluation...

Exercise and Assignment Two (refer to appendix 3.1B)

Appendix 3.3C: Lesson Plan for Control Group-Treatment D_2

(Use of Resources in lecturers' Demonstration)

Topic: Dynamics
Sub-topic: Introduction to Projectile Motion
Lesson objectives (refer to appendix 3.1C)
Teaching/learning resources: tennis ball, a feather and a stone
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	**Teaching Activities**	**Learning activities**
I (7 min)	**Introduction** Lecturer to review motion under gravity (under free fall) on areas such as: Maximum height reached Total time taken Velocity just before the object hits the ground Force at which it hits the ground	Students answer lecturers' question on: motion under gravity (under free fall) on areas such as: Maximum height reached Total time taken Velocity just before the object hits the ground Force at which it hits the ground
II (8 min)	Lecturer defines new terms: projectile, range Lecturer introduce the theory of projectile motion and path of projectile motion	Students answer lecturers' question on: new terms: projectile, range Students answer lecturers' questions on the theory of projectile motion and path of projectile motion
III (10 min)	Lecturer describe projectile motion	Students answer lecturers' questions on projectile motion
IV	Lecturer illustrate sketching of a	Students note down the sketch of sketching

(10 min)	diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building	of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building
VI (18 min)	Lecturer illustrate working related to: Time of flight; Range of flight and Angle of elevation	Students make notes of illustrations on: Time of flight; Range of flight and Angle of elevation
VII (7 min)	**Conclusion** Lecturer give an assignment on object thrown vertically upward	Students note down assignment on object thrown vertically upward

Self-evaluation...
Exercise and assignment Three(refer to appendix 3.1C)

Appendix 3.3D: Lesson Plan for Control Group-Treatment D_2

(Use of Resources in lecturers' Demonstration)

Topic: Dynamics
Sub-topic: Problem-Solving in Projectile Motion
Lesson objectives (refer to appendix 3.1D)
Teaching/learning resources: Lecturers' hand-out of the notes
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/Time	Teaching Activities	Learning activities
I (7 min)	**Introduction** Lecturer to review motion of an object thrown vertically upward	Students answer lecturers' question on: motion of an object thrown vertically upward
II (8 min)	Lecturer describe assumptions of projectile motion	Students answer lecturers' questions on assumptions of projectile motion
III (10 min)	Lecturer derives the equations of projectile motion	Students answer lecturers' questions on the equations of projectile motion
IV (10 min)	Lecturer illustrate sketching of diagrams on projectile motion	Students note down the sketching of diagrams on projectile motion
VI (10 min)	Lecturer illustrate working of time of flight, angle of elevation, maximum vertical height, maximum horizontal distance	Students write notes on illustrations time of flight, angle of elevation, maximum vertical height, maximum horizontal distance
VI (8 min)	Lecturer to state questions on time of flight, angle of elevation, maximum vertical height, maximum horizontal distance	Students answer lecturers questions on time of flight, angle of elevation, maximum vertical height, maximum horizontal distance
VII (7 min)	**Conclusion** Lecturer give an assignment on	Students note down assignment on projectile motion

	projectile motion	

Self-evaluation...

Exercise and assignment Four (refer to appendix 3.1D)

Appendix 3.4A: Lesson Plan for Experimental Group-Treatment

(Steeplechase Activities with Socratic Probing)

Topic: Dynamics
Sub-topic: Linear motion
Lesson objectives (refer to Appendix 3.1A)
Teaching/learning resources: Steeplechase track, water jump, hurdles, stops watch, work-sheets and pencils
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 12-18.

Lesson Development

Step/ Time	**Teaching Activities**	**Learning activities**
I (7 min)	**Introduction** Lecturer focuses students' attention to linear motion as the content to be learnt. Lecturer hands in worksheets and pictures with questions related to review of distance, displacement, speed, velocity and acceleration	Students respond to questions posed by the lecturer on linear motion In groups of six (6) members apart, students use worksheet and pictures to discuss questions on: displacement, speed, velocity and acceleration students write notes
II (14 min)	**Plenary session for students** Lecturer introduce steeplechase activities, hand in the work-sheets and pictures on the order of events, what is to be done and measurements for discussion	Students make short note, ask questions on the worksheet provided on steeplechase activities: order of events, what is to be done and measurements for discussion. Students discuss order of events and share roles in their groups and prepare to ask steeplechasers questions
II (8 min)	**Plenary session for steeplechasers** Lecturer introduce steeplechase activities, hand in the work-sheets and pictures on the order of events, what is to be done and measurements for discussion with students	Steeplechasers note likely questions to be asked by students on the worksheet and pictures provided on steeplechase activities: order of events, what is to be done and measurements for discussion with students
III (30 min)	**Steeplechase activities** Lecturer organize to take students and steeplechasers through warm-up exercises Lecturer works a learning facilitator to ensure that all activities are carried out by students Lecturer organize to take students and steeplechasers through cool down exercises	students and steeplechasers through participate in warm up exercises Students participate in steeplechase activities: Steeplechaser (guests and students) run on the track. Non-steeplechasers make measurements All students join in the track after steeplechasers are through to make one lap around the track Students participate in cool down exercises as well as attending to those who are too exhausted, attend to muscular injuries

VI (20 min)	**Preparation for group work** Lecturer facilitates students and steeplechasers discussion groups to consolidate ideas on statement of the laws of motion. Lecturer hands in the work-sheet used to guide students to derive equation of linear motion under uniform acceleration: $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$	Students discuss questions with steeplechasers. Students respond to questions in a whole class discussion to consolidate the ideas statement of the laws of motion. Students work in their discussion groups to follow the work-sheet to state laws of motion and derive the equations of linear motion under uniform acceleration: $v = u + at$ $v^2 = u^2 + 2as$ $s = u^2 + ½at^2$
VI (15 min)	**Plenary session** Lecturer guide students and steeplechasers as students report their findings to the whole class	Steeplechasers participate in the plenary session where students report their findings to the whole class. Lecturer guide students to report their findings to the whole class
VII (7 min)	**Conclusion** Lecturer guide students to summarize the main points Lecturer give an assignment on equations of linear motion Lecturer mention content of next lesson	Students summarize the main points Students note down assignment on equations of linear motion Students note content of next lesson

Self-evaluation...

Exercise and Assignment questions One (refer to appendix 3.1A)

Appendix 3.4B: Lesson Plan for Experimental Group-Treatment

(Steeplechase Activities with Socratic Probing)

Topic: Dynamics
Sub-topic: Relationship between Linear and Angular Motion
Lesson objectives (refer to appendix 3.1B)
Teaching/learning resources: Pictures, steeplechase track, water jump, hurdles, stops watch, work-sheets and pencils
Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/ Time	**Teaching Activities**	**Learning activities**
I (8 min)	**Introduction** Lecturer to hand in pictures and worksheets to students Lecturer to guide students to review velocity and acceleration	Students studies pictures and worksheets in groups of two or three. Making reference to their observations, students respond to lecturers' question on velocity and acceleration Students continue with discussion as steeplechasers are briefed
II (8 min)	**Plenary session for steeplechasers** Lecturer introduce steeplechase	Steeplechasers receive pictures and worksheets.

	activities, hand in the work-sheets and pictures on the order of events, what is to be done and measurements for discussion with students	Steeplechasers note likely questions to be asked by students on the worksheet and pictures provided on steeplechase activities: order of events, what is to be done and measurements for discussion with students
III (14 min)	**Steeplechase activities** Lecturer facilitates discussion between students and steeplechasers Lecturer hands in worksheet related to angular motion to students. Lecturer facilitate students to participate in group discussions on relationship between linear motion and angular motion	Steeplechasers discuss with students issues related an athlete taking a bend on the track. Students identify angular motion in steeplechase as a race. Students participate in discussions on relationship between linear motion and angular motion in steeplechase. In small groups, students attempt questions related to angular motion in steeplechase activities
III (13 min)	**Consolidation of ideas** The lecturer facilitates two groups selected at random to present their findings to the whole class	Two groups selected at random present their findings to the whole class on angular motion found in steeplechase activities Students ask their colleagues follow up questions
IV (10 min)	**Sketching of Diagrams** Lecturer hands in worksheets for illustration of diagrams on vector motion	Students identify vectors in steeplechase activities. Students work in groups to sketch diagrams to represent vector motion.
VI (20 min)	**Group work on problem-solving** Lecturer hands in work sheet for problem solving on centripetal acceleration, tangential acceleration, angular motion and angular momentum. Lecturer facilitates discussion between students and steeplechasers	In groups, students and steeplechaser discuss the main points in steeplechase involving angular motion. Students use work sheets to solve problem on centripetal acceleration, tangential acceleration, angular motion and angular momentum. Students make reference to text books available.
VI (8 min)	**Consolidation of ideas** Students are guided to present their findings to the whole class. Lecturer guide students to state second and third laws of motion and explain direction of torque	Students are guided to present their findings to the whole class and steeplechasers. Students respond to questions asked by steeplechasers and colleagues on their presentations Lecturer guide students to state second and third laws of motion and explain direction of torque
VII (7 min)	**Conclusion** Lecturer guide students on main points, Lecturer give an assignment on angular motion and content of the next lesson	Students answer questions on the main points Lecturer give an assignment on angular motion The students note content of the next lesson

Self-evaluation..

Exercise and Assignment (refer to appendix 3.1B)

Appendix 3.4 C: Lesson Plan for experimental Group-Treatment

(Steeplechase Activities with Socratic Probing)

Topic: Dynamics
Sub-topic: Projectile Motion
Lesson objectives (refer to appendix 3.1C)
Teaching/learning resources: pictures, Steeplechase track, water jump, hurdles, stops watch, work-sheets and pencils

Reference: Giambatlisa, A. R., Betty, M. & Richardson, R.C. (2007). *College Physics* (2nd ed.). New York. McGraw-Hill. Pp. 18-19.

Lesson Development

Step/Time	Teaching Activities	Learning activities
I (8 min)	**Introduction** The lecturer guide students to review motion under gravity from their experiences from steeplechase activities on: Maximum height reached; total time taken; Velocity just before the object hits the ground; Force at which it hits the ground	Students answer question on: motion under gravity (under free fall) on areas such as: Maximum height reached Total time taken Velocity just before the object hits the ground Force at which it hits the ground Students continue with discussion as steeplechasers go through plenary session
II (8 min)	**Plenary session for steeplechasers** Lecturer hands in pictures to guide students to define new terms: projectile, range; Lecturer introduces the theory of projectile motion and path of projectile motion	Lecturer hands in pictures and worksheets to guide steeplechasers on the questions to anticipate from students as they define new terms: projectile, range. Steeplechasers are guided on the effect of air resistance, projectile motion and path of projectile motion
II (8 min)	**Plenary session for students and steeplechasers** Lecturer hands in pictures to guide students to define new terms: projectile, range; Lecturer introduces the theory of projectile motion and path of projectile motion	Lecturer hands in pictures to guide students to define new terms: projectile, range; students make observations related to theory of projectile motion and path of projectile motion Students summarize assumptions in projectile motion
III (20 min)	**Steeplechase activities** Lecturer illustrate sketching of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building Work out: maximum vertical height, maximum horizontal distance angle of elevation	Students discuss with steeplechasers on the best way of doing ordinary and water barriers Students make sketch of a diagram on the path of traced by a body projected: -From the ground at an angle to the horizontal plane -Horizontally from an elevated point such as a cliff or a storey building Work out: maximum vertical height, maximum horizontal distance angle of elevation

VI (15 min)	**Consolidation of ideas** Lecturer guide students to present their findings on problems solved on: Time of flight; Range of flight and Angle of elevation	Students make presentation of working of problems on: Time of flight; Range of flight and Angle of elevation. Students answer questions from fellow students and steeplechasers
VII (7 min)	**Conclusion** Lecturer give an assignment on projectile motion, Lecturer give an assignment on projectile motion and content of the next lesson	Students answer questions on the main points Lecturer give an assignment on projectile motion The students note content of the next lesson

Self-evaluation..

Exercise and assignment Three (refer to appendix 3.1D)

APPENDIX 4: POST-TEST

Gender (Tick one) F ( ) M ( )

2 Hours
100 marks

Instructions to learners

i. $Take g = 9.81 ms^{-2}$
ii. *Answer all the questions in this paper.*

Test Items

1. (a) A bus accelerates from 76m/s to 284km/h in 4 seconds. What is its acceleration? (2 marks)
(b) A ball on a high building is allowed to fall freely. If air resistance is assumed to be negligible: how far will it fall after 4 seconds? (2 marks).What velocity is attained after 4 seconds? (2 marks) If the height of the building from the ground was 150m, what was the ball's velocity before hitting the ground? (2 marks)
2. (a) A motor vehicle of mass 0.8 tones is propelled up a hill of gradient 1 in 15 at a steady speed of 63km/h. find the work done against gravity per minute. Neglect frictional resistance (g = 9.81) (4 marks)
(b) A man pushes a lawn mower with a force of 86N. The handle of the mower is at 350 to the horizontal. If the mower moved a distance s and the work done was estimated to be 9.65 x 10-1kJ, determine the distance moved. (4 marks)
(c) A bullet of mass 40g is fired at a velocity of 280m/s. Determine the kinetic energy of the bullet. If it takes the bullet 5 seconds to hit the target, what is its power at the point of impact?
(d) An effort of 135N is used to lift a load of 876N through a height of 1.82m in a pulley system. If the distance moved by the effort is 15m, calculate: the work done in lifting the load; the work done by the effort; and the efficiency. Explain why the efficiency is not 100%. (5 marks)
3. (a)A ball of mass 150g horizontally projected at a velocity of 36km/h collided head-on with another ball of mass 350g moving at 7m/s in the opposite direction. If the collision is elastic, find their respective velocities after collision. Explain the term elastic collision (6 marks)
(b) A railway wagon of mass 35 tons travels along a level track at 15km/h and collides with another wagon of mass 15tonnes traveling in opposite direction at 20km/h. After impact, the first is seen to travel in the same direction as before with speed of 3km/h. Determine the speed of the second wagon (3 marks)
4. A drop forging die is lifted vertically to a height of 3m and allowed to fall into a work piece. determine:
   i. the velocity of the top die at impact (2 marks)
   ii. the time taken to fall the distance of 3m. (Take $g = 9.81m/s^2$) (2 marks)

   (b) A car of mass 1 ton is accelerated from a speed of 24km/h to a speed of 48km/h in 50m. Determine the average tractive effort required. What would be the average braking force required to bring the car to rest in 50m from 48km/h. (5 marks)
5. (a) What happens when a jumper clears the bar? If the jumper's centre of gravity is raised by a height h, how much energy is needed? What is considered in high jump? If a high jumper of mass 72kg clears 2.3m on earth, how much energy will he need and how high would he jump on the surface of the moon? (4 marks)

   (b) Suppose that at the start of a 100m race, the starter, armed with starting pistol, stands on the infield 5 meters away from the runner in lane 1, and 15 meters away from the runner in lane 8, when he fires the starting pistol. If the speed of sound is 344m/s and the runner in lane 1 finishes first, just 0.01 seconds ahead of the runner in lane 8, should the runner in lane 8 feel unhappy? If a race like the 400m was starting from staggered lane positions around the first bend where would the starter stand in order to be fair? (4 marks)

6. A lorry of 4.8 tones was traveling at a velocity of 98km/h. Determine the lorry's momentum

(2 marks)

A tractor needs an average effort of 1.2kN to drag a 1 ton concrete block with a uniform velocity along a horizontal surface. Determine the coefficient of friction between the block and the surface. (4 marks)

7. A steeplechaser took off at a velocity of 7m/s at an angle of 45^0 to step over the hurdle at the water jump. (4 marks)Assuming no air resistance, what was her velocity after 0.25 seconds? If the steeplechaser manages to propel himself and land 45 cm away from the water jump end, what was her take off velocity from the rail? (6 marks)

8. A 5kg mass is fired vertically upward with an initial velocity of 100m/s and during its fall back it hits another object which has just been fixed at mid height between the ground firing point and the maximum point reached by the object making a 0.55mm indentation onto the stationary object and comes to rest. Determine: the maximum height risen by the object; (2 marks)the time taken to reach the maximum height; (2 marks) the total time taken before impact with stationary object; (2 marks) the velocity at which it would have struck the ground if the stationary object were not introduced in its path and the force with which it strikes the stationary object (4 marks)

9. A body is thrown vertically upwards with an initial velocity of 100m/s. Calculate the time taken to pass a point 120m above the ground. (3 marks)Determine the angle of elevation of a gun to fire 60km with a muzzle velocity of 1000m/s. (4 marks)

10. (a) A projectile is fired with an initial velocity of 240km/h at 30^0 to, and above the horizontal, from a height of 1.5km above the ground assuming there is no air resistance, obtain:

    (ii) the horizontal range (4 marks)

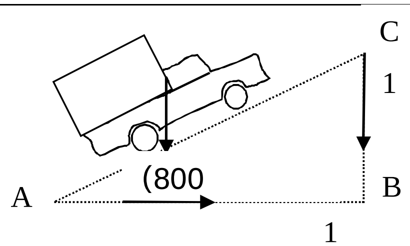
    (iii) the impact velocity and its angle relative to the horizontal (3 marks)

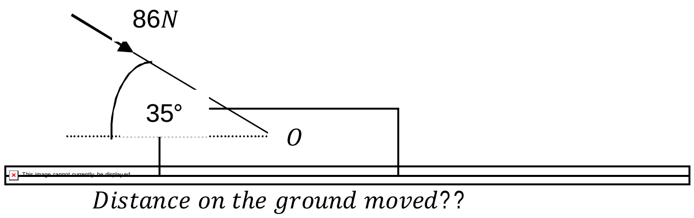
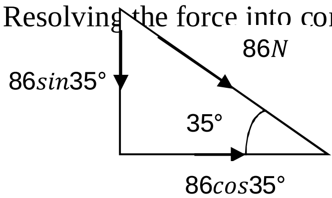
    (b) A pirate ship is sighted at 560m from a fort defending a harbor entrance. A defense cannon located at sea level fires balls at initial velocity v_0=82m/s.

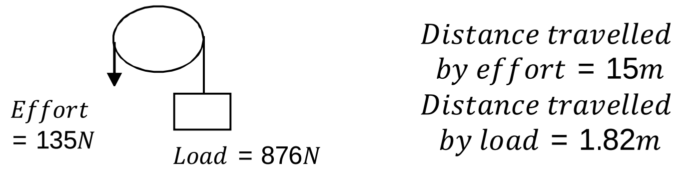
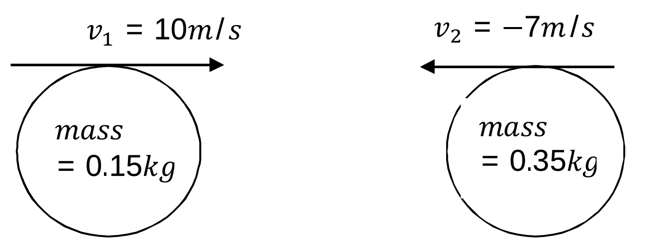
    i) At what angle from the horizontal must a ball be fired to hit the ship? (4 marks)

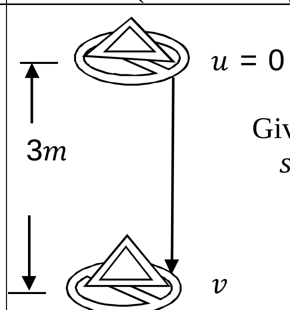
    ii) What is the maximum range of the cannonball? (3 marks)

APPENDIX 5: POST-TEST MARKING SCHEME

Qn	Description	Marks	Remarks
1. (a)	Given that: $u = 76m/s; v = 284km/h$ $= \frac{284 \times 1000}{3600} = 78.89m/s$ $t = 4\,s; \quad a = ??$ $a = \frac{v-u}{t} = \frac{(78.89 - 76)m/s}{4s} = 0.7225m/s^2$	M_1 A_1	Convert Ans. & Units
(b) (i)	Given that: $t = 4s$; $g = 9.81\ m/s^2$ $u = 0$; $s = ??$ To solve for distance travelled after 4s, apply the equation: $s = ut + \frac{1}{2}gt^2$ $s = (0 \times 4) + \left(\frac{1}{2} \times 9.81 \times 4^2\right) = 78.48m$ Therefore, the ball will fall 78.48m after 4seconds.	M_1 A_1	Substitute Ans. & Units
(ii)	To solve for the velocity attained after 4s, apply the equation: $v^2 = u^2 + 2gs$; since $u = 0$, $v = \sqrt{2 \times 9.81 \times 78.48}$ $v = 39.24m/s$ Therefore, velocity attained after 4 second was $v = 39.24m/s$.	M_1 A_1	Substitute Ans. & Units
(iii)	Given that: $g = 9.81\ m/s^2$; $u = 0$; $s = 150m$; $v = ??$ To find the velocity attained just before hitting the ground, apply the equation: $v^2 = u^2 + 2gs$; since $u = 0$, $v = \sqrt{2 \times 9.81 \times 150} = 54.24m/s$ Therefore, velocity attained just before thing the ground was $v = 54.24m/s$.	M_1 A_1	Substitute Ans. & Units
2. (a)	 Figure 5: **Work Against Force of Gravity** Assumption: Frictional force is negligible. $Velocity = \frac{63 \times 1000}{60} = 1050m/min$ $Ineveryminute, distancetravelleduphill = 1050m$ Vertical height $= \frac{1050m}{15} = 70m$	B_1 B_1 B_1	Diagram Vertical height Work done against

	Hence, in every minute, the vehicle will have been lifted a height of 70m. $Workdoneagainstgravitypermin$ $= force \times vertical\ distance$ $= (800 \times 9.81)N \times 70m = 549360J = 549.36kJ$ Therefore, work done against gravity per minute= $549.36kJ$	A_1	gravity Ans. & Units
(b)	 Resolving the force into components, we have  Figure 6: **Work Done** Given that $workdone = 9.65 \times 10^{-1}Kj$ $Workdone = force \times distancetravelled$ $9.65 \times 10^{-1} \times 10^{3} = 86cos35° \times s$ $s = \frac{9.65 \times 10^{2}}{86cos35°}$ $= 13.7m$ Therefore, distance travelled by the mower was 13.7m.	B_1 B_1 B_1 A_1	Diagram Resolution of forces Expression of work done Ans. & Units
(c) (i)	Given that: mass of bullet, $m = 40g = 0.04kg; u = 280m/s$ K.E of the bullet$= \frac{1}{2}mv^2 = \frac{1}{2} \times 0.04 \times 280^2 = 1568J = 1.6kJ$ Therefore, the K.E possessed by the bullet is 1568J.	B_1 A_1	K.E Ans. & Units
(ii)	Work done is equal to the K.E possessed by the bullet The bullet hits the power of the bullet at the point of impact Power$= \frac{workdone}{time} = \frac{1568J}{5s}$ $= 313.6J/s = 313.6\ watts$ Therefore, the power of the bullet at the point of impact is 313.6w.	B_1 A_1	Power Ans. & Units

(d)	 Figure 7: **Load Acting on Pulley System**		
(i)	$Work done to lift the load = 876N \times 1.82m = 1594.32J$ $= 1.6kJ.$	B_1	Ans. & units
(ii)	$Work done by the effort = 135N \times 15m = 2025J = 2.03kJ.$	B_1	Ans. & units
(iii)	$Efficiency = \frac{work output}{work input} = \frac{1594.32}{2025} = 0.7873 = 78.7\%$	B_1 A_1	Division Ans. & units
(iv)	The machine efficiency cannot be 100% because the work output is always less than work input for some work input is used up in overcoming internal friction and in giving the energy of motion to the moving parts.	B_1	Explanation
3 (a)	 Figure 8: **Momentum** Initial momentum$= (0.15kg \times 10m/s) + (0.35kg \times -7m/s)$ $= -0.95kgm/s$ Final momentum$= (0.15kg \times v_1 ms^{-1}) + (0.35kg \times v_2 ms^{-1})$ $= 0.15v_1 + 0.35v_2)$ Recall velocity of the approach is equal in magnitude to velocity of the separation but in opposite in sign: $u_1 - u_2 = v_2 - v_1 = -(v_1 - v_2)$ where $u_1 and u_2$are velocities of the approach and$v_2 and v_1$ are velocities of the separation for bodies 1 and 2 respectively and that elasticity, $e = 1$. $v_2 - v_1 = (10 - (-7)ms^{-1}$ $= 10 + 7ms^{-1}$ $\therefore v_2 - v_1 = 16 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(i)$ Again, $0.35v_2 + 0.15v_1 = -0.95 \ldots\ldots\ldots\ldots\ldots\ldots..(ii)$ (conservation of linear momentum) Solving the simultaneous equations (i) and (ii) we have: $0.35v_2 - 0.35v_1 = 0.35 \times 16 = 5.6 \ldots\ldots(iii)$	B_1 B_1 B_1 B_1 B_1	Diagram Initial momentum Final momentum Simultaneous equation Solving equations

	Subtracting (iii) from (ii) we have: $0.35v_1 + 0.15v_1 = -5.6 - 0.95$ $0.5v_1 = -6.55$ $v_1 = -\frac{6.55}{0.5} = -13.1ms^{-1} \ldots\ldots(iv)$ Substituting (iv) in (ii) we have: $0.35v_2 + 0.15(-13.1) = -0.95$ $0.35v_2 = -0.95 + 1.965 = 1.015$ $v_2 = 2.9ms^{-1}$ Therefore, the ball with a mass of 150g will move at a velocity of $13.1ms^{-1}$ in the opposite direction (to its original direction)while the ball with a mass of 350g will move in the opposite direction (to its original direction) with a velocity of $2.9ms^{-1}$.	A_2	Solution direction
(b)	Given that: First wagon mass=35tonnes =35000kg; Speed =36km/h second wagon mass=15tonnes =15000kg; Speed =20km/h After impact: Rebound speed for first wagon=3km/h Rebound speed for second wagon=?? (For conservation of linear momentum) $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $(35 \times 36) + (15 \times (-20)) = (35 \times 3) + 15v_2$ $15v_2 = 855$ $v_2 = \frac{855}{15} = 57ms^{-1}$ Therefore, the second wagon will travel in $57ms^{-1}$in the opposite direction (from the original direction).	B_2 B_2 A_1	Substitution Solving Ans. Direction & units
4. (a) (i)	 Given that: $g = 9.81ms^{-2}$; $s = 3m; u = 0; v = ??$ Figure 9: **Forging Die** Velocity of the top die just before impact, apply the equation: $v^2 = u^2 + 2gs$ $v^2 = 0 + 2 \times 9.81ms^{-2} \times 3m$ $v = \sqrt{58.86} = 7.672ms^{-1}$ Therefore, the velocity of the top die at impact was 7.6m/s	M_1 A_1	Working Ans. & units
(ii)	$v = u + gt$ $7.672m/s = 0 + 9.81t$	M_1	Working

	$$t = \frac{7.672ms^{-1}}{9.81ms^{-2}} = 0.782s$$	A1	Ans. & units
(b) (i)	Given that: mass, m=1tonne=1000kg; u=24km/h= $6.666ms^{-1}$; $v = 48km/h = 13.333ms^{-1}$; $s = 50m$ $$t = \frac{\frac{1}{2}(v+u)}{50} = 0.199s$$ Applying the equation: $v = u + at$ $$13.333 = 6.666 + 0.199a$$ Solving for a, $a = 100.49ms^{-2}$ $$Force = ma = 1000kg \times 100.49ms^{-2}$$ $$= 100.49kN$$ Therefore, it requires 100.49kN tractive force to accelerate a vehicle from a velocity of 24km/h to 48km/h in the direction of force.	B1 B1 A1	Working Working Ans. & units
(ii)	Given that: $u = 13.333ms^{-1}$; $v = 0$; $s = 50m$ Time taken to come to a halt, $t = \frac{\frac{1}{2}(13.333)}{50} = 0.1333s$ Acceleration $= \frac{v-u}{t} = -\frac{1.333}{0.1333} = 9.9977ms^{-2}$ $$Force = ma = 1000 \times 9.9977 = 9997.7N$$ Therefore, the average breaking force required to bring a 1 ton vehicle from a velocity of 48km/h is 9997.7N.	B1 A1	Working Ans. & units
5 (a) (i)	A high jumper must lift himself such that he does not knock the bar off. The equation that explains how much energy is needed is: $P.E = K.E = mgh$	B1	Explanation
(iii)	In high jump, what is considered is how high (in m) from the ground a jump clears the bar in the high jump.	B1	Explanation
(iv)	$K.E = P.E = mgh = 72kg \times 9.81ms^{-2} \times 2.3m = 1.679kJ$ On the surface of the moon, mass is $\frac{1}{6}$ th of the mass on the earth surface. Hence, he could jump $2.3 \times 6 = 13.8m$ (Considering conservation of momentum).	M1 B1	Working Explanation
(b) (i)	Given that: starter stand 5m away from the sprinter in lane 1; And 15m away from the sprinter in lane 8. Time taken by sprinter in lane 1 to hear, $$t = \frac{d}{v} = \frac{5m}{344ms^{-1}} = 0.01453s$$ Time taken by sprinter in lane 8 to hear, $$t = \frac{d}{v} = \frac{15m}{344ms^{-1}} = 0.04360s$$ Difference between the time after which sprinter in lane 8 heard the pistol, $t_d = 0.02907$ after the sprinter in lane 1 had started. If the sprinter in lane 1 completed 0.01s before sprinter in lane 8, then, he should complain because he was ahead of his counterpart by 0.019sec.	B1 B1 A1	Working Working Ans. & Explanation
(ii)	The starter should stand on a position that is equidistant from all the competitors, preferably a raised position behind the	B1	Explanation

	competitors.		
6. (a)	Given that: mass, $m = 4800kg; v = 98km/h = 27.22ms^{-1}$ $Momentum = mv = 27.22m \times 4800kg = 130656kgms^{-1}$	B_1 A_1	Working Ans. & units
(b)	Given that: mass, $m = 1000kg$; $Weightoftheblock, W = mg$ $= 1000kg \times 9.81ms^{-2}$ $= 9810N$; Horizontal force applied =1200N The horizontally applied force =frictional force opposing the motion of the concrete block. But $\mu = \frac{frictionalfroce}{normalreaction}$ Since normal reaction is equal to the weight of the concrete, $Normalreaction = 9810N$ $\mu = \frac{frictionalfroce}{normalreaction} = \frac{1200N}{9810N} = 0.1223$ Therefore, the coefficient of friction between the surfaces was 0.1223.	B_1 B_1 B_1 A_1	Working explanation Working Ans. & units
7. (a) **(i)**	Given that: $u = 7ms^{-1}; \theta = 45°; t = 0.25s, v = ??$ It is assumed that the motion shall have two components: Vertical and horizontal components. It is further assumed that the vertical and horizontal motions are independent of each other. Horizontal motion: The horizontal velocity is constant. Hence, $horizontalvelocity, u_x = ucos\theta = 7cos45° = 4.949ms^{-1}$ Vertical motion: $Initialverticalvelocity, u_y = usin\theta = 7sin45° = 4.949ms^{-1}$ The equation of the vertical velocity at any time is given can be obtained as shown below. Using the relation: $v = u + at$ Which becomes: $v_y = u_y - gt$or $usin\theta - gt$ Given that: $v_y = ??$ $u_y = 4.949ms^{-1}; a = -g = -9.81ms^{-2}; t = 0.25s$ $v_y = 4.949ms^{-1} - 9.81ms^{-2} \times 0.25s = 2.4965ms^{-1}$	B1 M_1 M_1 A_1	Explanation Initial velocity Working Ans. & units
(ii)	Let the steeplechaser take off at angle of $45°$ (optimum horizontal distance is covered when take is at $45°$) Horizontal motion: Horizontal distance, $x = ut$ But horizontal distance $x = 3.72m$ Considering that the steeplechaser will land 45cm after the water hole, x becomes: $x = 3.72m + 0.45m = 4.17m$ But $4.17 = ut$ or $t = \frac{4.17}{u}$ Considering the vertical motion to the ground, we have Again, $s = ut - \frac{1}{2}at^2$ and given that:	M_1 B_1	Horizontal distance Expression for time

	$s = 1.1m - 0.914m = 0.186m$ $g = 9.81ms^{-2}; u = ??;$ $0.186 = u(cos45°) \times \frac{4.17}{u} - \frac{1}{2} \times 9.81\left(\frac{4.17}{u}\right)^2$ $0.186 = 4.17 \times 0.707 - 4.905 \times \frac{4.17^2}{u^2}$ $2.76219 = \frac{85.29}{u^2}$ $u^2 = \frac{85.29}{2.76216}$ or $u = 5.56m/s$ Therefore, the take-off velocity from the rail is 5.56m/s The take-off velocity is important in determining the time taken to cover the water jump. The result from calculation the time take is 0.75s. The time taken to the rail is about 0.5045s. As such, steeplechasers attempt to clear the water jump in less than 1.25s second.	B_1 B_1 M_1 A_1	Working Working Working Ans. & units
8. **(i)**	Given that: $a = -g = -0.981ms^{-2}; u = 100ms^{-1};$ $v = 0ms^{-1}; s = ??$ $v^2 = u^2 - 2gs$ $0 = 10000 - 2 \times 9.81s$ $s = \frac{10000}{19.62} = 509.68m$ Therefore, the highest height the object rose was 509.68m	B_1 A_1	Working of distance Ans. & units
(ii)	$v = u - gt$ $0 = 100 - 9.81t$ $t = \frac{100}{9.81} = 10.19s$	B_1 A_1	Working of time Ans. & units
(iii)	Time taken to get to the Mid-height is ½ × 10.19 = 5.09s Total time taken = 5.09 + 10.19 = 15.28s.	M_1 A_1	Working Ans. & units
(iv)	Time taken to get to the max height is the same as the time taken to come back. Given that: $t = 10.19s;\ g = 9.81ms^{-2}; u = 0; v = ??$ $v = u + gt$ $v = 0 + 9.81 \times 10.19 = 99.96 \approx 100ms^{-1}$ As such acceleration up has the same value as the acceleration down except the direction in the opposite direction.	B_1 A_1	Working of velocity Ans. & units
(v)	$Force = ma = 5 \times 9.81 = 49.5N$	B_1 A_1	Working of force Ans. & units
9. **(i)**	Given that: $u = 100ms^{-1}; s = 120m; g = 9.81ms^{-2}; t = ??$ $v^2 = u^2 - 2gs$ $v = \sqrt{100^2 - 2 \times 9.81 \times 120}$ $v = 87.43ms^{-1}$ $87.43ms^{-1} = 100ms^{-1} - 9.81ms^{-2}t$ $t = \frac{12.57}{9.81} = 1.281s$ Therefore, the time taken to get to a distance of 120m is 1.281s.	B_1 B_1 A_1	Working of velocity Working of time Ans. & units

(b)	$u = 1000ms^{-1}; 9.81ms^{-2}; \theta = ??; t = ??$, horizontal distance, $x = 60000m; v = 0ms^{-1}$ $$x = \frac{u^2 sin2\theta}{g} = 60000$$ $$\frac{(1000ms^{-1})^2 sin2\theta}{9.81} = 60000$$ $$sin2\theta = \frac{60000 \times 9.81}{1000000} = 0.5886$$ $$\theta = 18.03°$$	B_1 B_1 A_1	Working of expression Working of angle Ans. & units
10. (a) (i) **(ii)**	$$g = 9.81ms^{-1};\ \theta = 30°; u = 66.67ms^{-1}$$ Vertical motion: $$u_y = 66.67 \sin\theta = 33.33ms^{-1}$$ Max height attained by the moving body, $$h = \frac{u^2}{g} = \frac{33.33}{9.81} = 6.69m$$ the height the object shall fall, $$s = 6.69m + 1500m = 1506.69m$$ On the way down, $$g = 9.81ms^{-1};\ \theta = 30°; u = 66.66; t = ??$$ $$t_1 = \frac{usin\theta}{g} = 3.398s$$ $$s = ut_2 + gt_2^2$$ $$1506.69 = 9.81t_2^2$$ $$t_2 = 12.39s$$ Time taken on the way down, Horizontal motion: Given that: $$g = 9.81ms^{-1};\ \theta = 30°; u = 66.66; t = 12.39s$$ Horizontal velocity remains constant throughout. Hence, Horizontal distance covered, $x = tucos\theta = 12.39 \times 66.66 \times 0.866 = 715.26$m	B_1 M_1 B_1 A_1	Working of time Working of total time Working of horizontal distance Ans. & units
(ii)	Vertical motion: Velocity before impact, $v^2 = u_y^2 + 2gs$ $$v = 171.93ms^{-1}$$ $$sin\theta = \frac{15096.69}{1593.75} = 0.945$$ $$\theta = 70.97°$$	B_1 A_1	Working of total velocity Ans. & units
(b) (i)	Launch angle, $\theta_0 = \frac{1}{2} sin^{-1}\frac{gR}{V_0^2} = \frac{1}{2}\frac{(9.81ms^{-2})(560)}{82ms^{-1}} = \frac{1}{2}sin^{-1}0.816$ The results displayed by the calculator is:54.7°. To obtain other angles we subtract from 180° to get:125.313°. Hence, the launch angle $\theta_0 = \frac{1}{2}54.7° = 27°$ or $\theta_0 = \frac{1}{2}125.313° = 63°$	B_1 B_1 A_1	Working of angle Working of other angles Ans. & units

(ii)	Maximum range corresponds to an angle θ_0 of 45°. Thus: $R = \frac{v^2}{g} sin2\theta_0 = \frac{82 m/s}{9.81 m/s^2} \sin(2 \times 45°) = 686m \approx 690m$ As the pirate ship sails way, the two angles at which the ship can be hit draws together, eventually merging at $\theta_0 = 45°$ when the ship is 690m away. Beyond that distance, the ship is safe.	B_1 B_1 A_1	Optimum angle Working of range Ans. & units

APPENDIX 6: TEST RESULTS FOR TREATMENT AND CONTROL GROUP

		CG_1		CG_2		CG_3		TG	
S. No.	Gender	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
1.	F	28	39	25	38	28	42	40	66
2.	F	25	32	37	39	14	24	38	62
3.	F	34	43	45	59	30	49	32	66
4.	F	25	34	20	33	19	47	39	69
5.	F	48	61	34	45	26	38	36	51
6.	F	32	38	22	32	28	37	32	43
7.	F	39	60	38	42	23	31	22	58
8.	F	21	46	28	31	43	39	25	59
9.	F	39	45	38	48	37	54	34	42
10.	F	32	57	22	25	25	46	22	44
11.	F	37	38	18	23	24	46	44	67
12.	F	28	54	22	31	38	52	22	51
13.	F	38	49	38	42	32	46	28	59
14.	F	22	38	33	40	27	50	46	54
15.	F	18	35	24	30	36	51	22	69
16.	F	29	58	36	30	43	47	41	50
17.	F	34	51	30	39	31	57	39	75
18.	F	33	65	18	32	42	64	32	64
19.	F	25	49	15	24	30	48	24	43
20.	F	34	65	32	35	42	56	21	58
21.	M	23	56	16	22	32	44	47	70
22.	M	42	53	22	45	23	51	21	48
23.	M	35	48	29	50	35	45	42	67
24.	M	26	49	34	55	28	51	29	65
25.	M	28	39	22	32	31	43	21	47
26.	M	37	35	41	45	21	42	42	44
27.	M	19	49	45	60	24	61	23	49
28.	M	41	49	41	62	33	49	37	74
29.	M	35	39	55	65	23	37	32	48
30.	M	32	28	21	44	24	49	26	76
31.	M	25	34	44	50	21	35	32	77
32.	M	12	24	30	38	23	39	35	63

33.	M	25	33	21	35	36	61	41	72
34.	M	30	39	33	55	24	25	23	42
35.	M	35	39	29	45	21	48	32	61
36.	M	27	45	44	50	24	44	22	40
37.	M	36	38	35	55	32	35	34	52
38.	M	22	43	23	42	36	41	30	62
39.	M	29	29	35	45	36	33	32	67
40.	M	31	42	36	50	37	48	28	49
41.	M	43	49	33	45	45	44	33	67
42.	M	34	48	35	58	35	47	35	69
43.	M	35	38	23	32	23	44	32	79
44.	M	32	52	42	55	25	57	24	47
45.	M	35	39	39	45	36	48	44	79
46.	M	46	47	38	52	33	45	33	52
47.	M	33	36	44	43	25	50	36	74
48.	M	28	38	41	46	29	28	37	79
49.	M	35	44	30	44	32	37	36	67
50.	M	28	43	32	43	30	42	22	53
51.	M	14	23	34	55	24	34	41	70
52.	M	27	32	28	42	35	37	35	69
53.	M	24	29	41	50	26	34	34	58
54.	M	48	27	38	52	26	44	28	60
55.	M	47	36	31	41	49	60	25	57
56.	M	32	37	39	50	32	46	43	79
57.	M	34	48	34	43	19	29	37	56
58.	M	32	45	24	43	23	52	42	70
59.	M	31	37	34	55	34	37	34	54
60.	M	33	44	41	54	36	49	34	45
61.	M	34	56	24	43	47	54	21	43
62.	M	33	57	29	42	48	68	38	74
63.	M	45	34	33	40	37	45	36	67
64.	M	29	44	27	45	25	47	24	59
65.	M	23	48	34	40	41	43	45	79
66.	M	31	37	35	37	39	62	35	84
67.	M	21	48	30	36	29	42	31	46
68.	M	32	34	25	44	42	51	29	67
69.	M	56	34	33	40	50	63	27	81

70.	M	25	75	26	44	42	54	29	50
71.	M	29	29	32	52	32	42	39	77
72.	M	19	33	26	40	33	57	42	65
73.	M	28	45	30	41	25	49	54	82
74.	M	38	34	25	42	33	47	44	68
75.	M	33	44	33	42	25	49	35	73
76.	M	32	36	23	30	38	59	43	77
77.	M	44	33	19	35	37	47	25	57
78.	M	22	35	22	41	44	39	33	78
79.	M	23	28	23	33	37	42	45	70
80.	M	24	33	20	32	26	50	48	83
81.	M	27	32	26	34	30	69	24	59
82.	M	24	29	34	51	29	51	66	69
83.	M	22	27	38	50	22	47	27	75
84.	M	36	47	20	40	43	57	45	68
85.	M	22	37	23	35	30	58	48	82
86.	M	24	38	37	42	27	35	34	75
87.	M	32	45	36	51	24	38	47	73
88.	M	25	28	24	35	24	39	31	80
89.	M	30	44	22	25	31	62	66	76
90.	M	29	34	18	25	22	47	38	76
91.	M	34	38	38	44	30	56	27	75
92.	M	57	75	23	32	49	64	36	82
93.	M	34	60	35	45	32	53	20	64
94.	M	22	36	26	34	22	39	22	78
95.	M	36	42	24	37	19	35	32	65
96.	M	32	44	21	30	31	56	23	54

Key:
Order of results is respectively:-

Treatment Group E_2- (Steeplechase Activities with Socratic probing and Socratic probing)

Control Group CG_1 (Lecture Method)

Control Group CG_2 - (Question and Answer and use of examples)

Control Group CG_3 (Lecturer's demonstration)

APPENDIX 7: QUESTIONNAIRE FOR MECHANICS LECTURERS (QML)

This questionnaire aims at getting your opinion pertaining to the teaching and learning of Mechanical Engineering Science. The information you give is for research purposes only and will be treated with confidentiality. Please do not write your name on any of these pages.

Part 1: General Information

1. Please indicate by putting a tick (√) to the appropriate option or by filling in the missing information.

   a) Gender: Male [ ] Female [ ]

   b) What is the number of students in your class? Male [ ] Female [ ]

   c) What is your highest academic/professional qualification?

      Diploma [ ] Higher diploma [ ] B. TEC [ ] BSC []

      M.TEC [ ] MSC [ ] MED [ ] Ph.D. [ ]

   d) For how long have you been teaching?

      1-5 years [ ] 6-10 years [ ] 11-15 years []

      16-20 years [ ] over 20 years [ ]

2. Have you attended any In-service Training (INSET)?Yes [ ] No [ ]

   a) If yes, indicate the type of INSET attended?

      Seminar [ ] SMASSE [ ] Workshop [ ] Conference [ ]

      Training Abroad: One month [ ] Two months [ ] One year [ ]

      School-Based Program [ ] (specify)..

      Others (specify)..

3. Have you participated in UNESCO-UNEVOC e-forum activity? Yes [ ]No [ ]

   a) If yes, which activity?

      Conference [ ] Discussion [ ] Contribution to an article [ ]

Part 2: Your opinion on students' performance in mechanics.

1. Please indicate your opinion on students' performance in mechanics by putting a tick (√) to the appropriate option by using the context of agreement using the words:

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

Students' performance involves:	**SA**	**A**	**U**	**D**	**SD**
a) System acquisition, maintenance, repair and operations					
b) Solving practical problems					
c) Make graphical and diagrammatical representations of phenomenon					
d) Algebraic expressions, equations used in problem solving					
e) Brief and precise explanations of the mathematical results					
f) Use various tools such as computer to do brainstorming					
2. Factors which affect students' performance in mechanics include:	**SA**	**A**	**U**	**D**	**SD**
a) Mechanics involves abstract mathematical calculations					
b) Teaching strategies					
c) Opportunities for practical applications					
d) Attitude towards mechanics					

e) Availability of teaching & equipment and resources					
f) Contextualizing learning of mechanics by steeplechase activities					
g) Lecturers preparation for lessons					

Part 3: Your opinion on mechanics teaching strategies.

1. The following are some of the teaching approaches used by lecturers of mechanics for teaching. Put a tick (√)show the extent of use of the method to:

		Always	Rarely	Not at all
a)	Lecture method			
b)	Dictation of notes			
c)	Question and answer			
d)	Use of examples and illustrations			
e)	Lecturers' demonstrations			
f)	Exercises & Assignment			
g)	Library research			
h)	Practical work/ students experiments			
i)	Small-group discussion			
j)	Collaborative learning			
k)	Steeplechase activities			
l)	Others (specify)			

2. Why students do you think interactive method of teaching may be preferred in mechanics? Indicate by putting a tick (√) to the context of your agreement using the words:

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

Interactive methods of teaching:	SA	A	U	D	SD
a) Anchor learning of mechanics concepts					
b) Motivate students to participate in learning mechanics					
c) Contribute to positive attitude towards mechanics					
d) Encourage construction of knowledge in mechanics					
e) Give students reasonable control over their own learning					
f) Encourage development of mathematical and process skills					
g) Provide interesting and meaningful experiences					
h) Socratic probing deepen understanding					
i) Students to take responsibility over their own learning					

Part 4: Your opinion on lecturers' demonstration a teaching strategy in mechanics

1. Which of the following resources do you use in lecturers' demonstration for teaching mechanics? Put a tick (√) your level of use of the resources in lecturer's demonstration.

		Always	Rarely	Not at all
a)	Colored charts			
b)	Tennis ball			
c)	Marble balls			
d)	Open pipes			
e)	Toys with flywheel system			
f)	Demonstration models			
g)	Running engines			
h)	Gear boxes			
i)	Brake-systems			
j)	Engineering drawing models			

2. What is your opinion concerning lecturer's demonstration as a teaching strategy in mechanics? Indicate your level of agreement by putting a tick (√) to the context of your agreement using the words:

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

Statement	**SA**	**A**	**U**	**D**	**SD**
a) Demonstration involves oral presentation and practical demonstration					
b) Oral presentation involves use of sketches, drawings, photos, and pictures among other resources					
c) A certain amount of information or theory supports students in understanding what is being done and why					
d) Stages of carry out a lecturers demonstration lesson: preparation, performing of the demonstration and discussion					
Situations where lecturers demonstration is preferred:					
a. There is shortage of materials and facilities					
b. Safety of students is a major consideration					
c. Experiment involves a sophisticated or expensive apparatus					
d. Time for students' experiment is limited					
e. In experiments certain specific skills are to be learnt					
Conditions necessary for lecturers demonstration to be successful include:					
a. Demonstration should be visible to the whole class					
b. Demonstration must be followed by practice by students in which they begin to imitate the skills observed					
c. There should be adequate time to critically evaluate the demonstration observations					

Part 5: You opinion on benefits of involving students in steeplechase activities

1. What is the most important benefit of involving students in steeplechase activities? Indicate by putting a tick (√) to the context of your agreement using the words:

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

What is the most important benefit of involving students in steeplechase activities?	**SA**	**A**	**U**	**D**	**SD**
e) Explaining ones thinking develops effective communication skills					
f) Participation in steeplechase activities develops estimation skills					
g) Developing and using mathematical expressions and equations in steeplechase activities develop problem-solving skills					
h) Simulation of mechanics problems develops analytical and critical thinking skills					

2. Indicate the context of your agreement with the steeplechase activities in teaching and learning of mechanics by putting a tick (√).

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

Students:	**SA**	**A**	**U**	**D**	**SD**
a) Have explanation of mathematical phenomena encountered in everyday life					
b) Collect data, organize and analyze data, interpret data and make conclusions					
c) Make graphical and diagrammatic representations of phenomena and carry out mathematical calculations					
d) Form algebraic expressions, equations and use them in problem solving					
e) Steeplechase activities can encourage improvisation of teaching/learning resources					
f) Use resources, charts diagrams, models can improve performance in mechanics					
g) Accurately and correct use of apparatus to get the best out of activities					
h) Steeplechase activities help demystify mechanics learning					

Part 6: Your opinion on difference in performance in mechanics by ability.

1. Why do you think about the difference in performance in mechanics between high and low ability group of students? Indicate by putting a tick (√) to the context of your agreement using the words:

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

Statement on effect of Ability on students' performance in Mechanics	**SA**	**A**	**U**	**D**	**SD**
a) The purposes of pre-test is identify students' learning abilities					
b) Students' ability can be expanded through hard work					
c) Gifted students benefit if grouping aims at meeting their academic needs					
d) Mixed ability grouping is preferred in small-group discussion					
Ability grouping is done for purposes of:	**SA**	**A**	**U**	**D**	**SD**
a) Acceleration in learning in mechanics					
b) Curriculum compacting in learning in mechanics					
c) Enrichment in learning in mechanics					
d) Cluster grouping in learning in mechanics					
e) Differentiation in instruction					
Negative Impact of Ability Grouping in Mechanics	**SA**	**A**	**U**	**D**	**SD**
a) Ability grouping is part of students labeling					
b) View that mechanics is meant for low ability students					

Part 7: Your opinion on effect of difference in performance in mechanics by gender.

1. Why do you think there is difference in performance in mechanics by gender? Indicate by putting a tick (√) to the context of your agreement using the words.

Strongly Agree- SA Agree-A Unsure-U Disagree-D Strongly Disagree-SD

Statement on Male and Female Students Performance in Mechanics:	**SA**	**A**	**U**	**D**	**SD**
a) Male and female students have the same ability in mechanics					
b) Male students are the majority in mechanics lessons					
c) Female perform better than men in lower cognitive problems					
d) Male students have higher spatial ability than women					
e) Engineering and technology are a preserve of male students					
Factors attributed to gender difference in performance	**SA**	**A**	**U**	**D**	**SD**
a) Lack of interest on the part of female students					
b) Mechanics is abstract in nature					
c) Classroom interactions					
d) Male get more opportunities to respond to higher order questions					
e) Lecturers interact more with male than female students					
f) Female students are discouraged by family from enrolling in mechanics					
g) Fewer female lecturers					

APPENDIX 8: INTERVIEW SCHEDULE

This interview schedule aims at getting the steeplechasers opinion pertaining to training techniques and programs to inform the Mechanical Science learning through steeplechase activities. The information given is for research purposes only and will be treated with confidentiality. The research will indicate the opinions or indicate the level of agreement with the statements.

Date of birth of steeplechaser………….. Competing experiences………
Major competitions………………………………………………………

Part One: General Information

1. What does technical training in steeplechase involve?
2. What is the role of efficient barrier clearance?
3. What is the purpose of maintaining a low hip as one kick back at the water jump hurdle?

Part Two: Steeplechase

The interviewer will indicate what is agreed upon by putting a tick (√) on the right hand side

	Techniques of doing hurdle at water jump involve:	*******
4.	Maintaining low hip	
5.	The leg on the hurdle is bent	
6.	The push from the barrier is delayed until the body is well beyond it	
7.	The athlete propel himself/herself to maximize the drive	
8.	Landing is done with the lead leg in the water while the trail leg steps outside the water	
	Ability developed include:	******
9.	Endurance and tact	
10.	Effective barrier clearance	
11.	Sprint throughout the race while reserving energy for the finishing kick	
12.	Proper takeoff and landing	
13.	Agility	
14.	Balance	
15.	Save energy	
16.	Maintain balance	
17.	Reduce time taken during the race	
18.	Precision	
19.	Estimation	
20.	Mental calculation	
21.	Predicting the likely action of fellow competitors	
22.	Mathematical skills is useful in steeplechase	
23.	**Mathematical skills useful in life include:**	******
	a) creative thinking	
	b) critical thinking	
	c) problem-solving	
	d) effective communication	
	e) analytical thinking	

APPENDIX 9: RESEARCH PERMIT

CONDITIONS

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed with-out prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2)/four (4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.

GPK6055t3mt10/2010

REPUBLIC OF KENYA

RESEARCH CLEARANCE PERMIT

(CONDITIONS—see back page)

PAGE 2

THIS IS TO CERTIFY THAT:

Prof./ Dr./ Mr./ Mrs./ Miss. DAVID MUTAHI MUTHONI

of (Address) UNIVERSITY OF NAIROBI P.O. BOX 92, KIKUYU

has been permitted to conduct research in .... Location, ... District, CENTRAL AND NAIROBI Provinces

on the topic Sustaining Students' competence motives in mechanics through steeplechase in Technical Colleges in Central & Nairobi Provinces, Kenya.

for a period ending 31ST JUNE, 20 13

PAGE 3

Research Permit No. NCST/RRI/12/1/SS/632

Date of issue 13/07/2010

Fee received SHS 2,000

Applicant's Signature

Secretary National Council for Science and Technology

APPENDIX 10: RESEARCH AUTHORIZATION

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telegrams: "SCIENCETECH", Nairobi
Telephone: 254-020-241349, 2213102
254-020-310571, 2213123.
Fax: 254-020-2213215, 318245, 318249
When replying please quote

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RRI/12/1/SS/632/3**

Date: **13th July 2010**

Mr. David Mutahi Muthoni
University of Nairobi
P. O. Box 92
KIKUYU

Dear Sir,

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Sustaining students' competence motives in mechanics through steeplechase in technical colleges in Central and Nairobi Provinces, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi and Central Provinces** for a period ending ***31st June 2013.***

You are advised to report to **the Provincial Director of Technical Education, Nairobi and Central Province, and the Principals of the Technical Colleges that you will visit in Nairobi and Central Provinces** before embarking on the research project.

On completion of the research, you are expected to submit two copies of the research report/thesis to our office.

P. N. NYAKUNDI
FOR: SECRETARY/CEO

Copy to:
The Provincial Director of Technical Training
Nairobi Province
Central Province