EFFECTS OF INTERACTIVE MULTIMEDIA SIMULATIONS ADVANCE ORGANIZERS TEACHING APPROACH ON STUDENTS' ACHIEVEMENT AND MOTIVATION TO LEARN SECONDARY SCHOOL PHYSICS IN NYAHURURU SUB-COUNTY, LAIKIPIA, KENYA

DAVID G. NGATIA

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DECLARATION AND RECOMMENDATIONS

Declaration

This is my original work and has not been presented before for any award of Diploma or conferment of Degree in this or any other University.

Signature: .... Date:...

David G. Ngatia

ED14/0395/13

Recommendations

This thesis has been submitted with our approval as University supervisors.

Signature: .... Date:...

Prof J.M. Changeiywo, PhD

Department of Curriculum, Instruction and Educational Management

Egerton University

Signature: .... Date:...

Dr. P. W. Wambugu, PhD

Department of Curriculum, Instruction and Educational Management

Egerton University

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DEDICATION

This work is dedicated to the memory of my late father Gideon Ngatia

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ABSTRACT

Physics knowledge is vital for socio-economic development of any society. Technologies transforming the world are directly linked to physics inventions. Despite its importance, achievement and motivation to learn physics subject at the Kenya Certificate of Secondary Education (KCSE) has remained low in comparison to other science subjects. One of the factors attributed to the low achievement and motivation to learn physics is the poor teaching approaches. There is therefore need for teachers to use teaching approaches that address the problem of the low achievement and motivation to learn physics. Interactive Multimedia Simulation Advance Organizers (IMSAO) is a teaching approach that combines both interactive multimedia simulations and advance organizers in the teaching/learning process which may enhance achievement and motivate learners. However, its effects on achievement and motivation to learn secondary schools physics had not been determined in Nyahururu Sub-County of Laikipia. This study investigated the effects of using IMSAO teaching approach on achievement and motivation to learn physics in secondary schools in Nyahururu Sub-County. The effect of IMSAO on achievement and motivation to learn physics by gender was also determined. Solomon-Four, Non-Equivalent Control groups' research design was used. The population of study comprised of all form two students in public secondary schools in Nyahururu Sub-County. A sample size of 168 students was used in the study. Four schools were purposefully sampled from the 24 Co-educational Day public secondary schools in the Sub-County. Random sampling was used to assign two schools to experimental groups and two schools to control groups. Experimental groups were taught using IMSAO teaching approach while the control groups were taught using Conventional Teaching Methods (CTM). Physics Achievements Test (PAT) and a Physics Motivation Questionnaire (PMQ) were constructed, validated and pilot tested for use in data collection. The reliability coefficients for PAT and PMQ were 0.83 and 0.79 respectively. Data was analysed using ANOVA, ANCOVA and t-tests. All hypotheses were tested at the coefficient alpha (α) equal to 0.05. The findings of the study showed significant statistical differences in achievement and motivation to learn physics for students exposed to IMSAO and those exposed to CTM, in favour of the experimental groups. The results also indicated a non-significant statistical difference in physics achievement and motivation to learn physics between boys and girls exposed to the IMSAO teaching approach. The researcher recommended the use of IMSAO by physics teachers, curriculum developers, and teacher trainers in order to improve on the achievement and motivation to learn physics in secondary schools.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

AAUW - American Association of University Women

ANCOVA -Analysis of Covariance

ANOVA -Analysis of Variance

CEMASTEA - Centre for Mathematics, Science and Technology Education in Africa

CTM - Conventional Teaching Methods

IMSAO - Interactive Multimedia Simulations Advance organizer

KCSE - Kenya Certificate of Secondary Education

KICD -Kenya Institute of Curriculum Development

KIE - Kenya Institute of Education; later became KICD

KIPPRA - Kenya Institute for Public Policy Research and Analysis

KNEC - Kenya National Examinations Council

MLA - Monitoring Learning Achievement Project

NESC -National Economic and Social Council

PAT - Physics Achievement Test

PISA - Programme for International Student Assessment

PMQ - Physics Motivation Questionnaire

SMASSE - Strengthening of Mathematics and Sciences in Secondary Education

SPSS - Statistical Package for Social Sciences

STEM - Science, Technology, Engineering and Mathematics

STI - Science, Technology, and Innovations

UNESCO -United Nations Educational Scientific and Cultural Organization

UNICEF -United Nations Children's Fund

URT - United Republic of Tanzania

CHAPTER ONE
INTRODUCTION

1.1 Background Information

The knowledge of physics is essential for scientific and technological development of any society (Sani, 2012). Physics is the science that attempts to describe how nature works using the language of mathematics. It is considered the most fundamental of all the natural sciences and its theories attempt to describe the behaviour of the smallest building blocks of matter. Physics plays a constructive role in the development of personalities and societies. The subject provides some hands-on experience in equipment handling that could be useful for minor repairs at home even without any specific training. Physics also help people to develop the scientific approach in their daily lives and make them practical persons (Edmund, 2005). It is therefore very important to have the subject included in the secondary school curriculum and further ensure that all students acquire the basic physics knowledge.

The technologies that are continually transforming the world can be directly traced to important researches in physics. For example, research on semiconductors enabled the first transistor to be developed in 1947. This seemingly simple device is the key component in most electronic systems, including computers, and is considered one of the most important inventions in human history that has tremendously changed the way of life of people worldwide (Khalija, 2004). In addition, the laws of optics describing the way light behaves have led to the development of the optical fibre networks that are beginning to crawl over the entire globe, easing communication and drawing the world close together.

Radiation oncology is an area of medical physics that involves applying radiation physics principles to the treatment of cancer. Medical physicists in cancer centres are responsible for the safe and accurate delivery of radiation to patients and also ensure that the treatment machines, imaging devices and information systems are functioning properly. There are countless more examples of research in physics that have led to the development of important technologies. The ongoing research on nanostructures and photonics, which are branches of physics, may lead to the next generation of technologies including faster and more robust computers and communication systems (Stephen, 2002). Physics is therefore relevant in almost all sectors of human life.

Physics theories have enabled people to obtain a greater grasp of the universe they live in. It is the theories of physics that have provided some of the deepest notions of space, time, matter, and energy (Modini, 2011). Physics theories allow conceptualization of the workings of the building blocks of all matter. These are things people would never be able to experience in everyday life. At the other extreme, the theories of cosmology inform how the universe began and how it could possibly end. This is an example of physics going beyond the limits of human experience to describe the universe. Physics as subject is therefore very useful globally making it pertinent for inclusion in the basic school curriculum.

Although there is varied opinion on the amount of trust placed in the theories and principles of physics, the fact remains that these theories and principles are produced from a rigorous and systematic method and they are constantly tested against experimental evidence. As such, physics theories give relatively concrete conceptions of notions beyond everyday experience. Interactive physics simulations can be used to teach and verify the physics concepts, theories laws and principles by providing an experience as close to the 'real thing' as possible. A simulated instruction has the advantage of allowing learners to 'reset' the scenario and try alternative variation of variables under consideration. This allows learners to develop experience of specific situations by applying their wider learning and knowledge (Glover, 2014). Computer interactive multimedia simulations could therefore be used in teaching abstract concepts in physics. This would help them visualise, comprehend, and apply the physics content taught in life situations and improving their achievement in the subject.

In spite of its great importance, students believe physics is one of the difficult subject studied in schools (Siringi &Waihenya, 2002). Poor methods of instruction could be one among other factors that could be contributing to this perception. Physics instruction is largely dominated by traditional content, knowledge, and pedagogies that seems to attract and reward students who are good in rote learning. In these methods, learners have a weak understanding of the central role of experiments in physics and are passive and conservative in their views on teaching and learning of physics. According to Angell *et al*. (2004) students' views about a subject influence their understanding and learning of that subject. Their research found out that students perceive physics as difficult because they have to contend with different representations such as experiments, formulas and calculations, graphs, and conceptual explanations. Indeed, many students find it difficult to define physics, let alone grasp the subtleties of all the formulas made up of strange looking symbols. Such perception could hinder meaningful learning resulting to rote learning. The use of interactive multimedia simulations could simplify physics teaching and make it interesting to the learners. Experiments could be simulated and students given opportunities to manipulate variables which can boost their self-efficacy and motivation to learn physics.

While physics is a fascinating subject and one would assume very useful to study, statistics have shown that even in Britain the number of entries to A-level examinations for physics fell steadily from 46,606 in 1985 to only 27,368 in 2006 (Modini, 2011). This represented a 41% decrease. Meanwhile over the same time, the number of students entering A-level examinations for biology increased by 36% and the number of students entering A-level examinations for chemistry stayed relatively constant. This decreasing trend in the number of senior school physics students is echoed in many other countries around the world. For example, during the past two decades, Australia and parts of the western world have raised a growing concern about the low enrolment in physics at senior secondary level. The number of senior students who choose physics is relatively small and has shown a declining tendency (Dekkers & de-Laeter, 2001; Bolstad & Hipkins, 2005; Lyons, 2005). Research has also shown that the interest of students in physics is declining (Rosier & Banks, 1990; Simpson & Oliver, 1990; George, 2000; Haussler & Hoffmann, 2000; Hoffmann, 2002; Trumper, 2006). In such circumstance, the number of students who decide to pursue Physics and engineering courses in university is very low (Smithers & Robinson, 2006). To reverse this trend, pedagogical measures need to be taken to make physics appealing to students.

In Kenya, although there has been an increase in the number of students taking physics at Kenya Certificate of Secondary Education (KCSE) over years, the number remains low when compared to the total candidature and the number of students taking other science subjects. For instance, out of the 433,014 students who sat for KCSE in 2012, only 118,508 students did physics. This translates to 27.37% of the total student population. In 2011 KCSE, out of the total candidature of 409,887, only 120,093 did physics translating to 29.3% (KNEC, 2013). This trend has been replicated over the years and agrees with the views shared by Wambugu and Changeiywo (2008), who observed that few students choose to pursue physics subject at the secondary school level. A study done in one County in Kenya by CEMASTEA (2016) also revealed that almost all students take chemistry, 85% take biology and only 38% take physics at KCSE level. Table 1 shows the enrolment in physics and other sciences in the KCSE from year 2012 to 2017.

Table 1:
Candidates Enrolment in Physics and other Science Subjects in KCSE from Year 2012 to 2017

		Candidature		
Year	**Gender**	**Physics**	**Chemistry**	**Biology**
2012	Male	87,329	237,293	205,926
	Female	31,179	190,010	180,612
	All	118,508	427,303	386,612
2013	Male	87,159	239,206	206,980
	Female	32,703	200,735	190,334
	All	119,862	439,941	397,314
2014	Male	94,226	255,734	220,650
	Female	36,526	221,659	209,933
	All	130,752	477,393	430,583
2015	Male	99,494	275,031	236,582
	Female	39,606	240,857	226,982
	All	139,100	515,888	463,564
2016	Male	106,604	296,302	254,560
	Female	43,186	270,534	255,422
	All	149,790	566,836	509,982
2017	Male	111,765	312,284	268,424
	Female	48,421	294,234	277,242
	All	160,186	606,518	545,666

Source: KNEC (2012, 2013, 2014, 2015, 2016, 2017, 2018)

Table 1 depicts a small increment in the overall enrolment in physics from 118,508 in 2012 to 119,862 in 2013 (1.14% increase). The overall increase in the physics enrolment has been gradual over all the years. The percentage increment in the physics enrolment as calculated from Table 1 is 9.8%, 6.39%, 7.69% and 6.94% for the years 2014, 2015, 2016 and 2017 respectively. Apparently, the number of students taking physics is less when compared to other subjects. For instance, in the year 2016, only 26.19% of the total candidature of 571,874 did physics. In the year 2017, out of the total candidature of 611,009, only 26.21% did physics. Over the same period, chemistry attracted 99.3% and 99.1 % of the total candidature in 2016 and 2017 respectively while biology attracted 89.3% in 2016 and 89.2% of the total candidature in year 2017.

A keen look at Table 1 reveals that, slightly over a quarter of all candidates sitting KCSE in any given year chose to do physics. This observation speaks volumes on how physics is perceived by learners and the level of motivation to enrol in the subject in comparison to other science subjects. It is also evident that the girls' enrolment in physics is very low in comparison with that of boys across all the years. Out of the 119,862 students who opted for physics in 2013, only 26.4% were girls. In 2014, out of 130,752 students who sat for physics, only 27.9% were girls. In 2015, 2016 and 2017, the percentage of girls doing physics out of all the candidates who sat for physics in that period was 28, 28.8 and 30.2 respectively. Though this depicts an increase in the number of girls doing physics, the numbers are still far less than that of boys. This is an indication that the teaching approaches used in physics teaching appeals more to boys than girls which may lock out many girls from pursuing STEM related courses.

Table 1, indicates that, out of any ten students doing physics in any given year, at most only three are girls. This is in contrast to the girls' enrolment in chemistry and biology in the same years. In the years 2014, 2015, 2016 and 2017, 46.4%, 46.7%, 47.7% and 48.5% of girls respectively sat for chemistry out of the total number enrolled for chemistry. This means that enrolment in chemistry is nearly equal for both genders. Similarly, girls' enrolment in biology in the KCSE has shown an increasing trend. Over the years 2014-2017, the percentage of girls taking biology has been 48.76%, 48.96%, 50.08%, and 50.81%. This indicates that almost equal or higher number of girls enrols for biology than boys. The implication of this is that fewer girls opt for physics at KCSE which may result to gender disparities in some science courses in tertiary institutions where physics subject is a prerequisite. This low enrolment in physics at KCSE examination has been replicated at Nyahururu Sub-County of Laikipia as shown in Table 2.

Table 2:
Nyahururu Sub-County candidates Enrolment in Physics and other Science Subjects in KCSE from Year 2015 to 2018

		Candidature		
Year	**Gender**	**Physics**	**Chemistry**	**Biology**
2015	Male	389	1272	1104
	Female	256	1393	1224
	All	645	2665	2328
2016	Male	428	1483	1185
	Female	304	1625	1501
	All	732	3108	2686
2017	Male	519	1530	1245
	Female	310	1850	1615
	All	829	3380	2860
2018	Male	185	1470	1152
	Female	74	1886	1625
	All	259	3356	2777

Source: Nyahururu Sub-County Education Report (2018).

Table 2 indicates low physics enrolment in comparison to other science subjects at KCSE in Nyahururu Sub-County of Laikipia. For instance in year 2018, paltry 259 students did physics while 3356 and 2777 students did chemistry and biology respectively. The number of boys taking physics at KCSE in the Sub-County across the years is higher than that of girls. This could be due to use of teaching approaches which appeals more to boys than girls. Table 1 and Table 2, implicitly reveals that motivation to do physics subject is lower in comparison to other science subjects as indicated by the low enrolment. In the same breath, Table 1 and Table 2 further indicate that less girls than boys opt to do physics as compared to other science subjects. The low enrolment could be a pointer to the low motivation to learn physics by students, which ultimately make them opt not to take physics in their final examinations.

Learners' motivation has been widely accepted as a key factor that influences the rate and success of learning. Cracker (2006) observed that the students who have negative attitude towards physics lack motivation for the learning process and those students who have positive attitudes towards subject have motivation for the learning process. According to him, motivation to learn physics change with exposure to physics, the learning environment, and teaching method employed by the teacher. For students to be motivated to learn physics, it is imperative that teaching approaches employed by the teachers be changed towards learner centred approaches.

The achievement of students in high school physics has generally been low in many countries. Sakiyo and Sofeme (2008) noted that students' performance in physics in Nigeria is low in both national and state examinations. UNESCO-UNICEF (2003) Survey indicates poor performance in physics for grade 8 pupils in some selected African countries as shown in Table 3.

Table 3:
Physics Performance in Selected African Countries for Grade 8 pupils in 2003

Country	Physics (%)Mean Score
Burkina Faso	40.15
Cameroon	39.06
Mali	34.13
Mauritania	27.35
Niger	33.13
Senegal	36.76

Source: UNESCO-UNICEF (2003) Monitoring Learning Achievement (MLA II) Project database

Table 3 provide evidence of low physics achievement in year 2003 across all the six African countries. The highest mean score is 40.15 % in Burkina Faso which falls far off the average score of 50%. In Tanzania, the performance in physics has also been poor. The percentage mean score for physics in national examinations in years 2004, 2006, and 2008 was registered as 45%, 46%, and 44% respectively (URT, 2008). In Nigeria, a decline in performance of students in secondary school physics has been noted and is major concern to researchers in that country (Ajayi, 2000; Mankilik, 2006; Ajayi, 2007; Ibidapo-Obe, 2007; Bilesanmi-Awoderu and Bamiro, 2008; Abdulraheem, 2012). The poor physics performance was also evident in the West African Examination Council (WAEC) (2015) results between 2010 and 2015 as presented in Table 4.

Table 4:
Trends in Students' Performance in Physics in the May/June West African Senior Secondary Certificate Examination (WASSCE) (2010-2015)

Year	Total No. Candidates	No. of Credit Pass	% Pass	No. of Fail	% Fail
2010	487,963	159,264	32.64	328,699	67.36
2011	587,772	157,543	26.80	430,229	73.20
2012	324,998	126,131	38.81	198,866	61.19
2013	298,971	86,612	29.17	212,359	70.83
2014	241,161	72,522	29.27	168,639	70.73
2015	529,425	165,604	31.28	363,820	68.72

Source: West African Examination Council, Research, and Statistics Unit 2015

In year 2010, out of 487,963 students that enrolled for physics, only 32.64% of the students had a minimum of credit pass, leaving 67.36% scoring below credit. In year 2011, 587,772 students enrolled for physics and only 26.80% had a minimum of credit pass, leaving 73.20% failing the examination. This trend remains similar in the other years. More than two-thirds of students who register to do physics fail to get a credit pass. This implies that only a few students would eventually be able to pursue physics related careers in higher institutions and consequently reduced manpower development in engineering and other related professional fields.

The achievement in physics in Kenya at KCSE level has also been low as indicated by KNEC reports over years. For example, although there was an improvement in the overall performance in physics from a mean 37.87% in year 2012 to 40.82% in year 2013 and from 38.84% to 43.68% in the years 2014 to 2015, achievement in physics at KCSE has remained far below the 50% mark. Between 2016 and 2017, a significant drop was recorded in the performance from 39.77% to 35.05% respectively. Table 5 depicts a trend of overall poor performance in the subject for the years 2008 to 2017. This could be attributed to lack of understanding of the physics concepts by learners due to use of teachers centred approaches in teaching.

Table 5:
Performance in Physics in KCSE in the Period 2008-2017

Year	Candidature	Mean % Score
2008	93,692	36.71
2009	104,883	31.31
2010	109,811	35.11
2011	120,093	36.64
2012	118,508	37.87
2013	119,819	40.10
2014	131,410	38.84
2015	139,100	43.68
2016	149,790	39.77
2017	160,182	35.05

Source: KNEC (2012, 2013, 2014, 2015, 2016, 2017, 2018)

A critical look at the physics achievement at KCSE in the years 2015 to 2017 indicate a dropping trend from 43.68% in year 2015 to 35.05% in year 2017. Apart from years 2013 and 2015, all the others years registered an average physics achievement mean of below 40%. This mean many students fail to get quality physics grades at KCSE that could enable them pursue physics courses. The low achievement in physics is replicated across the country in almost all counties and sub-counties in Kenya. Table 6 illustrates the low KCSE physics achievement in Laikipia County for the period 2014 to 2018 per Sub-County.

Table 6:
Laikipia County KCSE Physics Examination Mean Points per Sub-County between Years 2014 and 2018

	KCSE Physics Mean Points				
Sub-County	**2014**	**2015**	**2016**	**2017**	**2018**
Nyahururu	5.22	4.12	4.16	4.47	3.69
Laikipia North	4.49	5.27	4.72	5.38	4.66
Laikipia East	4.65	4.45	5.48	3.97	4.51
Laikipia West	5.60	5.51	4.47	3.71	3.62
Laikipia Central	4.74	4.23	3.36	3.40	3.27

Source: Laikipia County Education Report (2018)

From Table 6, it is evident that physics achievement at KCSE has not been good in all the sub-counties of Laikipia across the years. The Physics KCSE mean points in all sub-counties have never gone above 5 in a scale of 1 to 12 mean points. Nyahururu, Laikipia West, and Laikipia Central posted the lowest KCSE physics achievement means in the County. The researcher selected Nyahururu sub-county for the present study due to its proximity and higher numbers of public secondary schools with equipped computer laboratories which was a requirement in using the Interactive Multimedia Simulations Advance Organisers teaching approach .Although Laikipia West and Laikipia Central sub-counties also posted low physics achievement, they were not selected for study since they had largely inaccessible secondary schools and with no computer laboratories. The KCSE physics mean points for Nyahururu sub-county for the period 2010-2018 has been illustrated in Table 7.

Table 7:
KCSE Physics Mean Points and Grade between 2010 and 2014 in Nyahururu Sub-County in Laikipia, Kenya

Year	Mean Point	Mean Grade
2010	5.05	C-
2011	5.06	C-
2012	4.65	C-
2013	4.79	C-
2014	5.22	C-
2015	4.12	D+
2016	4.16	D+
2017	4.47	D+
2018	3.69	D

Source: Nyahururu Sub-County Education Report (2015, 2018).

According to the figures in Table 7, the best KCSE physics mean grade in Nyahururu Sub-County in the period 2010-2018 was grade C- , which has continuously declined to grade D. This is below the average grade of C (corresponding to 6 points) on a grading scale ranging from 1 to 12 points, where grade A corresponds to 12 points, A- to 11, B+ to 10, B to 9, B- to 8, C+ to 7, C to 6, C- to 5, D+ to 4, D to 3, D- to 2 and E to 1 point. This is a worrying trend bearing the fact that only few students and in most cases the apparently brighter students opt to do physics.

The poor performance in physics is perturbing considering the importance of physics as the key subject in technological advancement, which consequently would lead to attainment of Sustainable Development Goals (United Nations, 2016). In Kenya, the technological advancement is envisioned to accelerate the realization of the Big Four Agenda of the current Kenyan government namely Manufacturing, Universal Healthcare, Affordable Housing, and Food Security (KIPPRA, 2018) which may never be realised with the low achievement and motivation to learn physics. In addition, the Kenya Vision 2030 blueprint also aims to make Kenya a newly industrializing, middle-income country providing high quality life for all its citizens by the year 2030 (NESC, 2007). This could only be realized by exploiting knowledge in Science, Technology, and Innovation (STI) in all sectors. Improvement in the physics achievement and motivation could particularly spur such innovations. Physics knowledge is therefore fundamental in the realization of vision 2030.

Learning physics has been considered a problematic quest by many students causing some to develop a negative attitude towards the subject. Effective physics teaching must therefore encourage learning that motivates learners. Such learning could occur when physics teaching focuses on creating interactive learning that facilitate student self-direction in construction of knowledge (Zacharia, 2003). IMSAO teaching approach may come in handy to provide such an interactive environment. According to Ango (1990), students' poor performance in physics globally is largely due to poor teaching approaches that do not involve the students actively in the teaching-learning process. The low physics achievement could therefore be as a result of using teacher centred methods in the teaching of physics. Interactive Multimedia Simulations Advance Organizers is a teaching approach that combines both the interactive multimedia simulations and advance organisers in teaching. This is done through modelling learning of concepts by mimicking the real situations thus offering students an interactive environment in which they can manipulate variables in an apparent experimental set up conveniently and at their pace. The use of interactive simulations may improve the effectiveness of physics teaching (Van der Veen & van Joolingen, 2015) which may result to enhanced physics achievement (Zacharia, 2007; Ulukök, Çelik, & Sarı, 2013). Interactive simulations may therefore play a special role in physics teaching and learning. They may offer new educational environments which could enhance physics teachers' instructional potentialities and facilitate students' active participation in the learning process.

The technological advancements and the increasing availability of computers and related equipment such as smart boards as well as advent of physics simulation based software programs have led to the integration of simulations into the teaching–learning environment in physics classes (Rutten, *et al.,* 2012). Computer simulations have therefore found a place in the field of science education, with many educators concerned on how best to apply interactive simulations in teaching science to improve the learning outcomes in science teaching (Rutten, *et al.,* 2015).

Researchers and science educators have carried out studies to investigate the impacts of computer simulations on students' understanding of scientific concepts as well as motivation. Researchers conducted investigated the effectiveness of simulations from different points of view. For example, Jimoyiannis and Komis (2001) investigated the use of simulations in enhancing the effectiveness of traditional methods of teaching. The findings of this study indicated that simulations enhanced the effectiveness of the traditional methods of teaching science. Similar study by Chen and Howard (2010) which compared the effectiveness of computer simulations to the traditional methods in science teaching resulted to same findings. Sarı and Güven (2013) investigated the use simulations as pre-laboratory activities to enhance the effectiveness of laboratory equipment. The findings indicated a positive correlation on the use of simulation as a pre-laboratory activity with the effectiveness of handling laboratory equipment. Finkelstein, *et al.* (2004) investigated whether computer simulations could replace real equipment in teaching of science concepts. The study found out that computer simulations could not wholly replace the real equipment in science teaching but could facilitate faster acquisition of manipulative skills on the real equipment. Ünlü and Dökme (2011) study found out those computer simulations showed great potential in enhancing students' academic achievements if they are used as a part of an appropriate educational approach.

In addition, Gilakjani, Leong, and Ismail (2013) have explained that technology by itself cannot make education more effective but it needs an appropriate instructional method so that teachers provide opportunities for students to construct their own knowledge. The use of IMSAO teaching approach which combines both interactive multimedia simulations and advance organisers in teaching may therefore be an appropriate approach that could provide an opportunity for students to construct knowledge leading to improved physics achievement.

The abstract nature of physics concepts combined with poor teaching approaches, are some of the factors that tend to discourage students from studying physics making them have low achievement and motivation to learn the subject. If students do not understand physics concepts, they are unlikely to grasp the relevance of physics to society, and more importantly the relevance of physics to themselves (Neuschatz & Farling, 2002). This could make them be demotivated to study physics. For effective learning in physics, students need to know why physics is important and what careers or other benefits may stem from studying the subject. Teachers need teaching approaches that may make learning of physics more interesting to the learners thus motivating them to learn the subject.

One such approach is Interactive Multimedia Simulation Advance Organisers (IMSAO). Andrews and Bell (2000) defines simulations as “attempts to represent, mimic, or replicate real world stimuli, cues, responses, and interactions”. The use of simulation in the teaching of physics may enhance understanding of even the difficult and abstract concepts. Steinberg (2000) contends that one major way to promote learning is with computer simulations of physical phenomena. The simulations, if designed appropriately, can serve several purposes: to help students extend their experience with hands-on experiments and collect additional data; to make models explicit and help students collect model-based evidence; and to provide multiple representations of the same or related concepts. Simulations allow students to make connections with everyday life experiences hence promoting deep learning and allowing students to observe processes that are otherwise unobservable. This may leads to improved achievement and motivation to learn physics.

An advance organizer on the other hand is a statement, activity, video, computer animation, or a graphic that help the learner anticipate and organize new information (Ausubel, 1978). This is used at the beginning of a lesson in which new information is to be learned. An advance organizer often uses learner’s prior knowledge, so as to connect new learning to an existing cognitive structure and indicate to the learner what information from a lesson will be important. Advance organizers may therefore foster meaningful learning of physics and motivate students to learn the subject.

Interactive Multimedia Simulation Advance Organizers prepared for use in teaching activities may create a teaching atmosphere like laboratories where students are active (Perkins *et al.*, 2006). A variety of visual representations of physics concepts in the Interactive Multimedia

Simulation Advance Organizers could make abstract and invisible physics concepts visible to students (Finkelstein *et al*., 2005). Jones (1988) contends that proper integration and use of interactive multimedia simulations in education may smoothen the path to instructional enlightenment because it can, among other things, provide effective communication, clarify concepts, and enhance teaching and learning via the natural multisensory and intuitive approach. According to Jaakkola *et al*. (2011) the use of interactive multimedia computer simulations have a special role in physics education because they can support powerful modelling environments involving physics concepts and processes. Interactive simulations give an opportunity to the learners to adjust each of the parameters involved in the phenomenon depicted and improve students' comprehension of physical phenomena, especially of the most abstract ones.

Educational research has demonstrated that students learn much more effectively when they are active and in control of the learning process (Wieman, & Perkins, 2006; Wieman, 2007*;* McKagan *et al.*, 2009) Interactive Multimedia Simulation Advance Organizers can be immensely valuable tool when it comes to bridging the gap between teaching and the students' conceptual understanding of physics concepts (Gokhale, 1996; Tarekegn, 2009). The approach may make students active participants in the learning process. Simulations in physics can also be effective means of stimulating curiosity in students. Having simulations that students can use to explore a phenomenon on their own can produce more effective learning experiences (Christian & Belloni, 2001). Simulation offers idealized, dynamic, and visual representations of physical phenomena and experiments, which would be dangerous, costly or otherwise not feasible in a school laboratory. The use of simulation has the potential of relieving students from laborious manual processes, both expediting work production and enabling teachers and learners to focus on most important or salient issues without distraction (Osborne & Hennessy, 2003). Simulation use is considered to support physics learning through encouraging students to pose and investigate exploratory questions and yielding less 'messy' data (Baggott & Nichol, 1998). The students are offered an opportunity to manipulate experimental variables at their own pace and in a self-correcting way without the worry of making mistakes.

Motivation influences how and why people learn as well as how they perform (Pintrich & Schunk, 1996). Motivation can be either intrinsic or extrinsic. Intrinsic motivation is defined as the doing of an activity for its inherent satisfactions rather than for some separable consequence. When intrinsically motivated, a person is moved to act for the fun or challenge entailed rather than because of external rewards. Extrinsic motivation on the other hand is a construct that pertains whenever an activity is done in order to attain some separable outcome. According to Hendrickson (1997) Motivation is the best predictor of student achievement in the learning process. Unfortunately one of the reasons why the students are low motivated to study physics subject is the poor understanding of the basics of this subject in the first place. One of the ways to overcome this problem is to increase the student motivation to learn (Kalganova, 2001). Interactive Multimedia Simulations Advance Organisers (IMSAO) may be used to increase the learners' intrinsic motivation to learn physics. According to Csikszentmihalyi and Nakamura (1989) individual learners who are intrinsically motivated to learn a cognitive content holistically engage in the learning activities, remain highly focused throughout the activity and follow clearly defined goals. Interactive Multimedia Simulations Advance Organisers approach may offer students an opportunity to access the teaching and learning material at any time.

This study aimed to investigate the effects of using IMSAO teaching approach on students' achievement and motivation to learn the physics topic Measurement in Kenyan secondary schools. According to KNEC (2010, 2012, 2016), this has been one of the poorly done areas in KCSE. The students are unable to take measurements using Vernier callipers and micrometre screw gauge and to comprehend other related concepts in the topic such as zero errors and the least count. The KNEC (2016) report indicated that most students were unable to take cognizance of the concepts in a Vernier callipers and could not, by use of an illustration, locate the Vernier scale to show a reading of 3.14 cm. Measurement is a foundational topic that is required in all other physics topics and in carrying out physics practical which constitute 40% of the total KCSE physics score in national examination. The significance of Measurement topic is also underlined by its application in all real life situations.

1.2 Statement of the Problem

Physics subject is fundamental for technological growth of any society. The significance of physics to society is underscored by massive dependence on technology. Technologies that are changing the world today are a direct result of physics inventions. Despite its importance, the achievement and motivation to learn physics in Kenya Certificate of Secondary Education (KCSE) has been low over the years. Moreover, girls' achievement and motivation to learn physics has been lower than that of boys'. The low achievement and motivation to learn physics nationally has been replicated in Nyahururu sub-county of Laikipia. One among other factors attributed to the low physics achievement and low motivation to learn physics is the poor teaching approaches employed by the teachers. There is therefore need to apply some innovative teaching approaches which would lead to improved physics achievement and motivate learners to do physics. Interactive Multimedia Simulation Advance Organizers (IMSAO) is one of the approaches that may enhance students' achievement and motivation to learn physics. This is an approach that uniquely combines both interactive multimedia simulations and advance organisers in the teaching process. However, its effects in teaching the physics topic Measurement had not been investigated. This study aimed at filling the gap of knowledge by applying IMSAO approach in teaching the physics topic Measurement to form two students in Nyahururu Sub-County in Laikipia. Its effect on the achievement and motivation to learn physics in comparison to the use of Conventional Teaching Methods (CTM) was determined. The study also investigated the achievement and motivation to learn physics between boys and girls when exposed to IMSAO.

1.3 Purpose of the Study

The purpose of this study was to investigate the effects of Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach on students' achievement and motivation to learn the topic Measurement in form two physics syllabus.

1.4 Objectives of the Study

The study was guided by the following objectives:

i. To compare achievement in Physics between the students exposed to IMSAO teaching approach and those exposed to Conventional Teaching Methods (CTM).
ii. To compare motivation to learn Physics between students exposed to IMSAO teaching approach and those exposed to CTM.
iii. To compare achievement in physics of boys and girls when exposed to IMSAO teaching approach.
iv. To compare motivation to learn physics of boys and girls when exposed to IMSAO teaching approach.

1.5 Hypotheses of the Study

To achieve the objectives of the study, the following null hypotheses were tested:

Ho1: There is no statistically significant difference in achievement in Physics between students exposed to IMSAO teaching approach and those exposed to CTM.

Ho2: There is no statistically significant difference in motivation to learn physics between students exposed IMSAO teaching approach and those exposed to CTM.

Ho3: There is no statistically significant difference in achievement in physics between boys and girls exposed to IMSAO teaching approach.

Ho4: There is no statistically significant difference in motivation to learn physics between boys and girls exposed to IMSAO teaching approach.

1.6 Significance of the Study

The findings of this study may help the Ministry of Education, Curriculum developers, Universities and teacher training institutions in coming up with instructional materials and curriculum that will make the teaching of physics concepts easier and interesting to the students. Such materials may benefit the learners by enhancing their understanding of physics terms and concepts which have otherwise appeared abstract to them. Dynamic representations through simulations and advance organisers could enable more efficient communication of complex concepts and acts as cognitive props, alleviating the need for students to formulate their own misconceptions. This may in turn translate into improved achievement in physics and greater motivation to do physics.

The findings may also greatly help physics teachers by making them relevant in the 21st century by aligning their teaching in line with the IMSAO teaching approach. The use of IMSAO approach of teaching may help teachers integrate ICT in their teaching. This would enable them explain abstract physics concepts to the students easily and afford them time to concentrate on the weakness of individual students while the rest are engaged in interactive simulations. Faced with inadequate teaching resources and physical laboratory equipment, IMSAO approach may come in handy for the teacher in teaching abstract physics concepts while exposing the student to real laboratory apparatus virtually at minimal cost. The teacher training colleges and universities may greatly benefit from the findings, which may help them to train teachers with the effective skills, strategies and approaches to use when teaching scientific concepts. This will help in improving achievement in physics and also motivate learners to take physics at Certificate of Secondary Education (KCSE). The findings of the study will also help to close the gender gap in physics achievement at KCSE. This will ensure that both girls and boys perform well in physics, and are equally motivated to enrol and learn physics.

1.7 Scope of the Study

This study was carried out in secondary schools in Nyahururu Sub-County in Laikipia. The physics concept covered in this study was Measurement. This involved the study of the Measurement topic and mainly on the use of Vernier callipers and micrometre screw gauge in line with the Kenya Institute of Education (KIE, 2008) secondary school physics syllabus. This topic has been one of the poorly done areas in KCSE physics (KNEC 2010, 2012, 2016). This is despite its relevance in understanding other topics in secondary school physics syllabus and in carrying out physics practical, which constitute 40% of the scores in KCSE. Students are unable to take measurements using Vernier callipers and micro-meter screw gauge and to comprehend other related concepts in the topic. The effects of using Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach on students' achievement and motivation to learn Measurement topic in physics were determined.

1.8 Limitations of the Study

The study was limited to the topic measurement in secondary school physics syllabus as opposed to the whole secondary school physics syllabus. The results may therefore be limited in generalizing to all physics topics. However, this may not greatly affect the generalization of the IMSAO teaching approach on achievement and motivation to learn other physics topics since the instructional processes in all topics are similar.

The study was limited to form two Secondary school students in Nyahururu Sub-County in Laikipia. The result may therefore be limited in generalizing to other Secondary schools students in Kenya except for those with similar characteristics to the studied schools.

1.9 Assumptions of the Study

The researcher assumed that teachers in the experimental groups had the goodwill to cooperate in teaching using IMSAO while those in control groups would teach using Conventional Teaching Methods. This was affected by a thorough one-week training of the teachers in the experimental groups on the use of IMSAO that was followed by use of the same throughout the period of study.

Another assumption was that there were to be no disruptions of the schools programmes during the period of the study. This was not however the case and the researcher together with the teachers in experimental schools had to create time to make up for some disrupted lessons. In the control schools, learning went on as scheduled.

1.10 Definition of Terms

The following terms are operational in this study:

Achievement: This refers to successful finishing or gaining of something (Oxford Dictionary, 2010).In this study it referred to successful acquisition of physics knowledge and skills as reflected in the performance in a physics test. Further, the terms "achievement in physics" and "performance in physics" have been used interchangeably to mean the same thing.

Advance Organizer: This refers to any material that is introduced before an unfamiliar content to facilitate its assimilation. They, therefore, act as an anchor for the reception of new content (Ausubel, 1978). In this study, pictures, videos, charts and text handouts on Measurement were used as a bridge to help learners link between what they know about measurement and what will be learnt.

Boy: This refers to a male child or a young male person (Oxford Dictionary, 2010).In the study it referred to a male student in secondary school in Kenya. The term "male student" and "boy" have been used interchangeably in the study.

Conventional Teaching Methods (CTM): This refers to the commonly used teaching methods, which include lectures, discussion, demonstration, and class experiment. In this study, the phrase referred to all other teaching methods in which the teacher does not employ the multimedia simulations and advance organizer in his teaching and students remains passive and is not actively involved in the teaching-leaning process.

Gender: Gender refers to the socially constructed characteristics of women and men, such as norms, roles, and relationships of and between groups of women and men. In this study, it referred to the characteristics of boys and girls in secondary schools in Kenya

Gender Difference: Refers to differences between men and women in socio-cultural aspects rather than physical differences only (Oxford Dictionary, 2010). In this study, the difference between boys and girls physics achievement and their motivation to learn physics was considered.

Girl: Refers to a female child or young female person (Oxford Dictionary, 2010). In this study, it referred to a female student in secondary school in Kenya. The term "female student" and "girl" have been used interchangeably in the study.

Interactive Multimedia Simulations: This is a computer application that imitates a real scenario that responds to user multisensory inputs (Engelbart & Hooper 1988). In this study, it referred to a computer application models depicting a vernier caliper and a micrometre screw gauge, allowing students to manipulate input variables and view the results.

Interactive Multimedia Simulation Advance Organizers Approach (IMSAO): This refers to the approach of teaching which combines both interactive multimedia simulations and advance organizers in teaching the physics topic Measurement to form two students.

Measurement: This refers to the assignment of numerical value to a quantity or a trait. In this study, it referred to a topic in Kenya Secondary School Physics syllabus, which deals with the assignment of numerical values to physical quantities using various instruments such as Vernier callipers and micrometre screw gauge.

Motivation: refers to the acts, which involves a student's physically and cognitively urge to fulfil his needs, wants, or desires (Pintrich & Schunk, 1996). In this study, it referred to the intrinsic urge and interest to learn physics acquired by the learners when exposed to the interactive multimedia simulations advance organizers teaching approach.

Physics Achievement Test (PAT): This referred to a set of physics questions on the topic Measurement. In this study, it was used as a measure of students' understanding and achievement in physics.

Physics Motivation Questionnaire (PMQ): a set of questions that were used to assess the students' motivation to learn the topic measurement in physics. The questionnaire used six factors that influence motivation namely: self-efficacy, active learning strategies, physics learning value, social persuasion performance goal, achievement goal and teaching approach as adapted from motivation towards science learning questionnaire developed by Hsiao-Lin , Chi-Chin and Shyang-Horng (2005).

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter deals with the literature review on studies related to the present study. The literature reviewed includes the importance of physics globally, aims of teaching physics in Kenya, challenges faced in teaching physics, students' achievement in secondary schools physics, achievement of boys and girls in secondary schools physics, motivation to learn physics in secondary school , conventional teaching methods in physics, use of simulations in teaching and learning secondary schools physics, use of advance organisers in teaching and learning secondary schools physics, interactive multimedia simulations advance organizers approach in teaching and learning of secondary school physics, theoretical framework and finally the conceptual framework on which the study was based is discussed.

2.2 Importance of Physics Globally

The importance of Physics cannot be over emphasized as it forms the basis for technological advancement of any nation (Sani, 2012). The emergence of a highly competitive and integrated economy, rapid scientific and technological innovations, and a growing knowledge base will continue to have a profound impact on human lives. In order to meet the challenges posed by these changes, physics, together with the other science subjects, will provide a platform for developing scientific literacy and for building up essential scientific knowledge and skills for life-long learning in science and technology. Physics plays a vital role in the development of any society in many ways (Aliyu, 2011). Physics is used in electronics for developing transistors, diodes, and Integrated Circuit (ICs) which allow the development of radio transmitters and receivers, televisions, radios, tapes, compact disc players among others. Modern machines for health services like X-rays, Magnetic Resonance Imaging (MRI), Computerised Tomography (CT) scans, and ultrasound have been developed from the knowledge of Physics for use in taking images of the internal structure of patients. Solar energy has also been developed from the knowledge of physics and has been applied in storage and utilization of sun light for preservation and processing of food and generation of electricity. With physics innovations, technological advancement is poised to be realised in all spheres of life.

The knowledge of nuclear physics plays a role in the preparation and processing of fuel for utilization of nuclear power and development of nuclear weapons. Machinery developed from mechanics helps in the development of industries. Electricity and electronics developed from the knowledge of Physics is used for the development of telephones, optical cables, and internet that brings all parts of the world together. In transportation, cars, motorcycle, bicycle, ships, trains, as well as aeroplanes are all development from the knowledge of Physics. This is because they all use electric motors and principles of moments in their various parts. Computers and satellite were also developed from the Physics knowledge (Holbrook and Rannikmae, 1997). These devices are instrumental in human communication globally. Computer simulations are as a result of physics innovations. Science, particularly physics, has developed the ability to creatively utilize science knowledge in everyday life or in careers, to solve problems, make decisions and hence improve the quality of life.

Many of the technologies that are continually transforming the world can be directly traced back to important physics research. Research on the physics of semiconductors enabled the first transistor to be developed in 1947. This seemingly simple device is the key component in all of our electronic systems, including computers, and it is now considered one of the most important inventions in human history. The laws of optics describing the way light behaves have led to the development of the optical fibre networks that are beginning to crawl over the entire globe, drawing the world closer together (Khalija, 2004). According to Shaffer (1972), research activities in physics have increased the knowledge and understanding of matter. The application of such knowledge and understanding of physics has led to the creation of new tools that enable people to further probe the world. Moreover, the workplace and everyday living is becoming technological with the world becoming flooded with high-end technology products (Modini, 2011).

World over, physics as a branch of science has been identified as an important component of education. The changing social, economic, and technological circumstances, hopes and expectations of society in the modern times has put immense value in the study of science for which physics is part of. Such developments will require students who are well prepared to respond and contribute to those developments. Macedo (2006) identified four pillars that form the basis of learning science by students namely: learning to live together; learning to be; learning to do; and learning to know. These four pillars help educationists decide what should be included in scientific literacy for all.

The four pillars are:

i) Learning to live together

School science necessarily implies practical work of different sorts. For a number of reasons, both for managing the class and for good pedagogical reasons, students work in groups to carry out science investigations. When school science is taught and learnt appropriately, it should help to develop the way the students and future citizens act and how to live together sharing information and tackling challenges together. Learning to Live Together involves the development of social skills and values such as respect and concern for others, social and inter-personal skills and an appreciation of the diversity among people. These skills would enable individuals and societies to live in peace and harmony.

ii) Learning to be

Science itself has its own values and ways of being and school science ought to teach these values to students. Such values include calmness, self-control, modesty, tolerance among others. Such values will help to make the student reliable people in the society. Learning to be involves activities that promote holistic personal development (body, mind and spirit), for an all-round 'complete person.' These include cultivating one's self analytical and socials skills, creativity, personal discovery and an appreciation of the inherent value provided by these pursuits.

iii) Learning to do

Through science learning, students will learn to define, refine, and resolve problems and ideas. They will learn to do this through practical data gathering, collecting information from a range of sources, transforming that data to make broader generalizations, explaining their outcomes, and justifying their positions. The students start to realize the limits of their data and their arguments and how they might be developed further. Learning to do involves the acquisition of skills that would enable individuals to effectively participate in the global economy and society. These skills are often linked to occupational success, such as vocational and technical skills, apprenticeships, and leadership and management competencies. The students will learn new skills that will come in handy for tackling future challenges.

iv) Learning to know

Students will come to know basic concepts of science, how to use them to explain and understand the world around them, and how to change it. This is the sort of learning most closely related to current school science around the world. Learning to know involves the acquisition and development of knowledge and skills that are needed to function in the world. Examples of skills under this pillar of learning include literacy, numeracy, and critical thinking. However, the contexts for learning these concepts should relate to the lives and concerns of the students, rather than the arbitrary abstractions.

The four pillars highlight the need for individuals to "learn how to learn" and be able to cope with the rapid changes and challenges of the present and the future. It describes a holistic approach to learning that encompasses more than what occurs in the classroom. This is results to lifelong learning, a philosophy that involves the development of knowledge, skills, attitudes, and values throughout one's life (Macedo, 2006). Learning is seen not just as an intellectual process, but one that encompasses all aspects of an individual's life, including their role in the community, performance in the workplace, personal development, and physical well-being. The Interactive Multimedia simulations advance organisers teaching approach may help learners acquire the science process skills necessary for lifelong learning. The students may be able to make measurement in life situations, learn to work together and acquire knowledge and skills necessary in life.

Physics plays a crucial role in driving innovations and development of new technologies. Etienne (2003) outlines ways in which physics and physics-based businesses are contributing meaningfully to the society.

i. Physics inspires young people and expands the frontiers of their knowledge about nature.
ii. Physics generates fundamental knowledge needed for the future technological advances that will continue to drive the economic engines of the world.
iii. Physics contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries.
iv. Physics is an important element in the education of chemists, engineers, and computer scientists, as well as practitioners of the other physical and biomedical sciences.

v. Physics extends and enhances our understanding of other disciplines, such as the earth, agricultural, chemical, biological, and environmental sciences, plus astrophysics and cosmology – subjects of substantial importance to all peoples of the world.
vi. Physics improves our quality of life by providing the basic understanding necessary for developing new instrumentation and techniques.

The understanding of physics is typically required to pursue courses like Astronomy, Geology, chemistry, biology, and engineering amongst others. According to Udoh (2012) learning of physics offers the student an opportunity to think critically, reason analytically and acquire the spirit of enquiry. He asserted that physics is crucial for effective living in the modern age of science and technology. Given its application in industry and many other professions, it is necessary that every student is given an opportunity to acquire some of its concepts, principles, and skills. Notwithstanding the importance of this subject, it is widely recognized that the teaching and learning of physics has been fraught with challenges such as low achievement and enrolment both in secondary schools and tertiary institutions. Prominent among the causes for low enrolment of students in physics subject include: poor science and mathematics background of students, poorly equipped physics laboratories, inadequate motivation of teachers, poor remuneration, inappropriate teaching strategies employed by the teachers and insufficient number of qualified physics teachers (Jegede & Adedayo, 2013). IMSAO teaching approach may address the problem of inappropriate teaching strategies by making learning of physics interesting and enjoyable.

The contributions of Physics toward making the world worth living and boosting the prestige of several nations are too numerous to mention. In Kenya, the realization of vision 2030 is pegged on the exploitation of knowledge in science and technology for which physics is part of. Despite physics' immense contribution to the society, there has been continued low achievement and low enrolment in physics in Kenyan secondary schools (KNEC, 2013, 2016). The low achievement in physics could partly be attributed to traditional teaching approaches employed by the teachers (Kolawole, 2008). According to Fraser and Walberg (1995), suitable instructional approaches can be effective in promoting the development of logical thinking, as well as the development of some inquiry and problem-solving skills. For effective teaching and learning to occur, the teacher should therefore use an efficient approach of conveying the information to the learner. This study aimed to determine whether the use of IMSAO teaching approach would improve student achievement in physics and increase their motivation to learn physics.

2.3 Aims of Teaching Physics

The predominant aim of any physics curriculum is to provide physics-related learning experiences for students to develop scientific literacy, so that they can participate actively in the rapidly changing knowledge-based society, prepare for further studies or careers in fields related to physics, and become life-long learners in science and technology (Science Key Learning Area, 2014). The broad aims of the physics curriculum are therefore geared to enable the students to:

i) Develop interest and maintain a sense of wonder and curiosity about the physical world.
ii) Construct and apply knowledge of physics, and appreciate the relationship between physical science and other disciplines.
iii) Appreciate and understand the nature of science in physics-related contexts.
iv) Develop skills for making scientific inquiries.
v) Develop the ability to think scientifically, critically and creatively, and to solve problems individually or collaboratively in physics-related contexts.
vi) Understand the language of science and communicate ideas and views on physics-related issues.
vii) Make informed decisions and judgments on physics-related issues; and be aware of the social, ethical, economic, environmental, and technological implications of physics, and develop an attitude of responsible citizenship.

The Kenya secondary school physics curriculum is designed in line with the general objectives of education to offer varied experiences that may lead to an all-round mental, social, and moral development of the student (KIE, 2002). The syllabus portrays the nature of physics as body of knowledge about the physical environment, as a method of study and as a way of reasoning (Okere, 1996).The syllabus emphasizes both the understanding of the fundamental scientific concepts and principles and the experimental approach of investigation.

The following are the objectives for teaching physics in secondary schools in Kenya (K.I.E, 2002)

i) Help the learner to discover and understand the order of the physical environment.
ii) Make the learner aware of the effects of scientific knowledge in everyday life through application to the management and conservation of the environment.
iii) Enable the learner acquire knowledge and skills for solving problems
iv) Enable the learner to reason critically in any given situation.
v) Inculcate in learners a willingness to co-operate in using scientific knowledge to foster development in society.
vi) Prepare the learners for further studies or vocational training.

Okere (1996) has highlighted the following as the aims of teaching physics. Firstly, Physics is taught for promotion of public scientific knowledge about the physical world. SMASSE (2004) agrees with this view by indicating that physics enables the learners to make sense of their world by helping them restructure their ideas in useful ways. The learners should build coherent scientific perspective that they can relate with what they learn and to the world in which they live. The second aim for teaching physics is for sharpening of logical thinking amongst the youth. Schaffer (1972) notes that the study of physics allows objective thinking and the association of cause with effect to replace superstition and belief in magic. Teaching of physics helps foster and develop an individual with a scientific way of thinking (SMASSE, 2004). Thirdly, physics is taught for technological advancement since it is applicable in everyday situations; for promotion of scientific attitudes and for solving societal problems. The physics taught should be that which is relevant to societal needs (Okere, 1996).

The relevance of physics in technological and economic development of any society is therefore immense as clearly depicted from foregoing discussion. If technological development is to be realized and sustained, it is important that physics subject be given emphasis in schools to attract a large number of students who will take technologically oriented careers in future. Following low achievement of the subject at the KCSE level and the low students' candidature, this study investigated the use the Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach to find out its effects on the students' achievement and motivation to learn physics.

2.4 Challenges Faced in Teaching of Physics in Secondary Education

Despite its importance in technological development of any society, the teaching of physics in secondary Education has been faced by many challenges. Sani (2012) identified the following challenges:

i) Lack of competent physics teachers in the teaching profession

One of the greatest problems in teaching of physics in secondary schools is that of recruitment and retention of competent people into the teaching profession. Most secondary schools have a shortage of physics teachers. The future of any nation lies in the hand of effectively trained and professional teachers. However, teaching is considered as the last hope of the hopeless who fail to join other apparently lucrative professions (Aliyu, 2011). The people who eventually find themselves teaching physics are therefore largely incompetent and demotivated always seeking for greener pastures in other fields.

ii) Inadequate laboratory facilities in most secondary schools

Laboratories in most schools are not well equipped. Some have inadequate furniture and experimental apparatus required for physics teaching. A study done by Kapting'ei, Kimeli and Rutto (2014) also established that most schools in Kenya had comparatively smaller laboratories that could not accommodate a standard class of up to forty students. The situation has been made worse in Kenya because of the 100% transition of pupils from primary to secondary schools. Schools laboratories should be big enough to allow practical activities to be done by all students at the same time other than doing it in shifts in the case of smaller laboratories. Additionally, most schools lack competent laboratory technicians which makes the teachers' work very difficult for they have to juggle between teaching and setting up of the apparatus in case of a practical. In such cases, teachers are forced to assume the role of technicians, which compromises their effectiveness due to time constraints in balancing between teaching and being a technician. In the secondary schools that have laboratory technicians, it was established that more than half of the technicians were not trained in school's laboratory practice. Effective laboratory practice requires skills and professionalism that may not be achieved by untrained personnel. As such, the teaching of physics is compromised.

iii) Poor students' motivation to learn physics

Enrolment figures of most students in secondary schools are in socials sciences which surpass that of the students in physics and other core science courses. Physics subject attracts very few students. This may be attributed to the low motivation to learn physics. The poor motivation to learn physics results to poor understanding and grasp of practical concepts by learners. The goals of science education states that science and its processes should provide an opportunity for learners to develop thinking and process skills, which include deductive, logical, and hypothetical thinking. As such due to poor grasp and understanding of practical concepts by learners, these goals are hardly achieved.

iv) Lack of teaching aids

The use of teaching aids which is necessary for better assimilation of the physics concepts is also lacking in most of secondary schools (Aminu, 2006). Most schools lack sufficient laboratory resources. Physics laboratory is an indispensable facility in science education. If well equipped with the right kind of apparatus and chemicals, it should provide the best setting for teachers to assist students in acquiring scientific knowledge and skills. Inadequate laboratory resources therefore jeopardize physics practical instruction.

v) Lazy and uncommitted students

According to Wasagu (2005) students in contemporary generation are lazy or not serious in their studies. Due to physics rigorous mathematical component and seemingly abstract nature, students lack commitment and enthusiasm to undertake the physics tasks. Eventually, they opt out and select other subjects which appears less demanding to them.

vi) Lack of adequate and relevant textbooks

Physics textbooks used in secondary schools are inadequate and irrelevant to the local culture and some are beyond conception of the students. Inadequate textbooks and practical guides contributes to the ineffective teaching of physics since most students have no reference materials to refer to in supplementing what they have been taught in class. Effectiveness in Physics laboratory instruction requires that learners be provided with enough practical guides and textbooks. These resources give a wide range of practical activities together with detailed procedures to be followed hence boost practical instruction. The authors of physics textbooks should strive to draw examples and illustrations from the learners' experiences and the local culture to make the concepts appealing and relevant to the students. Some physics text books have illustrations that are not gender sensitive. Such books apparently portray physics as a male field by giving examples and illustrations that favour boys to girls.

vii) Lack of proper orientation to the students

There is no proper orientation given to the secondary school students on the career choice. Students are not well guided about the courses of choice that may require one to do physics. This makes the students who are good in physics to end up doing other unrelated courses.

Problems in teaching physics can be minimized by use of suitable teaching methods. If one learns physics concepts properly, one should be able to solve unseen problems. According to Anderson and Ronald (2007), scientific inquiry method implies involvement of students that leads to understanding. Furthermore, students' involvement in learning implies owning skills and attitudes that permit one to seek solutions to questions and issues while you construct new knowledge. "Inquiry" is defined as "a seeking for truth, information, or knowledge - seeking information by questioning." Student inquiry is defined as a versatile activity that involves making observations, posing questions, examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of the student's experimental evidence; using tools to gather, analyse and interpret data; proposing answers, explanation, and predictions; and communicating the results.

Nwosu (2004) postulated that physics teachers do not have the essential knowledge required for activity-based learning and as a result, the most predominant method of teaching has been the lecture method. According to Ajaja (2013), method adopted for teaching and learning science is one of the factors contributing to the low interest in science and hence expressed the need for a search for alternative instructional strategies that could stimulate students' interest and enhance their achievement. The use of various innovative teaching strategies is borne out of the fact that there are different topics to be taught and skills intended to be developed. Educators with a view to involving learners more in the teaching learning process have developed many innovative strategies. One such method is use of interactive multimedia simulation advance organizers teaching approach. This study determined its effects on achievement and motivation to learn physics in secondary schools.

2.5 Students' Physics Achievement in Secondary Education

According to the Programme for International Student Assessment (PISA, 2002), the performance of a country's students in science subjects have implications for the part that country will play in tomorrow's advanced technology sector, and for its general international competitiveness. This is because science plays a critical role in the socio-economic development of a country. Despite this critical role, the performance of students in science, particularly in physics, in Kenya's secondary schools has continued to be low for many years as reflected by the performance in national examinations (Musyoka, 2004).The Kenya

National Examination Council reports have indicated a trend of poor performance in physics in Kenya certificate of Secondary Education (KCSE) over a number of years as shown in Table 8.

Table 8:

Students' Overall Performance in KCSE Physics Examinations between Years 2003 and 2017

Year	Mean Score %
2003	34.06
2004	37.06
2005	35.99
2006	40.32
2007	41.32
2008	36.71
2009	31.31
2010	35.11
2011	36.64
2012	37.86
2013	40.82
2014	38.84
2015	43.68
2016	39.77
2017	35.05

Source: KNEC (2006, 2007, 2008, 2009, 2010 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018)

From Table 8, one can observe that the performance in Physics subject in KCSE has been below average over the fifteen-year period with the highest mean scores of 41.32% and 43.68% recorded in 2007 and 2015 respectively. This is much far below the average score of

50%. The average percentage means score over the 15 years' period is 37.64 which translates to a mean grade of D. The low performance in physics could be attributed to the poor instructional approaches employed by the teachers which make students demotivated to learn physics and ultimately performing poorly. This implies that very few students end up taking physics oriented course in tertiary institutions. There is need therefore for teachers to have a paradigm shift in their instructional approaches. The low performance in physics has been replicated in Nyahururu Sub-county in Laikipia where the physics mean grade points in KCSE at a scale of 1 to 12 has remained low as shown in the Table 9.

Table 9:

Comparative Performance and Enrolment of Physics and other Science Subjects in KCSE Examinations between Years 2015 and 2018 in Nyahururu Sub-County

	Physics		**Biology**		**Chemistry**	
Year	Enrolment	Mean Point	Enrolment	Mean Point	Enrolment	Mean Point
2015	645	4.12	2328	3.41	2665	3.17
2016	732	4.16	2686	2.89	3108	2.45
2017	829	4.47	2863	2.22	3380	2.79
2018	259	3.69	2777	2.70	3356	3.56

Source: Nyahururu Sub-County Education Report (2018)

Table 9 indicates low performance in all the science subjects in Nyahururu sub-county. The performance in physics is notably low when considering the enrolment in the subject which has been below 1000. It would be expected for the mean of physics to be far much higher than that of other science subjects due to the low number of students sitting for physics at KCSE. However, the means for physics across all the years is comparatively low. For instance, the mean for physics in year 2018 was 3.69 with an enrolment of 259 in comparison to chemistry mean of 3.56 with an enrolment of 3356 in the same year.

Kolawole (2008), argues that inappropriate teaching approaches employed by physics teachers in Kenyan secondary schools may be one of the contributing factors to poor performance in physics. Further, Wambugu and Changeiywo (2008) agree with this view and assert that the teaching approach that a teacher adopts may affect students' achievement. Therefore, using an appropriate teaching approach is critical to the successful teaching and learning of science. Most teaching approaches employed by teachers are predominantly teacher centred. To improve academic achievement, the teaching approaches adopted by a teacher should make learning more learner centred (Kiboss, 2000; Tanui 2003). This study aimed to employ the Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach and to determine its effect on achievement and motivation to learn physics in Nyahururu Sub-County in Laikipia.

2.6 Achievement of Boys and Girls in Secondary Schools Physics

The issue of unequal outcomes for men and women in math and science has been in the public domain for some time. Several researches have recognized differences in the academic achievement of boys and girls (Dwyer & Johnson, 1997; Entswisle *et al.,* 1997). In science, the gender gap in interest, involvement, and performance is well known and has been the subject of intense analysis. Internationally, it has been observed that boys show significant greater achievement in science (Gonzales *et al*., 2004; Martin, Mullis & Chrostowki, 2004). This may due to teaching approaches used which favour boys to girls. Observations of such differences have been strengthened by the view that boys are "naturally" better equipped to excel in science. Such stereotypes that men are naturally more talented and interested in science are thought to influence the science, technology and engineering aspirations and achievements of boys and girls, men and women (Revees & Budhani, 2002; Kiefer & Sekaqueptew, 2007). These stereotypes have had an effect on pursuit of science courses by both boys and girls. Girls feel science are dominated and meant for boys.

The Numbers on low female achievement in science is evident from the multicultural survey of science achievement carried out by International Evaluation of Educational Achievement (IEA). The gender difference always favoured males. In addition, boys outnumbered girls in the top 25% in science performance (Chang, 2008). In some countries, research has shown some decline in gender differences in science achievement but female representation in science related fields is still low (Jacobs, 2005).

Analysis of physics performance in the Kenya Certificate of Secondary Education (KCSE) carried out by the Institute of Policy, Research, and Analysis (IPRA) in 2003 revealed that at both national and provincial level, the averages of examination scores for boys were higher than those of girls. The study further revealed that in science subjects, the percentage of girls in physics in the four districts under study was 5% in Kiambu, 8% in Bungoma, 8.7% in Kisumu but 0% in Garissa where no single girl registered for physics (IPRA, 2003).

Globally, research on gender differences in academic achievement has been ongoing for decades. However, researchers have agreed on few of the findings. For example, it is widely acknowledged that, on average, females score higher than males on verbal ability tests (Hyde & Linn, 1988), and males score higher than females on tests of mathematics and spatial abilities (Hyde, Fennema, &Sherman, 1977; Hedges & Nowell, 1995). An additional agreed upon finding is that the physical sciences in high school, college, and the work force are dominated by males, with physics having the greatest under-representation of women (National Science Foundation, 2002).

Moreover, further research has overwhelmingly shown that there is indeed a gender difference in science learning, and women are still considered to be at a disadvantage (Ziegler, Finsterwald, & Grassinger, 2005). Numerous factors such as home and school type (Aldrige & Goldman, 2002), parental influence (Desimone, 1999), student personality (Paunonen & Ashton, 2001), and motivation (Skaalvik & Rankin, 1995) have all been cited to play significant roles in the problem. Low numbers of female physics teachers and professors (Neuschatz & McFarling, 2003), biased textbooks and instructional methods (AAUW, 1999), and stereotypical views of physics being a male domain (Schiebinger, 1999), have also been considered to be part of the problem. These factors have also affected the girls' performance of physics in Kenya

Due to the societal gender stereotyping which parents, and the type of schools students attend often unknowingly reinforce, boys tend to have more experiences with science related toys that encourage skills such as construction and manipulation than do girls (Aldridge & Goldman, 2002; Blakemore & Centers, 2005). This trend continues through adolescence, when the typical interests of boys include sports and computer games, which require attention to numerical information and builds the knowledge base, while many adolescent females are reportedly more concerned with peer relationships and personal appearance (Kimball, 1989).

The influence of parents, teachers, school type, peers, and society all appear to have a large effect on how girls view their science ability and potential (Walberg, 1981). Both male and female teachers have a negative attitude towards girls' abilities to perform well in mathematics and science. Teachers cite girls' fear of the subjects, lower determination, and lower intelligence when compared to boys. Teachers interact differently with boys and girls in science classes with some evidence suggesting that students benefit academically from having teachers who are of the same gender as themselves (Dee, 2007). In addition, schools, teachers, and the curriculum encourage girls to adopt passive and dependent behaviour while boys adopt aggressive and independent behaviour.

The differential treatment of boys and girls also affects performance. Beginning at infancy, girls' home environment is often very different from that of boys. Little girls play with dolls, stuffed animals, and domestic utensils, and tend to perform activities more related to fine motor skills such as drawing and sewing (Blakemore & Centers, 2005). In addition, girls are often discouraged from exploring on their own and are sometimes protected more than boys by parents from taking many risks. Boys, however, tend to play more with sports related toys, vehicles, tools, and building blocks, and are encouraged to take things apart and put them back together again, explore, and discover (Aldridge & Goldman, 2002; Jones, Howe, & Rua, 2000). Such play provides them with early opportunities to develop basic math and science skills, giving them what many see as an advantage toward learning science even before starting school.

However, various researches reports that girls perform as well, if not better than boys in science up until adolescence, when gender differences in science attitude, interest, and achievement begin to occur (Connolly, Hatchette, & McMaster, 1999). This gap in achievement continues to increase each year as students' progress through school, and by high school, females enrol in fewer science related electives, participate in fewer science based activities, have more negative attitudes toward science, and have lower science achievement scores (Kahle & Lakes, 1983; Oakes, 1990). Nevertheless, with serious intervention and application of modern teaching methods and techniques, it is possible to bridge the gap in gender disparity in physics achievement. Such interventions have been successful in UK where gender disparity in science subjects no longer exists (Boaler *et al*., 2015). For example, in England, Wales and Northern Ireland, girls and boys achieve at the same or similar levels in mathematics and science in General Certificate of Secondary Education (GCSE). Table 10 shows performance patterns at GCSE for mathematics and different sciences by gender for the three countries in 2009.

Table10:
Achievement of A-C Grades in GCSE by Gender, in England, Wales & Northern Ireland in 2009

	England		Wales		North Ireland	
Subject	**Girls (%)**	**Boys (%)**	**Girls (%)**	**Boys (%)**	**Girls (%)**	**Boys (%)**
Maths	57.0	57.6	53.2	54.7	59.0	65.3
Physics	93.1	93.2	92.5	93.4	93.1	90.3
Chemistry	94.3	93.7	92.6	92.2	91.6	93.7
Biology	90.9	92.8	92.2	92.8	90.2	90.8

Source: Joint Council for Qualifications (JCQ) 2009_National Provisional GCSE (Full Course) Results.

From Table 10, it can be deduced that the percentage of girls attaining quality grade is similar to that of boys in all the subjects across the three countries. In Ireland, girls outperformed boys in attainment of the quality grades. The equal achievement of girls and boys in the mathematics and sciences in the three countries has continued with some consistency. This is extremely positive, particularly given the widespread public perception, fuelled by media reports that males achieve at higher levels in mathematics and science than females (Boaler *et al*., 2015).

In Kenya, Aduda (2003) noted that physics achievement and enrolment by girls has remained low when compared to that of boys. A study carried out in Kenya by Barasa *et al.* (2015) revealed that boys performed better than girls in the physics achievement tests. Factors that were found to be significant in contributing to physics achievement included instructional methods, the school type, career expectations, love for physics and student gender. Factors that were not significant in influencing students' achievement in physics were physical ability, teachers' gender, and domestic duties. The findings of their study indicated that secondary school students perceive that students' gender has influence on their achievement in physics. The results however showed that the gender of the teacher may not be important in influencing academic achievement. The researchers recommended schools to encourage girls towards performing better in physics and work hard in promoting factors that promote achievement in physics. The achievement of girls in physics at KCSE has also been low. Table 11 shows the performance of candidates by gender in KCSE physics between 2011 and 2017.

Table 11:
Candidates Performance by Gender in KCSE Physics Examinations in Years 2011 to 2017

	Physics % mean		
Year	**All**	**Male**	**Female**
2011	36.64	37.42	34.55
2012	37.87	38.48	36.22
2013	40.82	41.10	38.19
2014	38.84	39.06	38.29
2015	43.68	44.00	42.99
2016	39.77	39.41	40.63
2017	35.05	35.30	34.48

Source: KNEC (2014, 2015, 2016, 2017)

It can be observed from Table 11 that the performance of girls in physics in KCSE is lower than that of boys save for the year 2016 when girls performance in physics was slightly higher than that of boys. In spite of the number of girls enrolled in physics being less, their mean achievement in physics has remained lower than that of boys. This could be due to poor instructional methods in physics which seems to favour boys. The same trend is replicated in Nyahururu sub-county of Laikipia where boys have been recorded to outperform girls as shown in Table 12.

Table 12:
Nyahururu Sub-County Performance by Gender in KCSE Physics Examinations in Years 2015 to 2018

KCSE Physics Mean Points			
Year	**All**	**Male**	**Female**
2015	4.12	4.13	4.11
2016	4.16	4.21	4.11
2017	4.47	4.52	4.43
2018	3.69	3.84	3.54

Source: Nyahururu Sub-County Education Report (2018)

Table 12 indicates better physics mean points for boys at KCSE as compared to girls. The Nyahururu Sub-County statistics in physics performance are similar to the national statistics where girls have continually been observed to lag behind in physics achievement. Being taught under the same conditions and environment, the causes of the differences in physics achievement between boys and girls may be attributed to the low motivation to learn physics which may stem from use of conventional teaching method that are not gender sensitive.

Despite equal education opportunities, there is growing evidence since 1990's that boys have continued to perform better than girls in physics (Elimu, 2007). However, there is no evidence to suggest that girls and boys have any significant inherent differences in ability (Bennett, 2003). According to Akweya, Twoli and Waweru (2015), girls can be 'delicate' and a 'small' attribute can lift or derail a girl from studying physics. That is why teachers of physics have to go an extra mile in preparation, instruction, and assessment in school physics in order to attract girls to the subject. The poor performance by girls in physics could be attributed to poor teaching approaches employed by the teachers. The researcher studied the use the Interactive Multimedia Simulation Advance Organizers teaching approach and determined its effects on physics achievement between boys and girls, in Co-educational Day public secondary schools in Nyahururu Sub-County in Laikipia with an aim of finding whether the use of IMSAO could close the gender gap in regard to physics achievement.

2.7 Motivation to Learn Physics

Motivation is an internal state that arouses, directs, and sustains students' behaviour. The study of motivation by science education researchers attempts to explain why students strive for particular goals when learning science, how intensively they strive, how long they strive, and what feelings and emotions characterise them in this process (Zusho & Pintrinch ,2003). According to Brophy (1988), motivation to learn is a student tendency to find academic activities meaningful and worthwhile and to try to derive the intended academic benefits from them. Motivation therefore influences how and why people learn as well as how they perform in a given subject (Pintrich & Schunk, 199 mo6).

Motivation can be either intrinsic or extrinsic. Intrinsic and extrinsic types of motivation have been widely studied, and the distinction between them has shed important light on both developmental and educational practices. Intrinsic motivation is defined as the doing of an activity for its inherent satisfactions rather than for some separable consequence. When intrinsically motivated, a person is moved to act for the fun or challenge entailed rather than because of external rewards. Extrinsic motivation on the other hand is a construct that pertains whenever an activity is done in order to attain some separable outcome. Extrinsic motivation thus contrasts with intrinsic motivation, which refers to doing an activity simply for the enjoyment of the activity itself, rather than its instrumental value (Richard& Edward, 2000).

Csikszentmihalyi and Nakamura (1989) have observed that, for the individuals learners who are intrinsically motivated to learn a cognitive content, it is typical that: they holistically engage in activities (mentally, physically); they remain highly focused throughout the activity; they follow clearly defined goals; they remain self-critical and realistically reflect on their own actions; are not afraid to fail; when learning or during learning activities they are relaxed. Research studies by Stipek (1998), also show that such students: independently start their learning; choose to do tasks or parts of tasks they find challenging; spontaneously integrate the knowledge acquired in school with their experiences gained outside school; ask questions and broaden their knowledge; complete additional tasks; persevere to complete the tasks they have undertaken; learn regardless of the presence of external enticements for example marks, or teacher's supervision; and take pride in their work.

Learning is a complex mental phenomenon in which motivation is one of the key variables. This hypothesis has been widely accepted by different schools of thought, such as Schiefele and Rheinberg (1997). These scholars have linked motivation, learning, and learning processes with academic results. Academic achievement is therefore affected by the level of motivation in a subject. Boekaerts (2001), one of the leading experts in the psychology of learning, sees motivation, together with cognition, as a key component in the learning process and concludes that the two, are inseparable and necessary in the quest to understand learners' behaviour. The cognitive component includes knowledge, skills, and abilities. Pintrich and Schrauben (1992) seem to share the same views in their socio-cognitive model of learning motivation. According to the model, the individual's participation in the learning process is conditioned by the interaction of motivational and cognitive elements. The motivational elements include learning self-concept, control, learning goals, interest in learning and importance assigned to knowledge.

Among cognitive elements, they list knowledge and learning, and general strategies of thinking. They point out, however, that both kinds of elements are influenced by the nature of learning tasks and by the teaching methods. According to Pintrich and Schunk (1996) students will actively engage in the learning tasks they perceive valuable and meaningful. When learning is not perceived as valuable and meaningful, students just resort to memorisation (Glasersfeld, 1989). Research on motivational theories and studies of students' learning reveals that self-efficacy, the individual's learning goal, the achievement goal, the students learning strategies, science learning value (or task values), and the teaching approach are important motivational factors that constitute students' motivation in learning science (Hsiao-Lin , Chi-Chin & Shyang-Horng, 2005).

The low enrolment in physics at the Kenya Certificate of secondary Education (KNEC, 2010) is an indicator that most students are not motivated to learn physics and lack self-efficacy. Given the low motivation to learn physics, the problem of attracting students to physics remains quite pressing (Hadzigeorgiou, 2016). One popular answer to the question regarding how to attract students to physics is by making physics relevant to the lives of students and also by making physics interesting. Indeed, over the past two decades, there have been proposals which aimed at making science education both personally and socially relevant to the lives of students (Aikenhead, 2003). To improve on students' motivation to learn physics the educators must move away from the conventional methods of instruction and towards students' engaging lessons. Alternative methods of instruction should be used to increase students' motivation to learn physics (Mualem & Eylon; 2009). Mualem and Eylon research highlighted the importance of visualization in improving student understanding of physical concepts. According to them experimentation and computer simulations are two important ways of delivering visual representations to students that traditional chalkboard work cannot match. Computer simulations affect students' overall perception of physics.

Improved visual context works to improve a student's confidence as they overcome their preconceptions of concepts and make sense of phenomena on their own terms, (Saglam & Millar; 2006). From the foregoing discussion, it is evident that the teaching approach used by the teacher can influence the level of motivation to learn and perform well in a given subject. One way the teacher can employ to increase the student's motivation in learning of physics is by making physics learning enjoyable and interesting. Interactive Multimedia Simulations Advance organizers cmay be an immensely valuable tool when it comes to bridging the gap between teaching and the students' conceptual understanding of physics concepts. Simulations may act as an effective means of stimulating curiosity in students to learn physics. The combination of interactive multimedia simulations and advance organisers in the teaching of physics could probably motivate and attract high enrolment in Physics subject at secondary school level.

In this study, a physics Motivation Questionnaire (PMQ) based on the six factors of motivation namely: self-efficacy, active learning strategies, physics learning value, social persuasion performance goal, achievement goal and teaching approach, as adapted from motivation towards science learning questionnaire developed by Hsiao-Lin , Chi-Chin and Shyang-Horng (2005) was used.

i. *Self-efficacy*. Students believe in their own ability to perform well in physics learning tasks.
ii. *Active learning strategies*. Students take an active role in using a variety of strategies to construct new knowledge based on their previous understanding.
iii. *Physics learning value*. The value of physics learning is to let students acquire problem-solving competency, experience the inquiry activity, stimulate their own thinking, and find the relevance of physics with daily life. If they can perceive these important values, they will be motivated to learn physics.

iv. *Social Persuasion Performance goal*. The student's goals in physics learning are to compete with other students and get attention from the teacher.

v. *Achievement goal*. Students feel satisfaction as they increase their competence and achievement during physics learning.

vi. *Teaching Approach*. In the class, the learning environment, teachers' teaching approach, and students' interaction influence students' motivation in physics learning.

This study investigated the effects of using Interactive Multimedia Simulation Advance Organizers on students' motivation to learn secondary school physics in Nyahururu Sub-County in Laikipia, based on the six factors of motivation to learn science.

2.8 Boys' and Girls' motivation to learn Secondary Schools Physics

Previous studies done on of students' motivation and attitudes towards physics reveals wide gender differences in motivation and attitudes towards physics. From the studies, male students have positive attitudes and high motivation to learn physics as compared to female students (Koballa, & Glynn, 2007). This gender disparity in motivation to learn physics could nowadays occur due to multiple reasons such as the current curriculum (where the visibility of female scientists is low) or because of societal stereotypes towards students and career choices in physics fields (Osborne *et al.*, 2010). The issue of societal stereotypes appears clearly in several research in which gender differences exist because of the prophecies or labelling that ultimately end up happening.

In many African countries, the number of women enrolled in science-based training and those involved in science- based professions are among the lowest in the world. Males continue to surpass females in the number of undergraduate degrees conferred in science and engineering fields especially in computer science, physical science and engineering (National Science Foundation, 2005). According to UNESCO report (2008) the share of females enrolled in science was below 20% in Botswana, Gambia, Guinea, and Nigeria. The proportion in engineering was below 10% in Ghana and Swaziland. It has also been observed that effective instruction has the potential to improve girls' attitudes and to increase their motivation to learn physics.

The problem of low enrolment of girls in physics has been observed and studied globally for a long time. Tillery (2007) identified four senses in which science, for which physics is part of, could be considered to be masculine. First, the majority of those who choose to study it are male, so that it is seen as a predominantly male area of academic activity. Secondly, physics mode of instruction suits more the interest and motivation of boys. Third, behaviour in science classes are such that boys and girls act out characteristic gender roles. On his fourth point, he suggested that because it has been socially constructed in a parochial male-dominated society, science is itself inherently masculine. However, according to him, the suggestions do not rule out that female are competent in studying science for milestone scientific works have been achieved by females like Madame Mary Curie and Florence Bacon in the history of science.

Further, Mwangi, Chiuri and Mungai (2001) have stress out that it is easier to shape girls' interest, behaviour, attitude and curiosity towards science at an early age and sustain the same to adulthood which can result to competitively equal number of girls in physics enrolment to boys. The factors of motivation of students, learners' ability, and teacher characteristics have been found to affect enrolment of girls in physics. Despite intervention measures by the Ministry of Education in Kenya to alleviate girls' polarization in enrolment and achievement in physics, the Ministry of Education Science and Technology (MOEST, 2001) module report upholds that there are negative influences in the teaching and learning of physics in secondary schools which make girls shy away from doing physics.

The Kenya National Examination Council examination reports (2013, 2014, and 2015) further attests to this. In the year 2015 KCSE results, for example, out of the total 242,933 girls who sat for KCSE, only 39,606 opted for physics. This constituted less than 20% of all girls who sat for KCSE that year. In the same year, 99,494 boys sat for physics out of the total boys' population of 278,638 that translated to 36% of the total boys' candidature. The low enrolment of girls in physics may be attributed to their low motivation to learn physics.

Hidi (1990) asserts that gender differences in motivation towards physics subject occur over a long period. He further pointed out that the long-term effects on gender differences on motivation to learn physics can take place because of factors in the learning environment. Schraw and Lehman (2001) underlined that motivation of girls towards physics learning can be increased by the partial effect of teaching them in a conducive learning environment and using the right approaches. Therefore, by using various innovative methods and techniques in physics teaching, both boys' and girls' motivation levels can be improved. It is in this regard that the researcher investigated the effect of Interactive Multimedia Simulation Advance Organizers teaching approach on motivation to learn physics between boys and girls exposed to the approach.

2.8.1 Self-Determination Theory of Motivation

Self-Determination theory was developed by Deci and Ryan and concerns itself with human motivation, personality, and optimal functioning of human beings. Self-determination theory focuses not only on the amount of motivation, but on different types of motivation (Deci & Ryan 2008). According to self-determination theory, people have three innate psychological needs, which are considered as universal necessities:

a) *The need for competence*. This means the desire to control and master the environment and outcome. People want to know how things would turn out and the results or consequences of their actions.
b) *The need for relatedness*. This involves the desire to "interact with, be connected to, and experience caring for other people". People's actions and activities involve other people and through this, people seek the feeling of belongingness.
c) *The need for autonomy*. This concern with the urge in people to be casual agents and to act in harmony with their integrated self. However, to be autonomous does not mean to be independent. It means having a sense of free will when doing something or acting out of own interests and values

Self-determination theory also differentiates between different types of motivation which are autonomous and controlled (Deci & Vansteenkiste, 2004). Autonomous motivation is concerned with intrinsic motivation and types of extrinsic motivation in which people integrated a value of an activity into their sense of self. When people are autonomously motivated, they gain self-support and self-advocacy through their own actions (Koestner, *et al.*, 2008). Controlled motivation on the other hand deals with both external (extrinsic) and introjected regulation. In external regulation, an individual's actions are "a function of external contingencies of reward or punishment". In introjected regulation, the rule of behaviour is somehow incorporated within one's self and is encouraged by various factors (approval motive, ego-involvements). Deci and Ryan (2008) stated that when people are controlled, they act, think, and feel in certain ways. The concepts of intrinsic motivation and extrinsic motivation could be important in the dimension of students' interest to learn physics. Previous studies specified that intrinsic motivation refers to the fact of doing an activity for itself, and the pleasure and the satisfaction derived from participation. On the other hand, extrinsic motivation pertains to a wide variety of behaviours which people are engaged in as a means to an end, not for their own sake. Although students' interest in a subject are more related to intrinsic motivation, there are researches in which motivation for studying physics comes from courses which are relevant to and provide a good preparation for future careers (Kember, 2000).

Self-determination and relevance to personal goals are part of the self-determination continuum. Ryan and Deci (2008) referred to self-determination as a student's freedom to have some choice and control of their learning. The goal setting theory is believed to be consistent with the cognitive revolution which emphasized the significant relationship between goals and performance (Lunenberg, 2011). The cognitive revolution proposed the basic contents of goal setting theory. Some of the striking categories include the following:

i. The more difficult the goal, the greater the achievement
ii. The more specific or explicit the goal, the more precisely performance is regulated
iii. Goals that are both specific and difficult lead to the highest performance
iv. High commitment to goals is attained when the individual is convinced that the goal is important and is attainable (or that, at least, progress can be made toward it).
v. Goals affect performance by affecting the direction of action, the degree of effort exerted, and the persistence of action over time.

When applied to the realm of education, Self-determination theory is concerned majorly with promoting in students an interest in learning, a valuing of education, and a confidence in their own capacities and attributes. These outcomes are manifestations of being intrinsically motivated and internalizing values and regulatory processes. Such motivation will result in high-quality learning and conceptual understanding, as well as enhanced personal growth and adjustment. In this study the use of IMSAO teaching approach was applied and its effects to intrinsically motivate students and arouse their interest in the learning of physics determined.

2.8.2 Self-efficacy Theory of Motivation

Theories of learning and motivation are essential in guiding the instructional process. Bandura's theory of self-efficacy is one of the theories that is particularly useful in the teaching process. Bandura (1997) suggests specific techniques that teachers can use to help students feel empowered to attempt new skills or challenging tasks. Instructors may find that some students are reluctant to take the risks associated with learning outdoor skills. Often, such students are afraid of unpleasant physical or social consequences of failure to perform the skill correctly. Self-efficacy theory provides a basis for helping such students succeed. Self-efficacy theory is grounded in understanding the relationship between one's beliefs and one's willingness to engage in behaviours necessary, to successfully accomplish a task.

As a social learning theory, self-efficacy theory not only offers a notably comprehensive understanding of the learning process, but also provides specific insights that teachers can use to guide students towards specific skills development. As a self-regulation theory, self-efficacy depends on the assumptions that motivated learners are more likely to succeed than less motivated learners and that goal setting is of primary importance when attempting to increase learning (Driscoll, 2005). Self-efficacy theory therefore addresses such notions by focusing on the learner's beliefs as a means of self-regulation.

The core of self-efficacy theory is about an individual's beliefs and actions. This is clear in Bandura's definition of the construct, "Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997). Self-efficacy is comprehensive in the fact that it addresses cognitive, affective, and behavioural processes of the learner. It attempts to explain the process that learners undergo as they confront new challenges by accounting for judgments, evaluations, and appraisals made by the learner.

According to Bandura, (1997) learners make assessments of the ability (skill) needed to confront a given challenge and they assess whether or not they possess the ability to meet the challenge within the given context successfully. Bandura refers to this as identifying "outcome expectancies" and "efficacy expectancies". In other words according to him one must believe that he possesses the skills (efficacy expectancies) and that he can successfully employ those skills (outcome expectancies). Merely knowing or possessing ability is insufficient. One must also maintain the belief that he or she can successfully execute the skill in a given situation. The learner's evaluation of his or her ability to meet the challenge successfully will influence the level of effort given to the task and the willingness to persist. The self-regulation of thought, motivation, control, and affective and physiological states are all components of efficacy beliefs (Bandura, 1997).

Self-efficacy has gained considerable popularity and one aspect that has likely contributed to the success of this theory is its intuitive appeal. Clearly, thoughts and beliefs influence ones behaviour. Bandura has explained this phenomenon and argued that by increasing a learner's self-efficacy, the learner will be more motivated, engaged, and successful. The ability to apply the theory depends on one's understanding of four sources of self-efficacy namely: enactive mastery experiences, vicarious experience, verbal persuasion, and physiological and affective states (Driscoll, 2005).

i. *Enactive mastery experiences*

These are also known as "performance accomplishments" and are psychological states through which a learner organizes his or her own set of beliefs regarding ability from a variety of sources. This is the most salient of four sources of self-efficacy because it provides a considerable amount of feedback for the learner. This source recognizes and identifies many of the components that lead to high levels of self-efficacy. Important aspects of this source include context specific beliefs about success, failure, and performance. It considers the relevance and importance of goals, selective self-monitoring, and recognizes that each learner brings his or her own background, self-concepts, self-knowledge, and personality to the learning experience.

Awareness of student's personality directs teachers to take steps toward knowing and understanding the learner. Past failure or success influences one's likelihood to believe that one will succeed or fail at a given task. Failures can undermine efficacious beliefs unless the teachers handle them correctly. The theory offers a variety of ways to overcome the negative influence of failures on self-efficacy. One way is to convince learners that they are succeeding. This will support "selective self-monitoring" which occurs when the learner's beliefs of personal self-efficacy are noticed and remembered over non-efficacious beliefs. Bandura (1997) however warns teachers not to confuse selective self-monitoring with lying to students about their progress; instead, the teacher should focus on reminding them of their successes. Providing appropriate attainment trajectories is another way to overcome the negative influence of failures by convincing learners of the difficulty of a task and providing realistic goals. This is an effort to communicate the importance of perseverance. Likewise, successes that come too easily are not beneficial because they create expectations of realizing results with ease, then, when trouble and difficulty arise, the learner is easily discouraged.

ii. *Vicarious Experiences*.

Modelling success is an effective means of promoting self-efficacy because people judge their abilities by comparing themselves to individuals that they believe are like themselves. Understanding this aspect of the phenomenon directs teachers to use the success of other participants to convince the learner of the possibility of success. Techniques to promote positive vicarious experiences include imagery, which more specifically, could include the use of visualization techniques or filming the learner enacting various steps of a desired skill and reviewing those, pointing out each specific success.

iii. *Verbal persuasion*

This simply constitutes verbal encouragement to the learner by the teacher or by the peers. This practice further supports efficacious beliefs. Saying to a learner, "good job" or "nice work" does not qualify as verbal persuasion. Instead, the teacher should give specific feedback and encouragement. Another important component of verbal persuasion is that the learner must perceive the provider of the encouragement to be a credible source. A final way to provide verbal persuasion is to remind the learner of previous success.

iv. *Physiological and affective states*.

If a learner is discouraged, frustrated, or dejected, then he or she will be distracted and less likely to succeed. The teacher can attempt to account for this by capitalizing on the novelty of the experience, remaining upbeat, and positive, using humour, and fondly remembering past success to physiologically and affectively hold and maintain the learners' interests and self-efficacy.

Self-efficacy theory guides instructional practice by explaining human behaviour related to motivation, self-regulation, success, and the accomplishment of tasks. Teachers are encouraged to focus on task-specific and sequential student achievements, in hopes of generalizing from mastery of specific tasks to broader and more complex outcomes. Such outcomes may be specific to a particular topics taught but teachers may also be interested in the transfer of learning into actions that are useful in the daily lives of participants. Self-efficacy researchers have actively pursued the notion of self-efficacy generalizing from a specific task to a broader and complex set of outcomes. Wise (1999) conducted a study that provides a good example of how task-specific self-efficacy can transfer to similar tasks. Wise findings demonstrated that educators could teach skills in ways that facilitate transfer of the skills to new contexts. It is important to remember, however, that the foundation for generalized self-efficacy was the performance accomplishments that occurred during individual learning encounters involving the teacher and the student. In the absence of successful performance accomplishments during these individual lessons and encounters, positive efficacy and outcome expectations may not have occurred and may not have generalized to the new setting. Given successful performance accomplishments, long-term results may naturally follow from repeated short-term successes. Such results could be enhanced through specific verbal messages aimed at generalizing self-efficacy. Essentially, effectiveness of self-efficacy lies in the collection of successful, individual lessons and the ability of the teacher to frame such encounters in ways that lead to efficacious, transferable beliefs of learners.

Self-efficacy defines the people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think and behave (Bandura, 1994).A strong sense of efficacy enhances human accomplishment and personal well-being in many ways. People with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided. Such an efficacious outlook fosters intrinsic interest and deep engrossment in activities. They set themselves challenging goals and maintain strong commitment to them. They heighten and sustain their efforts in the face of failure. They quickly recover their sense of efficacy after failures or setbacks. They attribute failure to insufficient effort or deficient knowledge and skills which are acquirable. They approach threatening situations with assurance that they can exercise control over them. Such an efficacious outlook produces personal accomplishments, reduces stress, and lowers vulnerability to depression. In contrast, people who doubt their capabilities shy away from difficult tasks which they view as personal threats.

Self-efficacy beliefs have also been found to influence academic motivation. There is evidence (Bandura, 1997) that self-efficacious students participate more readily, work harder, persist longer, and have fewer adverse emotional reactions when they encounter difficulties than do those who doubt their capabilities. Self-efficacy beliefs also provide students with a sense of agency to motivate their learning through use of such self-regulatory processes as goal setting, self-monitoring, self-evaluation, and strategy use. For example, there is evidence (Zimmerman, Bandura, & Martinez-Pons, 1992) that the more capable students judge themselves to be, the more challenging the goals they embrace. The greater motivation and self-regulation of learning of self-efficacious students produces higher academic achievement according to Multon, Brown, and Lent (1991).

Schunk (1989) discussed how self-efficacy might operate during academic learning. At the start of an activity, students differ in their beliefs about their capabilities to acquire knowledge, perform skills, master the material, and so forth. Initial self-efficacy varies as a function of aptitude (abilities and attitudes) and prior experience. Such personal factors as goal setting and information processing, along with situational factors (like rewards and teacher feedback), affect students while they are working. From these factors students derive cues signalling how well they are learning, which they use to assess efficacy for further learning. Self-efficacy theory is therefore useful in guiding educational design and instructional practice because it offers several specific explanations of how our beliefs about our ability to accomplish a task influence the effort we expend and ultimately our level of success. In order to apply self-efficacy theory to instructional design and teaching skills, one should first identify the specific desired outcomes and then consider how to instil the beliefs within students that they can accomplish these outcomes. In the case of teaching practical skills, instructors should provide a clear and realistic picture of desired outcomes by assisting each student to gain an understanding of how to set goals for her or his own individual success. With realistic, individualized goals established, the teacher can then support skill acquisition by utilizing Bandura’s four sources of self-efficacy. Motivation is enhanced when students perceive they are making progress in learning. In turn, as students work on tasks and become more skilful, they maintain a sense of self-efficacy for performing well. The use of IMSAO teaching approach was expected to boost the learners’ beliefs on their abilities and potential to achieve academically in performance of physics tasks.

2.8.3 Abraham Maslow's Theory of Motivation

Maslow's hierarchy of needs is a motivational theory in psychology which argues that while people aim to meet basic needs, they seek to meet successfully higher needs in form of a pyramid (Maslow, 1943). Abraham Maslow identified five categories of basic needs common to all people. Maslow represented these needs as a hierarchy in the shape of a pyramid. According to Maslow, individuals must meet the needs at the lower levels of the pyramid before they can successfully be motivated to tackle the next levels. The lowest three levels represent deficiency needs, and the upper two levels represent growth needs**.** The Maslow's hierarchy of needs is as shown in the Figure 1.

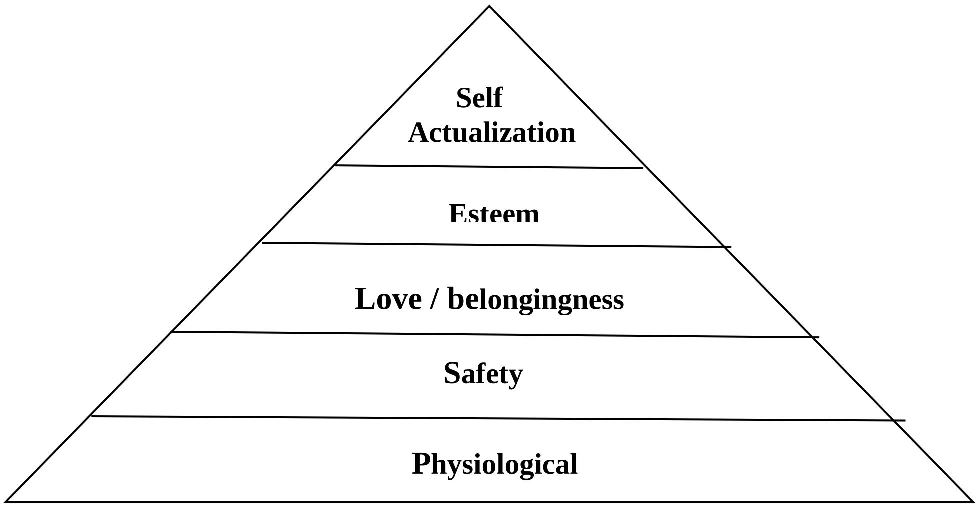

Figure 1: Maslow's Hierarchy of Needs

The following is a summary of the Maslow's hierarchical needs (Maslow, 1954):

i. Physiological needs - the need for food, drink, shelter and relief from pain.
ii. Safety and security – include needs for protection from physical dangers, economic security, preference for the familiar and the desire for an orderly, predictable world.
iii. Love or belongingness - needs to belong to a group or family become important motivators of a person's behaviour.
iv. Esteem or egoistic - a need both for self-esteem and the esteem of others, which involves self-confidence, achievement, competence, knowledge, autonomy, reputation, status and respect.
v. Self-actualisation – is the highest level in the hierarchy; these are the individual's needs for realising his or her own potential, for continued self-development and creativity in its broadest sense (Maslow, 1954).

The deficiency needs includes the physiological needs, safety needs and love or belongingness needs, while the growth needs includes self-esteem and self-actualisation needs. Maslow theory also explains that learning can only take place when deficiency needs have been met. Learner perceive education in more accurate terms when needs are met and learning becomes the priority. Educators should strive for excellence because teaching is an art of transmitting a purpose and mission. Therefore it is the teacher's responsibility to include a means of stimulation in their programs to catch students' interest (Steere, 1988).

In order to maximize on the effectiveness of school-wide and individual classroom teaching programs, administrators and teachers must consider students' needs and their hierarchical order. To satisfy the next need of understanding and knowledge, the teachers should allow the student time to explore areas of curiosity and to provide lessons that are intellectually challenging. By using the IMSAO teaching approach, the students can learn to be independent and learn from various angles. By getting involved intellectually, the students can satisfy their need to fulfil and explore, discover and solve new things.

2.9 Conventional Teaching Methods used in Secondary School Physics

The choice of the teaching method that a teacher adopts for instruction plays a major role in the learning process. Since learning and teaching are intertwined, the effectiveness of learning is largely influenced by the teaching approach employed. The learning process can be hindered by the teacher's personalities and preferences of teaching methods. Constructivist theorists hold the view that the most effective teaching method is one that actively engages the learners in construction of knowledge (Driver, 1989). If the goal of physics teaching is to provide learners with skills, values and positive attitudes towards physics, suitable methods need to be used. The particular method that a teacher uses is determined by a number of factors. These includes: the content to be taught, the objectives which the teacher plans to achieve, availability of teaching resources and the ability and willingness of the teacher to improvise if conventional teaching aids are not available, evaluation and follow-up activities, individual learners.

According to Yadav (2004) the methods of teaching physics can be broadly classified into two types: Teacher-Centred and Pupil-Centred methods. Teacher-Centred Methods are the type of teaching methods that focus on telling, memorizing, and recalling information. The students participation is very limited and they only ask questions or answers questions. Most of the time, the students are passive listeners and receive the knowledge. The teacher is the centre of process that goes on in the classroom. On the other hand, Pupil-Centred methods emphasizes on needs, requirements, interest and capability of students. The students are active participants in the learning process and their skills and abilities are developed. The climate in the classroom is conducive and flexible. The teacher and students jointly explore the different aspects of the task to be learnt. The role of the teacher is to create a conducive learning environment, formulate a learning task for the learners, have materials and resources available to the students, and help them identify issues, state hypotheses, clarify and test hypotheses and draw conclusions. In this section, some of the conventional methods used in teaching of physics, both teacher-centred and pupil-centred, have been discussed.

2.9.1 Lecture Method

Lecture method can be defined as a way of teaching by means of spoken word. It is an oral method of delivering information and creating understanding in learners (Mwaka, Musamas & Nabwire, 2014). During the teaching/learning process, the teacher engages in giving information while the learners listen and take down notes. This teaching method is therefore expository in nature. According to Nasibi (2003) and Twoli (2007), there are two types of lecture method: Formal lecture and informal lecture. Formal lecture happens when the teacher's talk and participation is at maximum. During formal lecture, the teacher purpose is to inform, persuade, or entertain. The role of the learners is limited to just listening. In the informal lecture, two-way communication is exhibited. The teacher informs the students and then the learners respond through questions, watching visual aids or doing exercises. The use informal lecture is therefore encouraged in the teaching-learning process.

Mwaka *et al.* (2014) highlighted situations that favour the use of lecture method:

i. Introducing new topics or lessons. This happens when the teacher provide an overview or a link to the previous knowledge.
ii. Interpreting or clarifying issues. The teacher can use the lecture method to clarify a concept to the learners.
iii. Reviewing a discussion. After a discussion, the teacher can use the lecture method to wrap up the main points of the discussion.
iv. When the content is extensive and has to be covered within a limited time frame
v. When classes are large and teaching materials inadequate
vi. When giving assignments, demonstrating or explaining visual aids.

For a lecture to be effective, the teacher should be equipped with lecturing skills as summarised by Twoli (2007) in Table 13

Table: 13
Effective Lecturing Skills

Lecture activity	Effective skill to learn
Explanation	- Use a logical and organised approach - Emphasize key points - Define key terms
Introduction and summary	- Use interest catching teaching aids - Use learners experiences - Link past and present - Give reviews and overviews - Give adequate summaries - Give relevant assignments
Maintain interest	- Use resources that vary stimuli - Use interesting and relevant examples - Infuse jokes in your lecture - Present lecture with enthusiasm
Questioning	- Ask thought provoking questions - Use low and high order questions - Distribute questions evenly to all - Encourage answers to questions
Communicating	- Clear voicing - Vary tone - Use appropriate language - Use eye contact
Time use	- Start and finish on time - Cover adequate content

Lecture method has its limitations when used in teaching of sciences. It makes learners to be passive in the learning process making learning not to be meaningful (Mukwa &Too, 2002). Even with the above lecturing skills, the method remains ineffective in teaching of physics since learners are not actively engaged in the learning process. Physics is a practical subject that requires students to manipulate apparatus by themselves in order to acquire science process skills. Some of its limitations include:

i. The teachers deny the learners the opportunity to learn by doing.
ii. It makes it impossible for the teacher to evaluate how much content the learners have understood since it is a teacher centred method.
iii. Lecture method is highly vulnerable to monotony unless the teacher has exceptional abilities to stimulate and sustain interest of the students
iv. The lecture method is inefficient in development of scientific attitudes and science process skills in learners
v. The lecture method makes the learners passive agents in the learning process.

2.9.2 Demonstration Method

Mukwa and Too (2002) defined demonstration as an activity in which a teacher uses experiment or some other actual performance to illustrate a principle or show the learners how to do something. This method involves presentation of pre-arranged series of events to a group of students for observation. Demonstrations should be selected appropriately both in terms of the learners' needs as well as the content, apparatus and procedures that can be observed profitably by learners. Mwaka *et al.* (2014) have outlined the following as requirements for a successful demonstration:

i. Plan in advance for the demonstration and be clear of the desired learning outcomes
ii. Ensure all materials and apparatus needed are available
iii. Pre-test the apparatus to be used to ensure they are in good working condition.
iv. Stand in a strategic place where all students can observe all that is being demonstrated.
v. Go through the demonstration slowly so that the learners can follow the procedure.
vi. In case of complex demonstration, show the complete procedure and then break it down into steps, demonstrating each step at a time.
vii. Engage the learners in a variety of activities to ensure active participation.

One of the limitations of the demonstration method in physics teaching is that it denies the learners the opportunity to acquire manipulative skill due to their passive role in the learning process. The learners just watch and make observation on what the teacher is doing. They are not given an opportunity to handle the apparatus by themselves. The method is also time consuming, more so in cases where the class is large and demonstration can only be done in groups.

2.9.3 Discussion Method

Discussion is the most common type of collaborative method of teaching in a class. It is also a democratic way of handling a class, where each student is given equal opportunity to interact and put forth their views. A discussion taking place in a classroom can be facilitated either by a teacher or by a student. A discussion in physics teaching could also follow a presentation or a demonstration. Class discussions can enhance student understanding of scientific concepts, add context to academic content, broaden student perspectives, highlight opposing viewpoints, reinforce knowledge, build confidence, and support student' learning (Petrina, 2007). The opportunities for meaningful and engaging in-class discussion may vary widely, depending on the subject matter and format of the course. Motivations for holding planned classroom discussion, however, remain consistent. An effective classroom discussion can be achieved by probing more questions among the students, paraphrasing the information received, using questions to develop critical thinking. Mukwa and Too (2002) highlighted the following as the key characteristics of a good classroom discussion:

i. There should be an interchange of ideas between the teacher and his students as well as amongst the students themselves.
ii. The teacher should present the topic for discussion to students. This will guide them and enable them to remain focussed on the relevant content without digressing.
iii. Everyone in the group or class should be given an opportunity to give his/her opinion as regards the topic of discussion
iv. The teacher should always act as a moderator or the overall leader of the discussion group.
v. When the topic to be discussed has been exhausted, the teacher should help the groups in making a summarised conclusion about the topic discussed.

Classroom discussion can either be informal or formal. The informal discussion is one which involves free verbal interchange of ideas from all the participants without being governed by pre-determined rules. The role of the teacher is to guide and to assist the students to arrive at the desired conclusion. In the formal discussion the participation of learners is governed by pre-determined procedures (Mwaka *et al.,* 2014). In such a case, the teacher presents his objectives and gives out the guidelines on how the discussion is to proceed. A formal discussion is able to keep students focussed to the end to the teacher's desired learning outcomes. Despite it being a learner centred method, classroom discussion has its weaknesses. It requires a lot of time which may not be available for the teacher; students may digress from the main topic of discussion; the introverts and the self-conscious students may not participate actively. The method may also not be applicable in teaching some physics concepts which are abstract and difficult to the learners.

2.9.4 Class Experiment Method

Class experiment or laboratory method is a hands-on approach to science teaching in which the students have the opportunity to gain some experience with the phenomena associated with their course of study (Vaidya, 2003). The student varying and manipulating the various variables that are under exploration characterizes the laboratory method of science instruction. The students control and observe changes under investigation. The students get equipped with the science process skills and build confidence in handling and manipulating the apparatus as they carry out the experiment. The method provides learners with the opportunity to think critically, discuss, and solve real life problems. In preparation for a laboratory session, the teacher need to:

i. Prepare in advance the experiment to be conducted ensuring availability of all the required apparatus.
ii. Determine the number of workstations and the size of the group in each station.
iii. Perform the experiment in advance to establish areas of difficulties.
iv. Read and study the theory on which the experiment is based in order to be knowledgeable on the facts and principles underlying such experiment.
v. Plan on how to guide the learners in preparing the lab reports.
vi. Ensure safety precaution measures are adhered to.

Some of the limitations of the class experiment method is that some learners may not have an opportunity to manipulate the equipment due to fear or lack of confidence in handling such apparatus. The method may also be unsuitable in situations where there are few apparatus and the number of students is big. In such cases, the interactive multimedia simulation advance organizers comes in handy since they allow the students to simulate the experiment without any fear of making errors and they afford the students opportunity to repeat and reset the simulated experiment to desired scenarios boosting their understanding of concepts (Zacharia, 2005).

2.10 Use of Simulations in Teaching and Learning of Secondary School Physics

Simulation has been defined as "attempts to represent, mimic, or replicate real world stimuli, cues, responses, and interactions" (Andrews & Bell, 2000). One major way to promote learning is using computer simulations of physical phenomena (Steinberg, 2000; Snirm *et al*., 1995). The simulations, if designed appropriately, can serve several purposes: to help students extend their experience with hands-on experiments and collect additional phenomenological data; to make models explicit and help students collect model-based evidence; and to provide multiple representations of the same or related concepts. Effective teaching and learning involves learners actively in scientific inquiry and knowledge construction. The use of appropriate ICT resources and effective learning strategies and approaches make learning meaningful to learners. Interactive nature and technology-driven activities make students apply knowledge directly to real-life situations and appreciate the importance of scientific ideas.

Studies have shown that lack of models or a representation of the invisible concepts is one of the reasons why students hardly understand science concepts. This is a real scenario in physics classroom setting that needs to be addressed by educators (Adam, 2010). The great challenge to science teachers is to devise or innovate ways to make teaching-learning interesting and meaningful. Simulation-based activities can be one of the strategies to increase students' interest resulting to higher level of their academic science performance. As Cathlene and Vida (2018) pointed out, simulations are simplified versions of the natural world and they have potential to facilitate learning and focusing students' attention more directly on the targeted physical phenomena. The use of interactive simulations is envisioned to recreate interesting, engaging, and realistic content that encourage active learning among students. This teaching and learning approach allows learner to explore and discover concepts on a particular topic in a more interesting way, instead of merely reading about it or having information just relayed from the instructor.

The use of computer technology in education has been there for more than forty years. Specifically, computer simulation as an instructional technology has been commonly used in education. According to Chen (2002), many probable advantages fronted for the use of computer simulation in teaching include: students have chances to receive additional contact with the variables tested in real experiences, students can be active during the simulated experiments by identifying the study problem, writing in their notebooks their hypotheses, planning and performing the simulated experiments, gathering results, collecting data in their notebooks, plotting these data back in the computer, and using the data for drawing tables and graphs. Huang (2002) study also revealed that computer simulations enhanced students' active involvement in the learning process, and facilitated their practice and mastery of concepts and principles; computer simulation helped students to meet their learning objectives or goals. They make students take an active role in the learning process.

Michael (2000) pointed out that simulation programs helped students learn about events, processes, and activities that either replicate or mimic the real world. According to him, computer simulation can afford learners numerous advantages. For instance, computer simulations can provide the students with the opportunity to engage in activities that may otherwise be unattainable, enhance academic performance, and be equally as effective as real-life hands-on laboratory experiences. He also noted a significant greater effectiveness of computer simulation instruction as compared to traditional instruction.

Many of the phenomena physics students learn about are dynamic in nature. However, conventional methods of teaching have been static and do not help students develop intuition about the dynamic aspects (Barowy & Roberts, 1999). Textbooks emphasize using formulae to get particular answers such as the amount of centripetal force required to keep a car on the road when it is going at a velocity (v) on a curve of radius (r). Students may learn how to get the answer, but not really understand the dynamics of a skid and how the propensity to skid is affected by ice or rain on the road (Mandinach & Cline, 1994) .According to them, Computer interactive multimedia simulations provide some new tools for illustrating and explaining physics dynamic phenomena. Many of the simulations serve as demonstrations and allow students to manipulate and experiment with them. This engagement is essential for real understanding of scientific concepts rather than just memorizing. In this study, computer Interactive Multimedia Simulations Advance Organizers was used to teach the topic Measurement and its effects on the achievement and motivation to learn physics determined.

2.11 Use of Advance Organizers in Teaching and Learning of Physics

An advance organizer is a cognitive instructional strategy used to promote the learning and retention of new information. Mayer (2003) defined an advance organizer as information that is presented prior to learning and that can be used by the learner to organize and interpret new incoming information. These organizers are introduced in advance of learning itself, and are also presented at a higher level of abstraction, generality, and inclusiveness; and since the substantive content of a given organizer or series of organizers is selected on the basis of its suitability for explaining, integrating, and interrelating the material they precede, this strategy simultaneously satisfies the substantive as well as the programming criteria for enhancing the organization strength of cognitive structure. According to Ausubel (1978) learning is based upon the kinds of super ordinate, representational, and combinatorial processes that occur during the reception of information.

There are two broad categories of advance organizers. One of them is expository organizers which are used whenever the new material is totally unfamiliar. They emphasize context and link the essence of the new material with some relevant previously acquired concepts. The other one is comparative organizers which are used when the material to be learnt is not entirely new. They are intended to point out ways in which that material resembles and differs from that which is already known (Awodun, 2016). A primary process in learning is sub-sumption in which new material is related to relevant ideas in the existing cognitive structure on a substantive basis.

Ausubel submitted that advance organizers might foster meaningful learning by prompting the student regarding pre-existing superordinate concepts that are already in the student's cognitive structure, and by otherwise providing a context of general concepts into which the student can incorporate progressively differentiated details. Ausubel further asserted that by presenting a global representation of the knowledge to be learned, advance organizers might foster "integrative reconciliation" of the subdomains of knowledge - the ability to understand interconnections among the basic concepts in the domain. Joyce *et al.* (2000), described three phases of activity in an advance organizer model:

a) Phase I (includes presentation of the advance organizer)
   i. Clarify the aims of the lesson
   ii. Presentation of the advance organizer

iii. Prompting awareness of relevant knowledge

b) Phase II (includes making links to/from the organizer)

i. Presentation of the learning task or learning material

ii. Make organization and logical order of learning material explicit

c) Phase III (strengthening of the cognitive organization)

i. Integrative reconciliation and active reception learning

ii. Elicit critical approach to subject matter

Advance organizers in form of a statement, activity, video, computer animation, or a graphic can help the learner anticipate and organize new information (Ausubel, 1978). They can be used at the beginning of lessons in which new information is to be learned. An advance organizer often call on prior knowledge, so as to connect new learning to an existing cognitive structure and indicate to the learner what information from a lesson will be important. Advance organizer is therefore a tool for helping students to access prior knowledge that in turn can clarify instructional material presented to them.

Ausubel (1978) advocated the use of advance organizer to foster meaningful learning, and he described the role of advance organizer in the progressive differentiation of learned concepts. He stated that sub-sumptive learning, the learning of details that are related to more general concepts, is more effective than superordinate learning in which the student learns a large number of details and then tries to fit them all together. The advance organizers support the notion of sub-sumptive learning by making explicit the general, superordinate concepts to be learned, and how they interrelate. It is into this framework that the learner can progressively articulate details of the concept. Advance organizer foster meaningful learning by both prompts the learner regarding pre-existing super ordinate concepts that are already in the student's cognitive structure, and providing a context of the most general concepts into which the student can incorporate progressively differentiated details.

The advent of the internet and multimedia, have given rise to a broad range of possible representations that may be utilized as advance organizers. Modern advance organizers take the form of text passages (Herron, 1994; Kang, 1996), graphical representations and maps (Herron, 1995), descriptions and pictures. Krawchuk (1996) presents a taxonomy of advance organizer that includes traditional textual summaries and basic themes that are presented before instruction, graphical organizers that provide organizations rendered in lines and arrows (like flowcharts), videos and pictorial graphic organizers. The latter category includes concept maps that present non-linear representations of information and knowledge to be learned. Advance organizers have been used successfully in a wide range of courses from elementary school (Kang, 1996) to graduate research methodology courses (Daros & Onwuegbuzie, 1999). They have, additionally been used in a wide variety of knowledge domains such as physics, biology (Shapiro, 1999) and economics (Peterson & Bean, 1998).

Advance organizer enhances the students' learning as they act as linking agents, of the previous knowledge to the newly learnt knowledge. According to Awodun (2016), there are several benefits of advance organizers to student achievement including that they can easily be connected to content standards across the curriculum; that they are flexible which make it easy to appropriately modify them for students with special need; and that they explicitly inform students what they will be learning thus reducing the possible stress of the unknown which has been shown to negatively impact student achievement. Advance organizers are beneficial in encouraging students to directly participate in their learning and to be self-reflective throughout the lesson. At the start of the lesson, teachers can use the advance organizers to facilitate whole class discussion about upcoming information, getting students thinking and talking about what they already know.

Educational researches, suggest that different combinations of verbal and visual organizers can facilitate learning in varying degrees depending on learning styles (Hatch & Dwyer, 1999). There are many graphic advance organizer possibilities which include Semantic Maps, Mind Maps, Step-by-Step Charts, Series of Events Chains, Sequence Organizers, Cause and Effect Chains, and Timelines (Minchin, 2004). With the advancement of technologies, teachers and designers started to use hypermedia programs, including digital video, power point presentation, and flash animations to construct advance organizers .These multimedia advance organizers have been found to be effective in teaching and learning of physics (Awodun, 2016). More specifically, multimedia advance organisers (those combining verbal and visual-using multimedia elements) may be more effective than advance organizers that are verbal or visual alone (Mayer, 1997). In this study, the researcher used Interactive Multimedia Simulation Advance Organizers approach to teach the topic Measurement and determined its effects on achievement and motivation to learn physics in Kenyan secondary schools.

2.12 Interactive Multimedia Simulation Advance Organizers Teaching Approach

Interactive multimedia computer simulations have become increasingly powerful and available to teachers in the past three decades. Presently science teachers can select from a wide range of interactive computer simulations available especially through the internet. The computer simulations are designed to facilitate teaching and learning through visualization and interaction with dynamic models of natural phenomena (Trundle & Bell, 2010). Computer simulations offer idealized, dynamic, and visual representations of physical phenomena and experiments which would otherwise be dangerous, costly, or not feasible in a school laboratory.

Since computer simulations show simplified versions of the natural world, they can focus students' attention more directly on the desired phenomenon (de Jong *et al.*, 2013). Furthermore, computer simulations may allow students to visualize objects and processes that are normally beyond the user' control in the natural world. In comparison with textbooks and lectures, a learning environment with a computer simulation has the advantages that students can systematically explore theoretical situations, interact with a simplified version of a process or system, change the time-scale of events, and practice tasks and solve problems in a realistic environment without stress (Rutten *et al.*, 2012). According to Psycharis (2011), a well-designed computer simulation can engage the learner in interaction by helping the learner to predict the course and results of certain actions, understand why observed events occur, explore the effects of modifying preliminary conclusions, evaluate ideas, gain insight, and stimulate critical thinking. The use of computer simulations may therefore positively affect student learning by developing in them skills of questioning and reasoning.

As the world moves towards the 21st Century, it is necessary that educators pause to evaluate the development of new technologies like interactive multimedia simulation advance organizers teaching approach and understand its impact on education. Through this innovative approach, users may be stimulated via their multisensory modalities to better focus on and retain the messages sent to them (Engelbart & Hooper 1988). Learners may benefit from multimedia because they could now enjoy learning intuitively, independently, or socially. According to Jones (1988), Proper integration and use of interactive multimedia advance organizers in education may smoothen the path to instructional enlightenment because it may, among other things, provide effective communication, clarify concepts, and enhance teaching and learning via the natural multisensory and intuitive approach. Khoo

(1994) highlights the following as possible advantages in using Interactive Multimedia Simulation Advance Organizers in the teaching learning process:

i. Reduced learning time: According to some research, interactive multimedia simulations and video disc training can reduce training time up to 60% over traditional classroom methods. This can be attributed to the immediate interaction and constant feedback, which provides excellent reinforcement of concepts and content. Also, self-paced instruction which allows students to control the pace and content of their learning i.e. more difficult concepts can be repeated or familiar content can be skipped.

ii. Reduced Cost: The cost of interactive multimedia lie in the design and production. When more students use the same program, the cost per student is reduced, unlike the traditional instructional system, which needs to cater to teacher salaries and overheads regardless of the number of students.

iii. Instructional Consistency and Fairness: Instructional quality and quantity are not compromised as technology based interactive instruction is consistent and reliable.

iv. Increased Retention: The interactive approach provides a strong learning reinforcement and therefore boosts content retention over time.

v. Mastery of Learning: A good interactive system can ensure the learning of the prerequisites by learners before proceeding to new content. This provides a strong foundation for continued learning and therefore helps to achieve mastery learning.

vi. Increased Motivation: Immediate feedback and personal control over the content provided by an interactive multimedia system has proven to be highly motivating to learners.

vii. More Interactive Learning: Interactive systems enable learners to have more responsibility and better control over their learning and this generates a greater interest to actively seek new knowledge rather than passively accept instruction.

viii. Increased Safety: Interactive multimedia simulations allow safe study of hazardous phenomena such as dangerous scientific experiments on harmful substances or natural disasters like volcanic eruptions or earthquakes by the learners.

ix. Privacy / accommodates Individual Learning Styles: This system allows for one to one learning and caters to the different learning styles of individuals. The freedom to ask questions repeatedly without embarrassment and the involvement of each individual learner motivates them and reduces the potential for distraction.

x. Flexibility: The flexibility comes from the ability to navigate, by using a keyboard, mouse, or touch screen, through an interactive program and to choose what and how much information we want and when we want it.

Interactivity in computer simulations is known to be beneficial for learning, (Bodemer *et al*., 2004; van der Meij & de Jong, 2006) but the degree of interactivity can vary greatly for different educational simulations. According to them, simulations provide a high degree of interactivity in terms of user control, dynamic feedback, and multiple representations. Interactive Multimedia Simulation Advance Organizers seem to be one of the most effective ways to use computers in physics education. The Interactive Multimedia Simulation Advance Organizers prepared to be used in teaching activities are able to create a teaching atmosphere like laboratories where students are active (Perkins *et al*., 2006).

A variety of visual representations of physics concepts in the Interactive Multimedia Simulation Advance Organizers may make concepts visible that are otherwise invisible to students (Finkelstein *et al.,* 2005). They could encourage students to carry out the processes used in physics research: to question, predict, hypothesize, observe, interpret results, and also motivates and cultivates students' interest in learning physics. They may also heighten the individualized instruction by allowing students to proceed on their own pace and be able to go back to master the skills (Ubiña & Patricio, 2007). Various interactive possibilities exist in simulation programs. A student may use different values in an experiment in a computer medium and observe the effect on the results conveniently and in shorter time. This gives the student the possibility of "Learning through inventing" (Monaghan, 1998). Simulations offer instructors the opportunity to provide students with an instructional tool that can help students transform their alternative science conceptions into correct science conceptions. Students could isolate and manipulate parameters and therefore help them to develop an understanding of the relationships among physical concepts, variables and phenomena (Arvind & Heard, 2010).

Dale (1969) theorized that learners retain more information by what they "do" as opposed to what is "heard", "read" or "observed". His research led to the development of the Cone of Experience. Dale's Cone of Experience is a model that incorporates several theories related to instructional design and learning processes. Today, this “learning by doing” has become known as “experiential learning” or “action learning”. Figure 2 illustrates the Dale’s cone of experience.

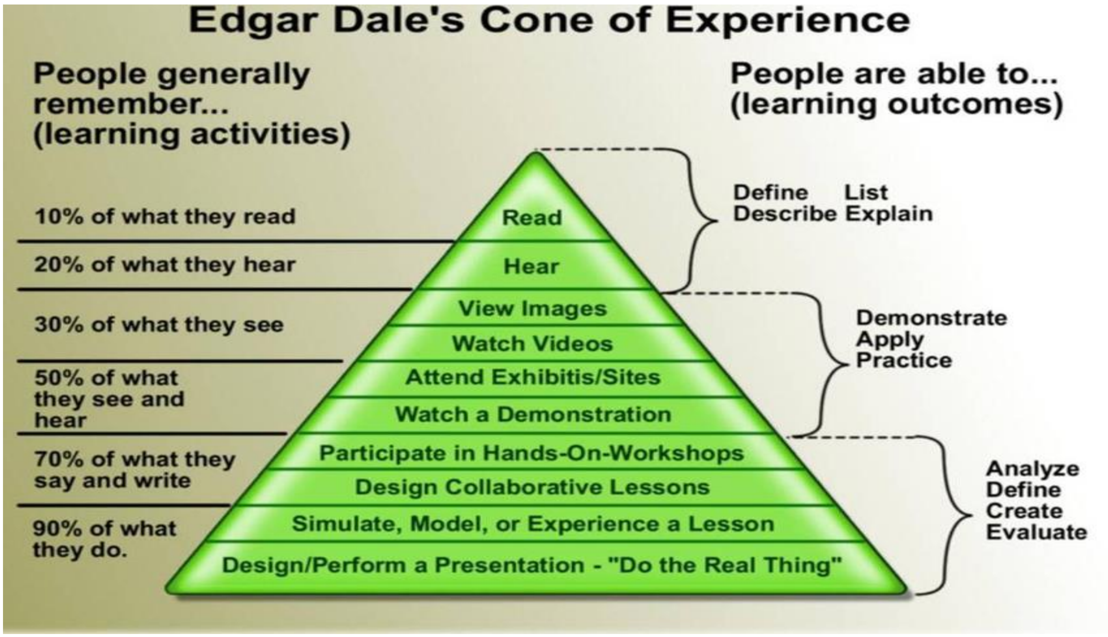

Figure 2: Edgar Dale’s Cone of experience

Source: Adapted from E. Dale, Audio-visual Methods in Teaching, 1969 pp. 108.

From Dale’s model, the least effective method at the top, involves learning from information presented through verbal symbols which includes listening to spoken words. The most effective methods at the bottom, involves direct, purposeful learning experiences, such as hands-on or field experience. Direct purposeful experiences represent reality or the closet things to real, everyday life. The cone chart indicates the average retention rate for various methods of teaching. The further you progress down the cone, the greater the learning and the more information is likely to be retained. It also suggests that when choosing an instructional method it is important to remember that involving students in the process strengthens knowledge retention. It reveals that “action-learning” techniques result in up to 90% retention. People learn best when they use perceptual learning styles. Perceptual learning styles are sensory based. The more the sensory channels possible in interacting with a resource, the better chance that many students can learn from it. According to Dale, instructors should design instructional activities that build upon more real-life experiences. Dales’ cone of experience is a tool to help instructors make decisions about resources and activities.

The model would help the instructor chose or simulate instructional resources that involve the learners actively and select the appropriate learning activities that appeal to all senses in the students to facilitate retention. According to one of the principles in the selection and use of teaching strategies, the more senses that are involved in learning, the more and the better the learning will be. Interactive multimedia simulations, which are representative models and mock-ups of reality, can be used to provide an experience that is close to reality. This could make learning experience more practical and accessible to the learner as it would provide learners with more concrete experiences that allow visualization and foster better understanding of the concept.

A study by Tolga (2011) on the effects of the Interactive Multimedia Simulation on students' learning in physics education showed that that the Interactive Multimedia Simulation were able to improve students' learning outcomes compared to traditional physics learning. This finding supports the studies conducted by Valerie and Hirschbuhl (1999) which found that interactive multimedia simulations promoted achievement and higher level thinking skills in science students. In this study, the researcher determined the effects of using a combination of interactive multimedia simulations and advance organisers (IMSAO) teaching approach on achievement and motivation to learn the physics topic Measurement to form two students.

2.13 Theoretical Framework of the Study

The theoretical framework of the study was based on the Bertalanffy's General Systems theory (Bertalanffy, 1968) and Bandura's Self-Efficacy theory of motivation (Bandura, 1994). The General Systems theory holds that a school operates as an open system with permeable boundaries and have both internal and external inputs and outputs. Freeman (1995) advanced that schools are essentially living systems and that without people they are nothing but concrete and paper. As living systems, they are in constant process of interaction with their communities and other institutions in them. The teaching / learning process will therefore have both inputs and outputs.

In a school set up, the learning outcomes are largely dependent on the teaching / learning approaches employed by the teacher in the delivery of the content.The approach involves setting goals and objectives, analysing resources devising a plan of action and continues to evaluation and modification of the instructional strategy. Instructional process, just like other systems, involves relationships, conditions, processes, causes, effects and feedback.

Instruction as a system involve decisions related to what will be taught, how it will be organized for learning, and how learning will be assessed.

For analytical purposes it is necessary to identify what students and teachers do within the system. It is important to address individual components of the system. The teacher specifies the content to teach and the objectives that will guide him in attaining the learning outcomes. He has to assess the entry behaviour of the learner which enables him to select the best teaching methods, resources, allocate time, and organise the learners in terms of their abilities. Gerlach and Ely (1980) illustrated the system approach to instructional process as shown in Figure 3.

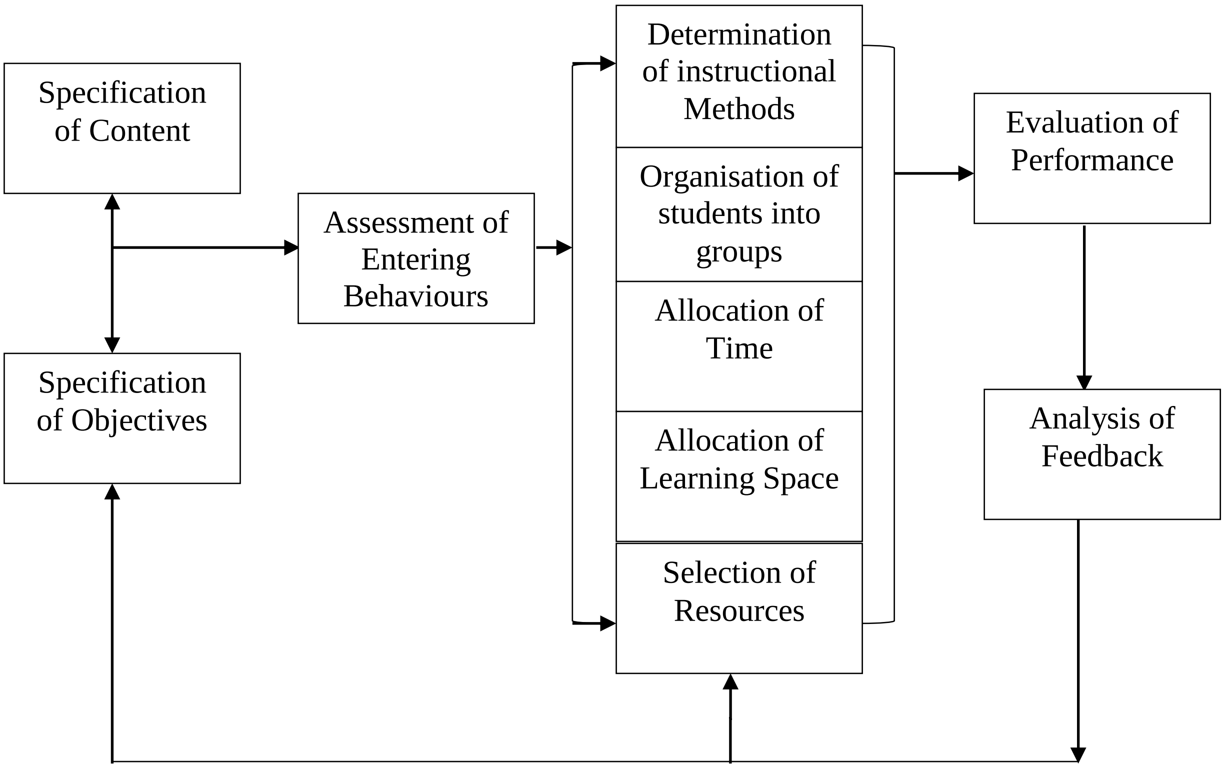

Figure 3: Gerlach and Ely Instructional System Model

The system approach to instruction model clearly illustrates the instructional process and the interrelationship between its components. When one component is altered within the system, there is change in the conditions for all the components. This means that when instructional systems are altered, the learning systems are altered as well. The evaluation of performance help to check what is working and what is not consequently giving feedback on whether to change and review the objectives, content or teaching methodologies to suit the learners need and ability. The system approach of learning enables the teaching-learning process to go through the learning cycles of knowledge construction. The approach organizes the learning environment such that it allows an interactive atmosphere where learners can collaboratively construct the new knowledge (Saettler, 1990). The system approach provides a framework that ties together the instructional approach and the learning outcomes. The IMSAO teaching approach was used as an intervention following poor achievement and low motivation to learn physics in secondary schools in Nyahururu Sub County in Laikipia.

Bandura (1977) Self-efficacy Theory hypothesized that self-efficacy affects choice of activities, effort, persistence, and achievement. People acquire information to appraise self-efficacy from their performances and observational experiences. According to Bandura and Cervone (1986), Successes in performance of a task raises efficacy while failures lower it. However, they noted that once a strong sense of efficacy is developed, a failure may not have much impact. Self-efficacy beliefs have also been found to influence academic motivation. There is evidence (Bandura, 1997) that self-efficacious students participate more readily, work harder and persist longer than do those who doubt their capabilities.

The task of creating learning environments conducive to development of cognitive skills largely depends on the talents and self-efficacy of teachers. Teachers with a high sense of efficacy about their teaching capabilities can motivate their students and enhance their cognitive development. In a personalized and conducive learning classroom structure, students' knowledge and skills enables all of them to expand their competencies and provides less basis for demoralizing social comparison (Schunk, 1981). As a result, students are more likely to compare their rate of progress to their personal standards than to the performance of others. Self-comparison of improvement in a personalized classroom structure raises perceived capability and hence motivation to learn. The IMSAO teaching approach provide a conducive environment that could motivate students to learn physics at their own pace..

2.14 Conceptual Framework of the Study

In this study, Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach and Conventional Teaching Methods (CTM) formed the independent variables on which the learning outcomes depended on. The learning outcomes, which are the dependent variables of the study, were the students' achievement in physics and motivation to learn physics. Achievement in physics was measured using a Physics Achievement Test (PAT). Motivation to learn physics was measured using a Physics Motivation Questionnaire (PMQ). The learning outcomes could have been influenced by other factors forming the extraneous variables. These included the students' gender, age, teachers' training, experience, and the type of school. The teachers' training and experience can determine their effectiveness in teaching the physics concepts thereby influencing the learning outcomes.

The type of school and gender of the student could also influence the achievement and motivation to learn physics. To take care of the extraneous variables, the researcher involved form two students who were presumably relatively of the same age. Teachers with a minimum qualification of a diploma in education and having more than 5 years teaching experience were involved in the study. The teachers in the experimental groups were required to have some basic computer literacy skills to ensure they had could easily grasp the skills on application the IMSAO teaching approach. The teachers were thoroughly trained for one week on the use of IMSAO. The effect of gender was taken care of by studying its effects on achievement and motivation to learn physics. Schools considered in the study were co-educational day public secondary schools with equipped computer laboratories. This ensured uniformity and eliminated any other factors associated with school type that could have influenced achievement and motivation to learn physics. Figure 4 shows diagrammatic representation of conceptual framework of the study.

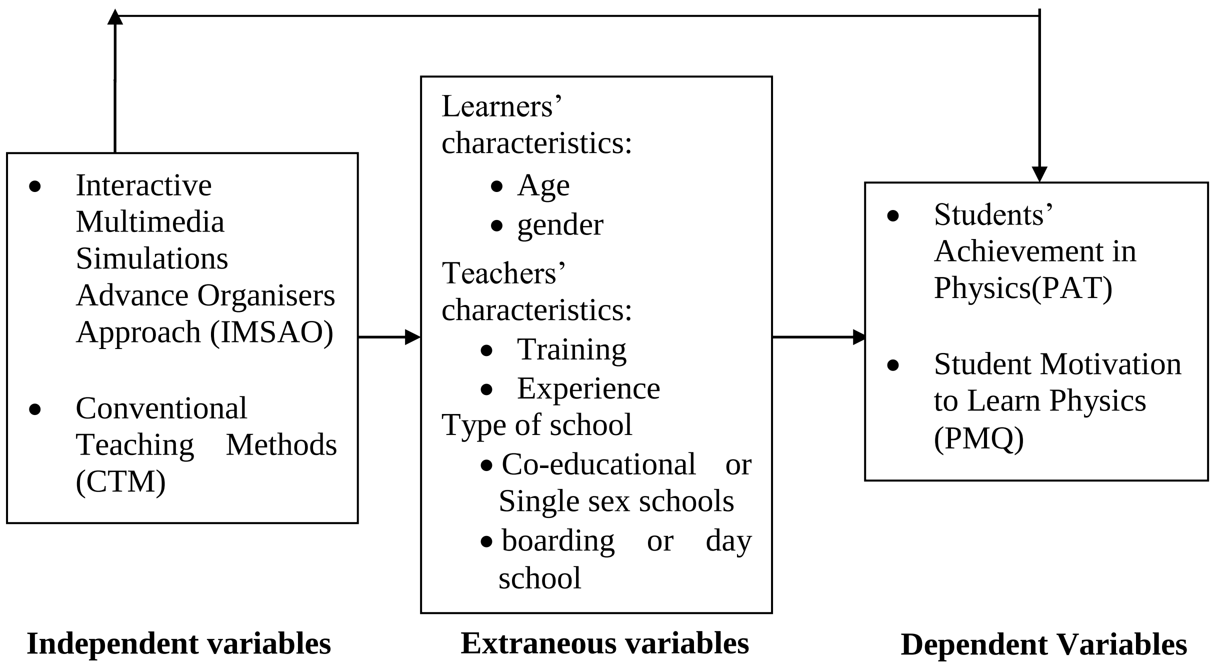

Figure 4: Diagrammatic Representation of the Conceptual Framework of the Study

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design used, the population studied, sampling procedure, the instruments used in data collection, data collection, ethical considerations, and data analysis procedures.

3.2 Research Design

This study is a quasi- experimental research. This is because the research involved human beings who could not be purely subjected to scientifically controlled conditions. Solomon's Four Non-Equivalent Control Group Design was specifically used. This is because secondary school classes once constituted exist as intact groups and school authorities do not normally allow such classes to be broken up and reconstituted for research purposes. Solomon Four-Non Equivalent Control Group Design is considered rigorous for quasi-experimental studies (Borg & Gall, 1989; Cook & Campbell 1979). This design makes it possible to evaluate the main effects as well as the reactive effects of testing, history and maturation (Fraenkel & Wallen, 2000). Figure 5 shows the representation of the Solomon Four Non-Equivalent Control Group design.

Group E1	O_1	X	O_2
Group C1	O_3		O_4
Group E2		X	O_5
Group C2			O_6

Figure 5: Solomon Four Non-Equivalent Control Group Design

Where O_1, O_3, are pre-test observations while O_2, O_4, O_5 and O_6 are post-test observations

X **-** is the treatment where students were taught using Interactive Multimedia Simulation Advance Organizers (IMSAO) approach.

Group E1 – the experimental group that received the pre-test, treatment X and the post-test.

Group C1 – the true control group, which received a pre-test, followed by a control condition and finally a post-test.

Group E2 –the experimental group that received treatment X and a post-test. This group was not pre-tested.

Group C2 –the control group that received the post-test only.

Group C1 and C2 formed the control groups that were taught using Conventional Teaching Methods (CTM) while Group E1 and E2, were the experimental groups, which were taught using IMSAO.

3. 3 Location of the Study

Laikipia County is one of the fourteen counties of the expansive Rift Valley region and one of the 47 counties in the Republic of Kenya. The County consists of five administrative sub-counties namely: Laikipia East, Laikipia North, Laikipia Central, Laikipia West, and Nyahururu. It is ranked as the 15th largest county in the country based on land size with 50% of it considered Arid and Semi-Arid Land (ASAL). It covers an area of 9,462 km^2 bordering other seven counties namely: Samburu County to the North, Isiolo County to the North East, Meru County to the East, Nyeri County to the South East, Nyandarua and Nakuru County to the South West, and Baringo County to the West. In terms of public educational institutions, the county has 518 Early Childhood Development Education (ECDE) centres, 340 primary schools and 96 secondary schools (Laikipia County Information Guide, 2014). The study was conducted in Nyahururu Sub-County of Laikipia.

3.4 Target and Accessible Population

The target population of the study comprised all form two secondary school students in Nyahururu Sub-County in Laikipia. The sub county has 33 public secondary schools with a total population of 13,234 students according to Nyahururu Sub-County Education Report (2014). To take care of the gender factor, schools considered in the study were co-educational day secondary schools. Nyahururu Sub-County was purposefully chosen because it had many public day Co-educational secondary schools with well-equipped computer laboratories which was necessary for the use of IMSAO teaching approach. The sub-county was also selected due to its proximity and its accessible terrain to the researcher. The achievement and enrolment in physics at KCSE was also low in the sub-county. Other sub-counties in Laikipia that posted low physics achievement at KCSE had fewer schools with equipped computer laboratories. There were 24 Co-educational Day public secondary schools out of the total 33 public secondary schools in Nyahururu Sub-County. This provided a wider frame in selecting schools that took part in the study and with similar characteristics. The accessible population comprised of all form two secondary school students in the sampled schools. The form two students were targeted because at their level, physics is a compulsory subject and the physics topic of Measurement II is covered at that level. This ensured a fair uniformity in the number of students for the four groups studied.

3.5 Sampling Procedures and Sample Size

The sampling units constituted schools and not individual students. Four schools were purposively sampled from a sampling frame consisting of all 24 public co-educational day public secondary schools in Nyahururu Sub-County in Laikipia. This was done to ensure the schools selected had equipped computer laboratories where the interactive simulations were to be carried out. A total population of 168 form two students, drawn from all the four sampled schools, took part in the study. From the four sampled schools, two schools were randomly assigned to experimental groups while the other two schools were assigned to control groups. In schools with more than one form two stream, similar approaches of teaching were used but one stream was randomly sampled and considered for the study. The composition of the sample size for the experimental and the control groups is as illustrated in Table 14.

Table 14:
Composition of the Sample size by Groups and Gender

Group/Gender	E1	E2	C1	C2	Total
Male	18	25	18	26	87
Female	19	20	18	24	81
Total	**37**	**45**	**36**	**50**	**168**

3.6 Instrumentation

The instruments used in the study for data collection were Physics Achievement Test (PAT) and Physics Motivation Questionnaire (PMQ). PAT was used to collect data on the level of Physics Achievement while PMQ provided data used to measure the level of motivation to learn physics. Students KCPE scores were captured and recorded together with the PAT scores in the PAT Mark sheet (Appendix D).

3.6.1 Physics Achievement Test

A pre-test Physics Achievement Test (PAT) on topic Measurement in the secondary school physics syllabus was constructed. The test comprised 20 items and tested the first three levels of cognitive domain namely knowledge, comprehension and application. The questions were set from the Measurement topic in the form two physics syllabus. The test measured the entry level of the learners. A post-test PAT was then constructed by reorganizing the questions in the pre-test PAT and administered after the treatment to all groups. This was done to allow a fair comparison between the pre-test and the post-test results in the true experimental and true control groups which were subjected to both PAT pre-test and post-test.

3.6.2 Physics Motivation Questionnaire

A Physics Motivation Questionnaire (PMQ) was developed to measure the level of motivation to learn physics. The PMQ consisted of 35, five Likert scale items. The questionnaire used six factors that influence motivation namely: self-efficacy, active learning strategies, physics learning value, social persuasion performance goal, achievement goal and teaching approach as adapted from motivation towards science learning questionnaire developed by Hsiao-Lin , Chi-Chin and Shyang-Horng (2005). PMQ was administered as a pre-test to Experimental group E1 and Control group C1. The PMQ was then administered to all the four groups after the post-test PAT.

3.6.3 Validity of the Instruments

The PAT questions and the PMQ questions were constructed by the researcher and first given to the supervisors for review and validation. The reviewed PAT and PMQ were then given to three experts from the Faculty of Education and Community Studies of Egerton University for standardization and to ensure that the instruments' had the face and content validity. Three physics Secondary school teachers with a minimum of five years teaching experience, and who are Kenya National Examination Council (KNEC) examiners in physics were involved in the reviewing the content validity of PAT.

3.6.4 Reliability of the Instruments

The instruments were pilot tested in a secondary school in Nyahururu Sub-County having similar characteristics with the selected schools to ensure their reliability. The pilot school was not involved in the study. The reliability coefficient for PMQ was computed using Cronbach's coefficient alpha while the Kuder-Richardson estimation formula for reliability was used for PAT. The K-R21 formula is effective since it is highly appropriate for teacher made test and short experimental tests developed by a researcher (Borg & Gall, 1989).The reliability coefficients were calculated using computer SPSS version 20 software. The reliability coefficients for PAT and PMQ were found to be 0.83 and 0.79 respectively, which met the threshold of reliability coefficient alpha of at least 0.70. According to Fraenkel and Wallen (2000), a coefficient of alpha value above 0.7 is considered suitable to make possible group predictions that are sufficiently accurate.

3.6.5 Construction of Instructional Materials

Instructional materials used in the study were based on the Kenya Institute of Education (KIE, 2008) syllabus. The physics topic Measurement II in secondary school physics syllabus was considered for the study. The concepts taught in this topic include use of Vernier callipers and Micrometre screw gauge in making measurements. Some concepts like negative and positive zero errors, pitch, and least count are not clear to learners when taught using the Conventional Teaching Methods. The topic has been reported to be difficult by KNEC reports and it is a foundational topic in entire secondary school physics course aimed at equipping learners with science process skills. The topic is very relevant in physics practical which constitute 40% of scores in the overall KCSE physics examination (KNEC, 2018). Interactive Multimedia Simulations Advance Organizers (IMSAO) teacher training manual and instructional materials were used to prepare teachers for the study (Appendix F). The researcher provided the pictorial, graphical, video, interactive multimedia computer simulations and programs used in the IMSAO. Teachers in the experimental groups were trained for one week on the IMSAO approach, installation, use of the IMSAO software program, administering the treatment and scoring of PAT. Further, they were given one week to familiarize themselves with the new approach and to seek clarifications in areas of difficulties on the use of IMSAO in teaching the physics topic measurement. The IMSAO training manuals were used throughout the treatment period, which lasted six weeks.

Teachers in the experimental groups were encouraged to continue using IMSAO even after the treatment period.

3.7 Data Collection Procedures

The researcher received an introductory letter from Egerton University to help in seeking for a permit to conduct the research from the National Commission for Science, Technology, and Innovation (NACOSTI). After obtaining the permit, the researcher took a copy of the research authorisation letter to the Education Office in the Nyahururu Sub-County in Laikipia and informed them of the purpose, scope and time frame of the study.The sampled schools were then visited, and their principals' consent sought in conducting the research. Teachers involved in the study were briefed on the roles that they would play in the research. An IMSAO teaching module constructed based on the topic Measurement in secondary school physics syllabus was used in training the teachers in the experimental groups for one week on the use of the module in teaching. The teachers were further trained for another one week on the scoring of PAT and given time to familiarise themselves with the IMSAO approach. During the training week, the simulation software was installed in the computers in the experimental schools and the teachers once again inducted on the effective and efficient use of the simulation program.

Physics Achievement Test (PAT) on the topic of Measurement in the secondary school physics syllabus was used as a pre-test before the administration of the treatment. The students in the experimental groups were taught the topic measurement using the IMSAO approach while those in control groups were taught using the Conventional Teaching Methods (CTM).The treatment period lasted four weeks. The researcher constantly and randomly visited the schools studied to ensure effective administration of the treatment. A post-test PAT, constructed by reorganizing the questions in pre-test PAT, was then administered to all groups. All teachers involved in the study were briefed again on the scoring of PAT to ensure uniformity in marking. The scores obtained from both the pre-test and post-test PAT were used in data analysis.

Physics Motivation Questionnaire (PMQ) was used as a pre-test and later administered to all the four groups of study after the post-test PAT to measure the level of motivation to learn physics. The PMQ pre-test and post-test scores provided data that was used to determine the effects of IMSAO on motivation to learn physics. The teachers were provided with a mark-sheet which they used to fill in the PAT scores for each student and their respective KCPE marks obtained from the student detail records. The KCPE scores were used as covariate in the data analysis. The training and the treatment period took six weeks of the normal teaching lessons in the school.

3.8 Ethical Considerations

The researcher visited Nyahururu Sub-county Education office and sought for an introductory letter to visit schools in the area. The researcher then visited the schools sampled for study and explained to the principals about the scope and nature of the study. Consent to carry out research in their schools was sought. The physics teachers in the schools were also informed about the study and briefed on the roles they would play in the study. The teachers in the experimental schools were voluntarily trained on the use of IMSAO teaching approach. Their willingness to participate in the study was sought. The students who took part in the study were also duly informed about the research and their consent sought.

Participating students were requested not to write their names, but only admission numbers on the Physics Achievement Test (PAT) and Physics Motivation Questionnaire (PMQ). This was done to safeguard their privacy and to ensure anonymity. The students were also informed that the data provided was to be held with uttermost confidentiality and was for research purposes only. While doing data analysis, the researcher maintained anonymity of students and schools studied by coding all the information provided.

3.9 Data Analysis

PAT and PMQ pre-test and post-test scores were coded and used in data analysis. Data was analysed both qualitatively and quantitatively. Analysis of Variance (ANOVA) was used to test statistical significant difference within and between the means in the post-test PAT scores and post-test PMQ scores for the groups exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach and those exposed to Conventional Teaching Methods. t-test was used to test for any statistical significant difference in achievement in physics between boys and girls when exposed to IMSAO teaching approach. The t-test was also used to test for any statistical significant difference in motivation to learn physics between boys and girls exposed to IMSAO teaching approach. Analysis of covariance (ANCOVA) was used to cater for any initial differences within the groups of study with KCPE marks as a covariate. A computer program, Statistical Package for Social

Science (SPSS version-20) was used for the data analysis. All hypotheses were tested at the significance level of alpha (α) equal to .05 which is suitable for social science researches. Table 15 gives a summary of the methods used to test the hypotheses.

Table 15:
Summary of Methods used to Test Hypotheses

Hypotheses	Independent Variable	Dependent variable	Statistical tests used
Ho1: There is no statistically significant difference in physics achievement between the students exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) and those exposed to Conventional Teaching Methods (CTM).	• IMSAO teaching approach • Conventional Teaching Methods (CTM)	Students' score in post-test Physics Achievement Test (PAT)	ANOVA ANCOVA t-test
Ho2: There is no statistically significant difference in motivation to learn physics between the students exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) and those exposed to Conventional Teaching Methods (CTM).	• IMSAO teaching approach • Conventional Teaching Methods (CTM)	Students' score in Physics Motivation Questionnaire (PMQ)	ANOVA ANCOVA t-test
Ho3: There is no statistically significant difference in achievement in physics between boys and girls exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO)	• Students' gender	Students' score in Physics Achievement Test (PAT)	t-test ANCOVA
Ho4: There is no statistically significant difference in motivation to learn physics between boys and girls exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO)	• Students' gender	Students' score in Physics Motivation Questionnaire (PMQ)	t-test ANCOVA

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter constitutes the research findings and discussions on the effects of Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach on physics achievement and Motivation to learn physics. First, the pre-test analysis is presented. The subsequent four sections contain the results of the four objectives of the study. The hypotheses were tested at α=.05 level of significance using t-tests, ANOVA and ANCOVA. The results of each hypothesis tested have been discussed and related to the findings of similar studies done in the past.

4.2 Pre-test Analysis

Pre-testing was done to establish the homogeneity of the experimental and the control groups before the administration of the treatment. This also helped to identify the entry behaviour of the subjects under study. Groups E1 and C1 were pre-tested on the physics achievement using pre-test PAT while motivation to learn physics was pre-tested using a pre-test PMQ. The pre-test analysis involved comparing the students' pre-test mean scores of the groups on Physics Achievement and motivation to learn physics based on the teaching approach and gender. A t- test was used to test for homogeneity of the experimental and control groups before administration of the treatment. The results of the comparison for the pre-test PAT and PMQ scores between Experimental and Control groups E1 and C1 are shown in Table 16.

Table 16:
Comparison of the Students' Pre-test Mean Scores in Physics Achievement Test and Motivation to Learn Physics between E1 and C1

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics achievement (PAT)	E1	37	17.89	3.60	71	0.167	0.868
	C1	36	17.69	6.18			
Motivation to Learn Physics (PMQ)	E1	37	2.67	0.20	71	0.250	0.803
	C1	36	2.66	0.17			

For PAT:
Critical values (df = 71, t =1.99, ρ=0.05)
Calculated values (df = 71, t =0.167, ρ=0.868); ρ >.05; not significant
For PMQ:
Critical values (df = 71, t =1.99, ρ=0.05)
Calculated values (df = 71, t =0.250, ρ=0.868); ρ >.05; not significant

The results in Table 16 show that the physics achievement pre-test mean score (M = 17.69, SD = 6.18) of C1 was not statistically significantly different from that (M = 17.89, SD = 3.60) of E1 at the 0.05 level, t (71) = 0.167, ρ = .868 which is greater than .05. This means that the two groups were similar before the administration of the treatment as measured by physics achievement pre-test mean scores. Students motivation to learn physics mean score (M = 2.67, SD = 0.20) of E1 was not significantly different from that of C1 (M = 2.66, SD = 0.17) at the 0.05 level, t (71) = 0.250, ρ =.803. This indicated that the two groups were similar at the point of entry in terms of motivation to learn physics. Given the similarity in characteristics between the two groups E1 and C1 in the Physics achievement and the motivation to learn physics, the four groups were considered suitable for the study as they were drawn from same population and sampled randomly.

The differences in Physics achievement pre-test mean scores and student motivation to learn physics pre-tests by gender were also examined during the pre-test analysis. Boys' and girls' pre-test scores in PAT and PMQ for group E1 and C1 were compared. The t-test was carried out to determine the differences and the results are in Table 17.

Table 17:
Comparison of the Students' Pre-test Mean Scores on Physics Achievement Test and Motivation to Learn Physics by Gender

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics achievement	Male	36	19.72	4.09	71	3.488	0.001*
	Female	37	15.92	5.15			
Motivation to learn physics	Male	36	2.69	0.18	71	1.002	0.320
	Female	37	2.65	0.18			

For PAT:
Critical values (df = 71, t =1.99, ρ=0.05)
Calculated values (df = 71, t =3.488, ρ=0.001); ρ <.05; *significant
For PMQ:
Critical values (df = 71, t =1.99, ρ=0.05)
Calculated values (df = 71, t =1.002, ρ=0.320); ρ >.05; not significant

The t-test results indicated a significant difference in Physics Achievement between male students (M = 19.72, SD = 4.09) and female students (M = 15.92, SD = 5.15) at the .05 level of significance, t (71) = 3.488, ρ = 0.001, ρ<.05. This significant difference was in favour of boys. This implies that boys' achievement in physics was higher than that of girls' before the treatment. The test further indicated that there was no statistically significant difference in motivation to learn physics between male students (M = 2.69, SD = 0.18) and female students (M = 2.65, SD = 0.18) at the .05 level, t (71) = 1.002, ρ = 0.320, ρ ›.05. This is an indication that both male and female students studied had similar point of entry in terms of motivation to learn physics.

4.3 Difference in Students Physics Achievement by Teaching Approach

The first objective sought to compare the differences in physics achievement between students exposed to IMSAO teaching approach and those exposed to Conventional Teaching Methods (CTM). Analysis of the first hypothesis which stated that there is no statistically significant difference in physics achievement between the students exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) and those exposed to Conventional Teaching Methods (CTM) was done. The physics achievement test post-test means were used to determine the differences in the experimental and the control groups (E1, E2 C1and C2) that took part in the study. Table 18 gives the descriptive statistics about the post-test PAT scores for the four groups.

Table 18:
Students' Physics Achievement Post-test Mean Scores and their Standard Deviations

Group	N	Mean	Std. Deviation
E1	37	53.70	5.79
E2	45	52.49	5.58
C1	36	31.11	8.17
C2	50	28.96	7.80

A closer look at the scores in the Table 18 shows that the post-test PAT scores for the experimental groups E1 (M = 53.70, SD = 5.79) and E2 (M = 52.49) were higher than those of the control groups C1 (M = 31.11, SD = 8.17) and C2 (M = 28.96, SD = 7.80). The Standard Deviation (SD) in the experimental groups was smaller as compared to the SD in the control groups showing that individual scores in the control groups varied greatly from each other. The fact that E1 and E2 scored higher than the C1 and C2 gives an indication that the IMSAO teaching approach could have had an impact. Figure 6 shows the graphical illustration of the results.

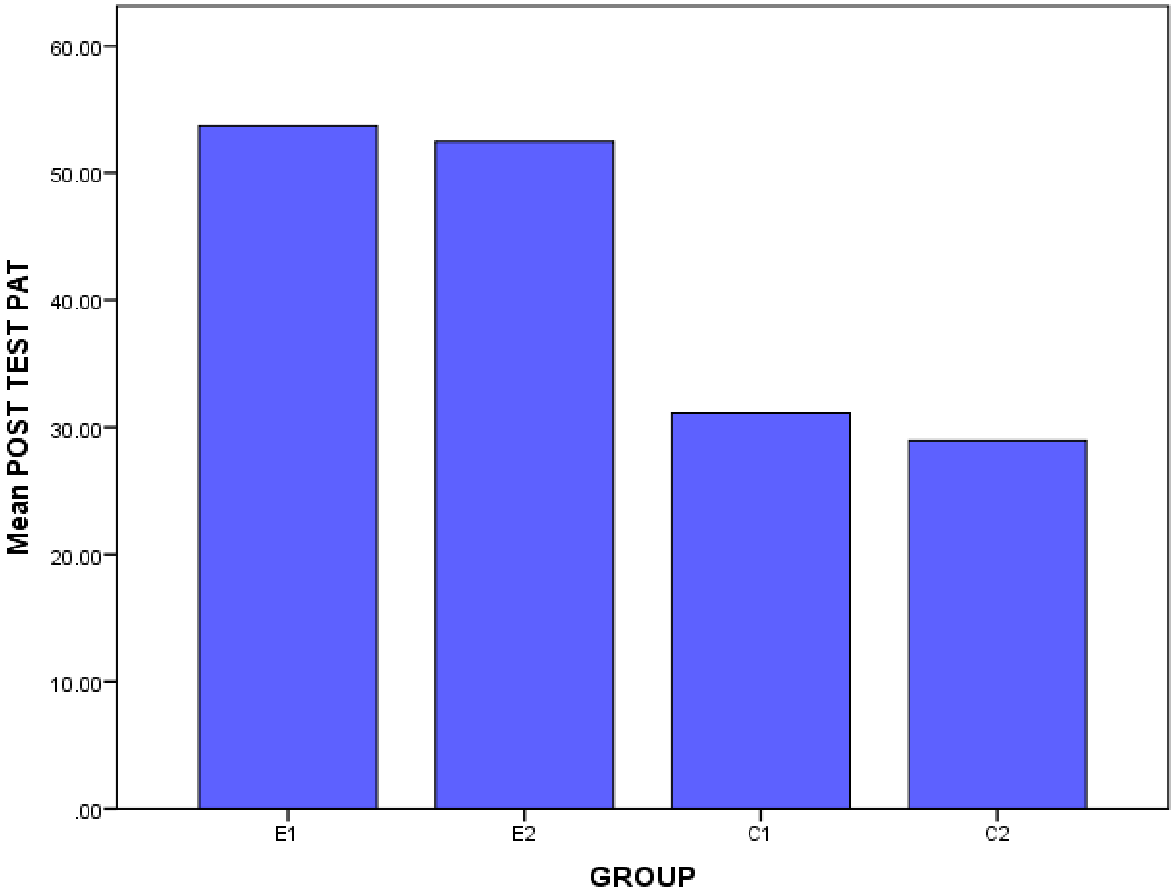

Figure 6: A Bar Graph illustration of the Post-Test Pat Mean Scores for the Groups Studied

The graph showed clearly that the post-test PAT means for the experimental groups were higher in comparison to the means of the control groups. To establish whether the differences among the mean scores were statistically significant or not, Analysis of Variance (ANOVA) test was done. ANOVA compared the variability in Physics achievement Test mean scores *between* the different groups (believed to be due to the independent variable or the treatment-IMSAO) with the variability *within* each of the groups (believed to be due to chance or use of CTM). An F ratio was calculated which represented the variance between the groups, divided by the variance within the groups and the results given in Table 19.

Table 19:
Comparison of Students' Physics Achievement Post-test Mean Scores by Teaching Approach

Scale	Sum of Squares	df	Mean Square	F-ratio	ρ-value
Between Groups	22673.544	3	7557.848	157.007	.000*
Within Groups	7894.450	164	48.137		
Total	30567.994	167			

Critical values (df = 3, 164; F =2.65; ρ=0.05)
Calculated values (df = 3, 164; F =157.007, ρ=0.000); ρ <.05;* significant

The results of the ANOVA test in Table19 indicated that the difference among the Physics Achievement Test mean scores of E1, C1, E2 and C2 were significant at the 0.05 level in favour of the experimental groups, $F(3,164) = 157.0$, $\rho < .05$. The large F ratio indicated that there was more variability between the groups caused by the independent variable than there was within each group. The results from Table 18 did not however indicate which groups were significantly different. The statistical significance difference between each pair of groups was further carried out using Least Significant Difference (LSD) Post Hoc Multiple Comparisons test. The test was selected because it is suitable for cases where the sample sizes of the groups being compared are small (Field, 2005). The results of the test are summarized in Table 20.

Table 20:
Multiple Comparison of Physics Achievement Post-test Mean Scores by Teaching Approach

Paired Group	Mean Difference	ρ-value
E1 versus E2	1.21	.432
E1 versus C1	22.59	.000*
E1 versus C2	24.74	.000*
E2 versus C1	21.38	.000*
E2 versus C2	23.53	.000*
C1 versus C2	2.15	.158

*Significant at .05 level; ρ<.05

The Least significant Differences (LSD) test in Table 20 further indicated significant differences between the physics achievement post-test mean scores of the experimental groups (E1 & E2) and control groups (C1 & C2).

Since the ANOVA test do not have features to level out initial differences in the groups, Analysis of Covariance (ANCOVA) test was carried out with the KCPE scores as the covariate, to remove any initial differences in the groups. The adjusted physics achievement post-test mean scores with KCPE marks as the covariate are summarized in Table 21.

Table 21:
Adjusted Physics Achievement Post-test Mean Scores with KCPE as the Covariate

Teaching approach	Mean	Std. Error
E1	53.64	1.14
E2	52.48	1.03
C1	32.24	1.16
C2	28.93	0.98

The results in Table 21 show that the adjusted post-test mean scores of the experimental groups E1 (M = 53.64) and E2 (M= 52.48) were higher than those of the control groups C1 (M = 32.24) and C2 (M = 28.93). Preliminary checks were conducted to ensure that there was no violation of the assumptions of homogeneity of variances using the Levene's test as indicated in Table 22.

Table 22:
Levene's Test of Homogeneity of Variances for Adjusted Physics Achievement Post-test Mean Scores

F	df_1	df_2	Sig.
2.172	3	164	.093

Not Significant at 0.05 level; α › 0.05

The results in the Table 22 confirms that the adjusted Physics achievement post-test mean scores variances for the groups were not significant at α=.05 level of significance. The adjustment of the post-test PAT mean scores using KCPE scores as covariate did not significantly affect the variance of the group. The groups were therefore homogeneous. The assumption of the equality of variances was therefore not violated and ANCOVA test on the variances could be done. The ANCOVA analysis was conducted in order to find out whether the differences among the mean scores were significant. The results of the ANCOVA test are contained in Table 23.

Table 23:

ANCOVA Test on Students' Physics Achievement Post-test Mean Scores by Teaching Approach

Scale	Sum of squares	Df	Mean Square	F-ratio	ρ-value	Partial Eta Squared
KCPE	61.95	1	61.95	1.29	.258	.008
GROUP	22504.88	3	7501.63	156.11	.000*	.742
Error	7832.50	163	48.05			

Critical values (df = 3, 163; F =2.65; ρ=0.05)
Calculated values (df = 3, 163; F =156.11, ρ=0.000); ρ <.05; *significant

The ANCOVA test from Table 23 showed that the differences among the groups were significant in favour of the experimental groups [F (3,163) =156.11, p=.000, Partial Eta squared=.742]. The effect size, as indicated by the corresponding partial eta squared value showed that much of the variance in the Physics Achievement Post–test mean scores could be attributed to the teaching Approach. The value in this case was 0.742 which translates to 74.2 % contribution to the differences in variances in the groups. The effect of the covariate, in this case the KCPE marks, was found not to be significant in affecting the Physics Achievement post-test mean scores [F (1,163) =1.29, p=.258, Partial Eta squared=.008].The covariate only influenced only 0.8% of the variances in the groups. The ANCOVA test did not however reveal where the differences in the variances among the groups were. There was therefore need for the multiple comparison test to reveals where the differences were. The results of the Post Hoc are given in Table 24.

Table 24:
The ANCOVA Multiple Comparisons on Students Physics Achievement Post-test Mean Scores

Paired Group	Mean Difference	p-value
E1 versus E2	1.162	0.451
E1 versus C1	22.41	0.000*
E1 versus C2	24.72	0.000*
E2 versus C1	21.24	0.000*
E2 versus C2	23.55	0.000*
C1 versus C2	2.31	0.131

*Significant at 0.05 level; $\rho<.05$

The results in Table 24 reveal that the differences between paired groups E1-C1 ($\rho < 0.05$), E1-C2 ($\rho < 0.05$), E2-C1 ($\rho < 0.05$) and E2-C2 ($\rho < 0.05$) were significant at the 0.05 level. However, the differences between groups E1-E2 ($\rho > 0.05$) and C1-C2 ($\rho > 0.05$) were not significant. This indicates that the significant differences were due to the IMSAO teaching approach. Further Comparison of PAT post-test means for combined experimental groups and combined control groups was done using a t-test to establish the effect of IMSAO on physics achievement.

4.3.1 Comparison of the Students' Physics Achievement Post-test Mean Scores between the Experimental and Control Groups

Further analysis was done to establish whether there were any significant differences between post-test mean score of the treatment groups (E1 and E2 combined) and control groups (C1and C2 combined). The comparison was conducted using the t-test and the results given in Table 25.

Table 25:
Comparison of the Students' Physics Achievement Post-test Mean Scores between the Experimental and Control Groups

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Achievement	Experimental	82	53.04	5.67	166	21.60	0.000*
	Control	86	29.86	7.98			

Critical values (df = 166, t =1.962, ρ=0.05)
Calculated values (df = 166, t =21.60, ρ=0.000); $\rho <.05$; *significant

The results in Table 25 show that the Physics Achievement post-test mean (M = 53.04, SD = 5.67) score of the combined experimental groups was higher than that of combined control groups (M = 29.86, SD = 7.98). The difference between the means of the two groups was significant at the 0.05 level in favour of the experimental groups, t (166) = 21.60, $\rho < 0.05$. A PAT mean gain analysis was further carried out for groups E1 and C1 to establish the effect of IMSAO on physics achievement mean gains.

4.3.2 Comparison of Students Physics Achievement test Mean Gain by Teaching Approach

The gain made by learners in the physics achievement test was obtained by getting the differences between the PAT pre-test and post-test mean scores of the groups E1 and C1. This gave an indication of the relative effects of treatment on study groups that were pre-tested. The results are summarized in Table 26.

Table 26:
Students' Physics Achievement Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains by Teaching Approach

Stage	Scale	Group	
		E1 N = 37	**C1 N = 36**
Pre-test	Mean	17.89	17.69
	Standard Deviation	3.60	6.18
Post –test	Mean	53.70	31.11
	Standard Deviation	5.79	8.17
	Mean Gain	**35.81**	**13.42**

The results in Table 26 show homogeneity of both the experimental and control groups at the stage of the pre-test in terms of the mean scores in the Physics Achievement Test. The means scores of groups E1 and C1 were 17.89 (SD = 3.60) and 17.69 (SD = 6.18) respectively. The two groups were therefore similar before the treatment was administered. After the treatment, the mean scores of E1 and C1 were 53.70 (SD = 5.79) and 31.11 (SD = 8.17) respectively. The increase in the physics achievement mean scores as measured by the mean gain was 35.81 for E1 and 13.42 for C1. This indicated that the experimental group mean score improved with a higher margin than that of the control group. A t-test was further carried out to determine whether the difference between the mean gains of the two groups were significant. The results of the t-test are indicated in Table 27.

Table 27:
Comparison of Students' Physics Achievement Mean Gain of E1 and C1

Group	N	Mean Gain	SD	df	t-value	ρ-value
E1	37	35.81	6.69	71	11.79	0.000*
C1	36	13.42	9.36			

Critical values (df = 71, t =1.99, ρ=0.05)
Calculated values (df = 71, t =11.79, ρ=0.000); ρ <.05; *significant

The results of the t-test indicate a significant difference between the mean gain (M = 35.81) of E1 and that of C1 (M =13.42), t (71) = 11.79, ρ < 0.05 in favour of E1. Since both groups were similar before the commencement of the treatment, the major improvement in the mean scores of E1 was could be attributed to the treatment. From all analysis done to compare the effect of IMSAO and CTM on physics achievement, the results have shown statistically significant differences in post-test PAT means in favour of the experimental groups. The null hypothesis (Ho1), which stated that there is no statistically significant difference in physics achievement between the students exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) and those exposed to Conventional Teaching Methods (CTM) was therefore consequently rejected at .05 level of significance. This therefore means that IMSAO had a positive impact in the physics achievement in the experimental groups.

4.3.3 Discussion on Students' Physics Achievement by Teaching Approach

The study established that students taught though IMSAO teaching approach achieved significantly higher scores in the PAT than those taught through CTM. The results of ANOVA, ANCOVA, and gain analysis showed statistical significant differences in PAT mean scores between the experimental groups and control groups, in favour of the experimental groups. This is a pointer that IMSAO teaching approach was more effective in improving students' Physics achievement as compared to the Conventional Teaching Methods. The approach provided learners with a conducive learning environment where they could virtually manipulate and take measurements of various objects in a simulated manner. Due to its interactive nature, the students were given immediate feedback on the successes and failures in the simulated activity. The approach also gave students a chance to repeat given tasks until they mastered the skill. This enabled all learners to do a lot of practice in measurement topic resulting to better comprehension of concepts and consequently improved physics achievement. Since IMSAO teaching approach appears to improve achievement in physics when compared to the conventional teaching methods, it should therefore be used in the teaching of physics in secondary schools to reverse the current trend of low achievement in the subject.

The findings of the study are in tandem with researches carried out by Holec, Spodniaková and Raganová (2004). Their study used interactive computer simulations to teach the physics topics mechanics in secondary schools in Slovak Republic. A test was given and the effect of interactive computer simulations on student performance was compared with performance of students not exposed to the treatment. The results indicated that integration of computer simulations into school physics influenced students' level of physics knowledge positively. A similar study was carried out to investigate the contribution of an interactive computer simulation to students´ learning of physics concepts (weight and mass) by Cândida, José and Armando (2014). They evaluated the progresses in understanding made by students in three different scenarios: using only "hands-on" activities, using only a computer simulation, and using both. Their findings indicated that the total gains were higher when students used the computer simulation alone or together with "hands-on" activities. These results relate with the findings of the present study on IMSAO which was found to improve the physics achievement.

The results of the present study also agree with the findings of the research conducted in Kenya by Jesse, Twoli and Maundu (2014). In their study, they found out that physics performance is enhanced when the subject is taught using interactive computer assisted instruction. The findings are also in agreement with the observations made by Rupe (1986) who found out that the use of interactive computer programs in the instruction enhances learning rate leading to better performance. Additionally, Fraser and Walberg (1995) observed that the use of computers for instruction resulted in increased student interest, cooperation, achievement in science, and coverage of science curriculum.

Similar researches carried out by Kara (2008), which investigated the retention effect of computer assisted instruction on students' academic achievement for teaching the topics Force and Pressure in physics, indicated a positive effect. This concurs with the findings of the present study. Altun, Yiğit and Alev (2007) equally found out that computer assisted instruction and simulations in teaching of physics is more feasible than the traditional approaches in terms of cognitive and affective behaviours. According to their study, Students' perceptions about physics before and after the applications of the interactive computer instruction significantly changed positively. Sarı and Güven (2013) used inquiry learning with interactive computer simulations and found out that that the interactive simulation reinforced inquiry-based learning and resulted to high students' academic achievement and motivation compared to traditional methods. Rutten, van Joolingen and Van der Veen (2012) studied a total of 510 articles published between 2001 and 2010 that had investigated the effect of simulations on science teaching. It was found that all of the analysed articles reported that the use of simulations has positive effects on science teaching.

Other investigations have however reported less impressive results in the use of computer simulations in science teaching. Some of them found no advantage in using computer simulations over traditional methods (Winn *et al.,* 2006).Other studies also showed that the use of computer simulations was less effective than traditional instruction and hands-on laboratory strategies in improving achievement in science (Abdulwahed &Nagy, 2011). Even when the gains made by students were shown through the use of technologies such as computer simulations, these researchers argued that the gains should be attributed to effective teaching methods and effects of teachers. In addition, Abdulwahed and Nagy (2011) recommended that computer simulations might be most effective when they are integrated as a complementary part of a course involving "hands-on" activities. This was the case with the IMSAO teaching approach which helped learners to effectively handle and use the real apparatus after exposure to the interactive simulations.

The results of the present study indicated a positive impact in physics achievement when Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach was used in comparison with the Conventional Teaching Methods. The IMSAO teaching approach therefore improved the physics achievement.

4.4 Difference in Students Motivation to Learn Physics by Teaching Approach

The second objective sought to compare students' motivation to learn physics between students exposed to IMSAO teaching approach and those taught using Conventional Teaching Methods (CTM). The analysis of the second hypothesis which stated that there is no statistically significant difference in motivation to learn physics between the students exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) and those exposed to Conventional Teaching Methods (CTM) was carried out.The Physics Motivation

Questionnaire (PMQ) post-test means were analysed to determine the differences in the experimental and the control groups (E1, E2 C1and C2) that took part in the study. Table 28 gives the descriptive statistics on the post-test PMQ scores for the four groups.

Table 28:
Students' Physics Motivation Post-test Mean Scores and their Standard Deviations

Group	N	Mean	Std. Deviation
E1	37	4.531	0.099
E2	45	4.525	0.109
C1	36	2.655	0.156
C2	50	2.671	0.160

The results of Table 28 indicated that the post-test PMQ scores for the experimental groups E1 (M = 4.531, SD = 0.099) and E2 (M = 4.525, SD= 0.109) were higher than those of the control groups C1 (M = 2.655, SD = 0.156) and C2 (M = 2.671, SD = 0.160). The standard deviation was greater in the control groups than in the experimental groups indicating that the PMQ scores for individual students in the control groups varied greatly from each other. Given the differences in the Means Scores of the PMQ between the Experimental and the Control groups in favour of experimental groups as indicated in Table 28, there was need for further analysis to test whether the differences were statistically significant. Comparison of Students' Physics Motivation Post-test Mean Scores by Teaching Approach was done using ANOVA.

4.4.1 Comparison of Students' Physics Motivation Post-test Mean Scores by Teaching Approach

In order to find out whether the differences among the PMQ post-test mean scores of the groups were statistically significant, an ANOVA test was conducted. The results are as shown in Table 29.

Table 29:
Comparison of Students' Physics Motivation Post-test Mean Scores by Teaching Approach

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	145.71	3	48.57	2678.51	.000*
Within Groups	2.97	164	.018		
Total	148.68	167			

Critical values (df = 3, 164; F =2.65; ρ=0.05)
Calculated values (df = 3, 164; F =2678.51, ρ=0.000); ρ <.05; *significant

The ANOVA test results in Table 29 revealed that the difference in physics motivation post-test mean scores for the four groups E1, E2, C1 and C2 was significant at the α = .05 level, in favour of the experimental groups, F(3, 164) = 2678.51, ρ < 0.05. The ANOVA test did not however indicate where the differences in the means were in the groups. This called for further analysis by use of post hoc test to identify where the differences occurred. The Least Significant Differences (LSD) test was used. The test is suitable in cases where the number of subjects in the groups studied is small. The results are summarized in Table 30.

Table 30:
Multiple Comparison of Physics Motivation Post-test Mean Scores by Teaching Approach

Paired Group	Mean Difference	ρ-value
E1 versus E2	0.005	.856
E1 versus C1	1.875	.000*
E1 versus C2	1.859	.000*
E2 versus C1	1.870	.000*
E2 versus C2	1.854	.000*
C1 versus C2	0.017	.572

*Significant at .05 level; ρ < 0.05

The LSD Post-hoc results in Table 30 further indicated significant differences between the physics motivation post-test mean scores of the experimental groups (E1 & E2) and control groups (C1 & C2). To level out any initial differences in the groups, KCPE scores of the students, which is an indirect indicator of the level of motivation to learn physics, was used as a covariate to adjust the PMQ mean score. Analysis of Covariance (ANCOVA) test was then carried out on the adjusted PMQ mean scores. The adjusted physics motivation post-test mean scores with KCPE marks as the covariate are summarized in Table 31.

Table 31:
Adjusted Physics Motivation Post-test Mean Scores with KCPE Scores as the Covariate

Teaching approach	Mean	Std. Error
E1	4.529	0.022
E2	4.525	0.020
C1	2.658	0.022
C2	2.671	0.019

The results in Table 31 show that the adjusted physics motivation post-test mean scores of the experimental groups E1 (M = 4.529) and E2 (M= 4.525) were still higher than those of the control groups C1 (M = 2.658) and C2 (M = 2.671) on a Likert scale of 1 to 5. This means that the groups exposed to IMSAO teaching approach had higher PMQ scores in comparison to those exposed to CTM. The ANCOVA analysis was conducted on the adjusted PMQ means in order to find out whether the difference among the PMQ post-test mean scores were statistically significant while factoring in the KCPE marks as the covariate. The results of the ANCOVA test are contained in Table 32.

Table 32:
ANCOVA Test on Adjusted Students' Physics Motivation Post-test Mean Scores by Teaching Approach

Scale	Sum of squares	df	Mean Square	F-ratio	ρ-value	Partial Eta Squared
KCPE	.04	1	.04	2.43	.121	.015
GROUP	145.00	3	48.33	2688.77	.000*	.980
Error	2.93	163	.02			

Critical values (df = 3, 163; F =2.65; ρ=0.05)
Calculated values (df = 3, 163; F =2688.77, ρ=0.000); ρ <.05; *significant

The results in Table 32 showed that the differences among the groups are significant in favour of the experimental groups [F (3,163) =2688.77, ρ =.000, Partial Eta squared=.980]. The effect size, as indicated by the corresponding Partial Eta squared value showed that much of the variance in the Physics Motivation Post–test mean scores could be explained by the teaching approach. The value in this case was 0.980 which translates to 98 % contribution to the differences in variances in the groups. The effect of the covariate, in this case the KCPE scores, was found not to be statistically significant in affecting the Physics Motivation post-test mean scores [F (1,163) =2.43, ρ =.121, Partial Eta squared=.015].The covariate therefore only influenced 1.5% of the variances in the groups. The ANCOVA test did not however reveal where the differences in the variances among the groups were hence the need for multiple comparison (Post Hoc) test to reveals where the differences were. The results of the LSD multiple comparison tests are given in Table 33.

Table 33:
The ANCOVA Multiple Comparisons on Adjusted Students Physics Motivation Post-test Mean Scores

Paired Group	Mean Difference	ρ -value
E1 versus E2	0.004	0.892
E1 versus C1	1.871	0.000*
E1 versus C2	1.858	0.000*
E2 versus C1	1.867	0.000*
E2 versus C2	1.854	0.000*
C1 versus C2	0.012	0.672

*Significant at .05 level; $\rho < 0.05$

The results in Table 33 shows that the differences between paired groups E1-C1 ($\rho < 0.05$), E1-C2 ($\rho < 0.05$), E2-C1 ($\rho < 0.05$) and E2-C2 ($\rho < 0.05$) were significant at the 0.05 level. However, the differences between groups E1-E2 ($\rho > 0.05$) and C1-C2 ($\rho > 0.05$) were not significant. The differences between the experimental and the control groups PMQ mean scores were therefore statistically significant in favour of the experimental groups. Further comparison of PMQ post-test mean scores between the combined experimental groups and the combined control groups was carried out using a t-test.

4.4.2 Comparison of Physics Motivation Post-Test Mean Scores between the Experimental and Control groups

Analysis was further done to establish whether there were any significant differences between physics motivation post-test mean score of the treatment groups (E1 and E2 combined) and control groups (C1and C2 combined). The comparison was conducted using the t-test and the results given in Table 34.

Table 34:
Differences in Students' Physics Motivation Post-test Mean Scores between the Experimental and Control Groups

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Motivation	Experimental	82	4.53	0.103	166	21.60	0.000*
	Control	86	2.66	0.157			

Critical values (df = 166, t =1.962, ρ=0.05)
Calculated values (df = 166, t =21.60, ρ=0.000); ρ <.05; *significant

The results in Table 34 show higher Physics Motivation post-test mean (M = 4.53, SD = 0.103) of the experimental groups than that of control groups (M = 2.66, SD = 0.157). The difference between the means of the two groups was found to be significant at the 0.05 level in favour of the experimental groups, t (166) = 21.60, $\rho < 0.05$. This means that student exposed to IMSAO had a higher motivation to learn physics than those exposed to the CTM. The statistically significant differences in the motivation to learn physics may be attributed to IMSAO. Additional analysis was done to compare the PMQ mean gain by teaching approach of E1 and C1.

4.4.3 Comparison of Students Physics Motivation Mean Gain by Teaching Approach

The gain made by learners in the Physics Motivation test was obtained by getting the differences between the pre-test and post-test mean scores of the groups E1 and C1. This gave an indication of the relative effects of treatment on the motivation to learn physics on the studied groups. The results are summarized in Table 35.

Table 35:
Students' Physics Motivation Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains by Teaching Approach

Stage	Scale	Group	
		E1 N = 37	**C1 N = 36**
Pre-test	Mean	2.671	2.661
	Standard Deviation	0.197	0.167
Post –test	Mean	4.531	2.655
	Standard Deviation	.099	0.156
	Mean Gain	**1.86**	**-0.006**

The results in Table 35 show similarity in the motivation to learn physics for both the experimental and control groups at the stage of the pre-test in terms of the mean scores in the Physics Motivation. The means scores of groups E1 and C1 were 2.671 (SD = 0.197) and 2.661 (SD = 0.167) respectively. The two groups were therefore relatively homogenous before the treatment was administered. After the treatment, the mean scores of E1 and C1 were 4.531 (SD = 0.099) and 2.655 (SD = 0.156) respectively. The increase in the Physics Motivation mean scores as measured by the mean gain was 1.86 for E1 and -0.006 for C1. This indicated that the experimental group (E1) mean scores improved while that of the control1group (C1) dropped. A t-test was further carried out to determine whether the difference between the mean gains of the two groups were significant. The results of the t-test are given in Table 36.

Table 36:
Comparison of Students' Physics Motivation Mean Gain of E1 and C1

Group	N	Mean Gain	SD	df	t-value	ρ-value
E1	37	1.859	0.207	71	33.83	0.000*
C1	36	-0.006	0.262			

Critical values (df = 71, t =1.99, ρ=0.05)
Calculated values (df = 71, t =33.83, ρ=0.000); ρ <.05; *significant

The results of the t-test indicated a significant difference between the mean gain (M = 1.859) of E1 and that of C1 (M =-0.006), t (71) = 33.83, $\rho < 0.05$ in favour of E1. Since both groups were similar before the commencement of the treatment, the major improvement in the Physics Motivation mean scores of E1 was attributed to the treatment (IMSAO teaching

Approach). Use of IMSAO increased the self-efficacy of learners making them more motivated to learn physics than their counterparts taught through CTM.

Since all analysis carried out indicated statistically significant differences in PMQ mean scores between the experimental and the control groups, in favour of the experimental groups, the second null hypothesis (Ho2) which stated that there is no statistically significant difference in motivation to learn physics between the students exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) and those exposed to Conventional Teaching Methods (CTM) was consequently rejected at .05 level of significance. This indicates that IMSAO teaching approach enhanced the students' motivation to learn physics.

4.4.4 Discussion on Student Motivation to Learn Physics by Teaching Approach

All statistical tests showed statistically significant differences in motivation to learn physics between student exposed to IMSAO and those exposed to CTM. This is an indication that IMSAO teaching approach affected students' motivation to learn physics positively when compared to CTM.

The findings of the present study agrees with results of a similar study carried out by Cracker (2006) which associated students' motivation towards physics courses with the methods of teaching. According to his study, students are motivated to learn physics if they know how to plan and implement the strategies of solution to the question through innovative and learner centred teaching methods. The IMSAO teaching approach was interesting to the learners and they found it enjoyable to carry out simulated physics activities. This motivated them to learn physics and gain self-efficacy.

Student motivation towards physics plays a powerful role in how they think about using problem-solving method in their physics or any science class (Levin *et al.*, 2012). Using virtual laboratories and simulations in physics education was found to increases student motivation and provides a fun learning environment in a research carried out by Arvind and Heard (2010). In their study, they found out that teaching physics through interactive simulations resulted to a positive impact on students' academic achievement and their motivation to learn physics. This agrees with the present study findings on the use of IMSAO teaching approach which made physics learning to be fun. The students were highly motivated to learn physics and this was evidenced by the increased frequency with which they visited the computer labs even at their own free time to experiment with the interactive simulations. Oloruntegbe & Alam, (2010) also found out that virtual laboratories make learning physics concepts less complicated, and are effective in changing students' negative perceptions of the course. Similarly, Tüysüz, (2010) in his research states that virtual laboratories positively affect students' motivation towards the course.

A research carried out by Marilyn *et al*., (2010) also indicated that participative engagement by learners creates an enjoyable environment, which provides the catalyst for active learning and conceptualization in science. Their study revealed that students taught using computer assisted instructions looked keen and showed a lot of interest during lessons. They were curious to observe what was coming next and highly motivated to learn science. This sort of expectation created readiness to learn and hence to be engaged. This is in agreement with the results of the present study, which indicated that IMSAO teaching approach which incorporated interactive computer simulations and advance organisers enhanced students' motivation to learn physics.

Another study done by Neumann, Hood, & Neumann (2012) showed that the simulation software teaching programs provide immediate feedback and practice with useful visuals which create relevant lessons, providing students with the motivation to actively participate in the learning process. When students learn science through simulations, videos, graphics, animations, audio and other multimedia learning elements, they have the potential to engage, which ensures their effective participation in the learning process. Further research by Özan & Ozdemir (2010) revealed that the use of multimedia content increase students' motivation in learning. All these researches support the findings of the present study on the use of IMSAO teaching approach.

From a research done by Uğur (2017) on use of interactive multimedia simulations on motivation to learn physics, majority of students stated that simulations made physics lessons interesting, focused their attention on learning, provided beautiful diagrams and they enjoyed doing simulations on computers. Students also gave the view that simulations are more effective in understanding of physics concepts. All these opinions showed that computer simulations have positive effects on students' beliefs and perceptions towards learning physics. Students have a more positive attitude to teaching with computer simulations in terms of contributions to their motivation. Sari, Ulukök and Özdemir (2013) indicated that simulation applications have more positive effects on students' attitudes towards science lessons compared to traditional instructions.

Interactive Multimedia simulation is an innovative and effective teaching and learning tool, that helps students to be motivated in the learning process and helps them understand the information presented (Neo & Neo, 2001). Since there are many abstract concepts in physics content, students find it hard to visualise the concepts and thus have difficulty learning them. In order to change this perception about physics subject, it is necessary to make use of technology which concretizes abstract concepts. Learners should be active participants in the teaching and learning process instead of being passive. The results of all the discussed findings concurs with the results of the present study which indicate that IMSAO teaching approach increased students' motivation to learn physics.

4.5 Difference in Physics Achievement by Gender of Students Exposed to IMSAO

The third objective aimed to compare physics achievement of boys and girls when exposed to IMSAO teaching approach. The analysis of the third hypothesis which stated that there is no statistically significant difference in achievement in physics between boys and girls exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) was done. The physics achievement post-test mean scores of boys and girls exposed to IMSAO teaching approach were analysed using t-test. From the literature reviewed, when Conventional Teaching Methods have been used, there has been a significant difference in achievement by gender in favour of boys. There was therefore need to analyse whether the use of IMSAO teaching approach could close the gap of gender disparity in physics achievement in secondary schools.

4.5.1 Difference in Physics Achievement by Gender in Experimental Groups

The physics achievement post-test mean scores of the male and female students in the experimental groups (E1 & E2) were considered. The t-test was done to establish whether the means score for the male and female students in the experimental groups were significantly different. The results are contained in Table 37.

Table 37:
Comparison of the Students' Physics Achievement Post-test Mean Scores by Gender between the Experimental Groups E1 and E2

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Achievement	Male (E1&E2)	43	52.93	5.68	80	0.177	0.860
	Female (E1 & E2)	39	53.15	5.73			

Critical values (df = 80, t =1.99, ρ=0.05)
Calculated values (df = 80, t =0.177, ρ=0.860); ρ >.05; not significant

The results in Table 37 indicated that male (M=52.93) and female (M=53.15) students' physics achievement post-test mean score were not statistically significantly different at .05 level (t (80) =0.177, ρ=.860). The results indicate that physics achievement is not significantly affected by student's gender when using IMSAO teaching approach. Since pre-test PAT analysis had indicated a significant difference between the physics achievement of boys and girls in favour of boys, the non-significant difference in post-test PAT can be attributed to IMSAO teaching approach.

IMSAO teaching approach, due to its visual interactive nature, equally helped both boys and girls to understand the Measurement concepts, which consequently improved their achievement in PAT. To rule out whether this non-statistically significant difference was due to their initial entry point, comparison of post-test mean scores by gender was done using the ANCOVA with the KCPE scores as the covariate. The adjusted mean scores with KCPE as the covariate are in Table 38.

Table 38:
Students Exposed to IMSAO Adjusted Physics Achievement Post-test Mean Scores with KCPE as the Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Achievement	Male	43	52.74	0.886
	Female	39	53.36	0.932

The results in Table 38 reveals that the adjusted male students mean scores on physics achievement post-test (M = 52.74) were comparable with those of the female students (M =

53 .36). This was confirmed by the ANCOVA results with KCPE scores used as covariates in Table 39.

Table 39:
Differences between Physics Achievement Adjusted Post-test Mean Scores of Male Students Exposed to IMSAO and that of their Female counterparts

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Achievement	Contrast	7.326	1	7.326	.226	.636
	Error	2564.682	79	32.464		

Critical values (df = 1, 79; F =3.96; ρ=0.05)
Calculated values (df = 1, 79; F =0.226, ρ=0.636); ρ >.05; not significant

The results of the ANCOVA test showed that the difference between the mean scores of the male and female students on Physics Achievement Post-test was not significant at .05 level, (F (1, 79) = 0.226, p= .636).

Based on these results, the null hypothesis (Ho3) which stated that there is no statistically significant difference in physics achievement between boys and girls exposed to IMSAO teaching approach was accepted at .05 level of significance. This is an indication that IMSAO teaching approach has an effect of improving physics achievement for both boys and girls.

To further ascertain that the non-statistically significant difference between boys and girls post-test PAT mean score was purely due to the IMSAO teaching approach, similar comparative tests were done on boys and girls in the control groups. A t-test was carried out to determine whether the physics achievement post-test PAT mean scores were significant for the male and female students in the control groups. The results are as shown in Table 40.

Table 40:
Comparison of the Students' Physics Achievement Post-test Mean Scores by Gender between the Controls groups (C1 and C2 combined)

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Achievement	Male (C1 and C2	44	30.45	9.25	84	0.704	0.483
	Female (C1 and C2	42	29.24	6.45			

Critical values (df = 84, t =1.984, ρ=0.05)
Calculated values (df = 84, t =0.704, ρ=0.483); ρ >.05; not significant

Male students' physics achievement post-test mean scores in the control groups (M= 30.45, SD=9.25) was found not to be significantly different from that of female students' (M= 29.24, SD=6.45) at .05 level (t (84) =0.704, ρ=.483). Comparison of post-test mean scores by gender for students in the control groups was done using the ANCOVA with the KCPE scores as the covariate. The adjusted mean scores with KCPE as the covariate are in Table 41.

Table 41:
Students Not Exposed to IMSAO Adjusted Physics Achievement Post-test Mean Scores with KCPE as the Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Achievement	Male	44	30.71	1.211
	Female	42	28.97	1.240

The physics post-test mean scores for the male students in the control groups (M=30.71) was found to be comparable with the physics achievement post-test mean scores of their female counterparts (M=28.97). The ANCOVA test results confirmed this as shown in Table 42.

Table 42:

Differences between Physics Achievement Adjusted Post-test Mean Scores of Male Students Not Exposed to IMSAO and that of their Female counterparts

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Achievement	Contrast	62.595	1	62.595	.990	.323
	Error	5246.919	83	63.216		

Critical values (df = 1, 83; F =3.95; ρ=0.05)
Calculated values (df = 1, 83; F =0.990, ρ=0.323); ρ >.05; not significant

The results in Table 42 indicates that the there is a non-statistically significant difference in physics achievement test post-test mean scores between the male students and female students in the control groups, (F (1, 83) = 0.990, p= .323).This indicated that even in the control groups, the physics achievement in PAT was not significantly different. This called for further tests on the post-test PAT mean scores for boys in the experimental groups and girls in the control groups. A t-test was carried out and the results given in Table 43.

Table 43:
Difference in Physics Achievement Post-test Mean Scores by Gender between Males in Experimental Groups and Females in Control Groups

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Achievement	Male (E1 & E2)	43	52.93	5.68	83	17.99	0.000*
	Female (C1&C2)	42	29.24	6.45			

Critical values (df = 83, t =1.984, ρ=0.05)
Calculated values (df = 83, t =17.99, ρ=0.000); ρ <.05; *significant

An examination of the results of the t-test indicated a significant difference between the physics achievement post-test mean scores of the male students in the experimental (E1 &E2) groups (M= 52.93, SD=5.68) and of female students in the control (C1&C2) groups (M= 29.24, SD=6.45) at .05 level (t (83) =17.99, ρ<.05). The male students in the experimental groups had a significantly higher physics achievement post-test means score than their female counterparts in the control groups. This is an indication that the IMSAO teaching approach affected positively the students' physics achievement. To find out whether the entry behaviour had an effect on the difference between the physics achievement post-test mean scores for the compared groups, ANCOVA test was done, with the KCPE scores as a covariate. The adjusted physics achievement post-test mean scores with KCPE as the covariate are in Table 44.

Table 44:
Adjusted Physics Achievement Post-test Mean Scores by Gender between Males in Experimental Groups and Females in Control Groups with KCPE as a Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Achievement	Male	43	52.96	0.949
	Female	42	29.21	0.961

The adjusted physics post-test mean scores for the male students in the experimental groups (M=52.96) was found to be higher than the adjusted physics achievement post-test mean scores of the female students in the control groups (M=29.21). The ANCOVA test results confirmed this difference as shown in Table 45.

Table 45:
Differences between Physics Achievement adjusted Post-test Mean Scores of Male Students in Experimental Groups and Female Students in the Control Groups

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Achievement	Contrast	11117.05	1	11117.05	298.17	.000*
	Error	3057.36	82	37.29		

Critical values (df = 1, 82; F =3.95; ρ=0.05)
Calculated values (df = 1, 82; F =298.17, ρ=0.000); ρ <.05; *significant

The results from Table 45 indicates a significant difference in physics achievement post-test mean scores between the male students in the experimental groups and female students in the control groups, (F (1, 82) = 298.17, $p < .05$). This indicated that male students exposed to IMSAO approach had significantly better physics achievement post-test mean scores than the female students not exposed to the IMSAO teaching approach. KCPE scores had insignificant effect on the physics achievement post-test mean scores as a covariate. Since pre-test results had indicated a statistically significant difference in PAT scores in favour of boys, further analysis was done to establish whether girls exposed to IMSAO were better in physics achievement than boys exposed to CTM. Additional analysis was therefore done using a t-test to establish whether there were statistically significant differences in the post-test mean scores between the male students in the control groups and the female students in the experimental groups. The results are contained in Table 46.

Table 46:
Differences in Physics Achievement Post-test Mean Scores by Gender between Males in Control Groups and Females in Experimental Groups

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Achievement	Male (C1&C2)	44	30.45	9.25	81	13.23	0.000*
	Female (E1 & E2)	39	53.15	5.73			

Critical values (df = 81, t =1.984, ρ=0.05)
Calculated values (df = 81, t =13.23, ρ=0.000); ρ <.05; *significant

Table 46 results indicated a significant difference between the physics achievement post-test mean scores of the male students in the control (C1 & C2) groups (M= 30.45, SD=9.25) and of female students in the experimental (E1& E2) groups (M= 53.15, SD=5.73) at .05 level (t (81) =13.23, ρ<.05). The female students in the experimental groups had a significantly higher physics achievement post-test means score (M=53.15) than their male counterparts (M=30.45) in the control groups. This indicated that the IMSAO teaching approach affected positively the students' physics achievement in both boys and girls. To find out whether the entry behaviour influenced the differences between the physics achievement post-test mean scores in the compared groups, ANCOVA test was done with the KCPE scores as a covariate. The adjusted physics achievement post-test mean scores with KCPE as the covariate are in Table 47.

Table 47:
Adjusted Physics Achievement Post-test Mean Scores by Gender between Females in Experimental Groups and Males in Control Groups with KCPE as a Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Achievement	Male	44	30.64	1.187
	Female	39	52.95	1.262

The adjusted physics post-test mean scores for the female students in the experimental groups (M=52.95) was found to be different from the adjusted physics achievement post-test mean scores of the male students in the control groups (M=30.64). The ANCOVA test was done to establish whether the difference was significant as shown in Table 48.

Table 48:
Differences between Physics Achievement adjusted Post-test Mean Scores of Female Students in Experimental Groups and Male Students in the Control Groups

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Achievement	Contrast	9854.76	1	9854.76	162.323	.000*
	Error	4856.88	80	60.71		

Critical values (df = 1, 80; F =3.96; ρ=0.05)
Calculated values (df = 1, 80; F =162.323, ρ=0.000); ρ <.05; *significant

The results in Table 48 indicates a significant difference in physics achievement post-test mean scores between the male students in the control groups and female students in the experimental groups, (F (1, 80) = 162.323, p <.05) in favour of the female students. This indicated that female students exposed to IMSAO approach had significantly better physics achievement post-test PAT mean scores than the male students exposed to CTM. KCPE scores did not significantly affect the physics achievement post-test mean in the compared groups. The results indicate that the IMSAO teaching approach affected positively the Physics achievement post-test mean scores.

Further analysis was conducted to establish whether there were significant differences in the mean gains in the physics achievement by gender between male and female students exposed to IMSAO teaching approach. The gain made by students in the physics achievement test was obtained by getting the differences between the pre-test and post-test mean scores of the male and female students in group E1 .This indicated the relative effects of IMSAO teaching approach on experimental group E1 by gender. The results are summarized in Table 49.

Table 49:
Students' Physics Achievement Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains in the Experimental group E1 by Gender

Stage	**Scale**	**Gender**	
		Male N = 18	**Female N = 19**
Pre-test	Mean	19.94	15.95
	Standard Deviation	2.92	3.12
Post –test	Mean	53.67	53.74
	Standard Deviation	5.95	5.79
	Mean Gain	**33.73**	**37.79**

The results in Table 49 show a higher mean gain in the Physics Achievement Test for both male and female student exposed to IMSAO teaching approach. The male students mean score rose from 19.94 (SD=2.92) in the pre-test to 53.67 (SD=5.95) in the post-test while the female students mean score rose from 15.95 (SD=3.12) in the pre-test to 53.74 (SD=5.79) in the post-test. To find out whether the mean gains in the physics achievement by gender were significantly different, a t–test was carried out and the results given in Table 50.

Table 50:
Comparison of Students' Physics Achievement Mean Gain by Gender in Group E1

Gender	N	Mean Gain	SD	df	t-value	ρ-value
Male	18	33.73	5.76	35	1.917	0.063
Female	19	37.79	7.04			

Critical values (df = 35, t =2.021, ρ=0.05)
Calculated values (df = 35, t =1.917, ρ=0.063); ρ >.05; not significant

The results of the t-test indicate there was no significant difference between the mean gain (M = 33.73) of male students in the physics achievement and that of female students (M =37.79), t (35) = 1.917, ρ > 0.05. The results therefore indicate that IMSAO teaching approach positively affected their mean gain for both gender in the physics achievement. To fully establish whether it was the treatment that resulted to non-significant differences in the physics achievement mean gain by gender, similar tests were carried out on the control group (C1) that was subjected to pre-test and post-test. The gain made by students in the physics achievement test was obtained by getting the differences between the pre-test and post-test PAT mean scores of the male and female students in group C1. The results are contained in Table 51.

Table 51:

Students' Physics Achievement Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains in the Control Group C1 by Gender

Stage	Scale	Gender	
		Male N = 18	**Female N = 18**
Pre-test	Mean	19.50	15.89
	Standard Deviation	5.079	6.77
Post –test	Mean	30.39	31.83
	Standard Deviation	9.51	6.77
	Mean Gain	**10.89**	**15.94**

The results in Table 51 indicate marginal mean gains in the Physics Achievement Test for both male and female students in the control group. The male students mean score rose from 19.50 (SD=5.079) in the pre-test to 30.39 (SD=9.51) in the post-test while the female students mean score rose from 15.89 (SD=6.77) in the pre-test to 31.83 (SD=6.77) in the post-test. To find out whether the mean gains in the physics achievement by gender were significantly different in the control groups, a t–test was carried out and the results given in Table 52.

Table 52:
Comparison of Students' Physics Achievement Mean Gain by Gender in Group C1

Gender	N	Mean Gain	SD	df	t-value	ρ-value
Male	18	10.89	9.86	34	1.660	0.106
Female	18	15.94	8.34			

Critical values (df = 34, t =2.021, ρ=0.05)
Calculated values (df = 34, t =1.660, ρ=0.106); ρ >.05; not significant

The results of the t-test indicate there was no significant difference between the mean gain (M = 10.89) of male students in the physics achievement and that of female students (M =15.94), t (34) = 1.660, ρ > 0.05 in the control group C1. The mean gains were however less in comparison with the mean gains by gender in the experimental group E1. Since pre-test results had indicated a statistically significant difference in physics achievement by gender between students exposed to IMSAO teaching Approach and those exposed to CTM in favour of girls, the results affirms that the significant difference in the Physics achievement was due to the treatment. The results of these analyses therefore indicate that IMSAO teaching approach positively affected the mean gain for both gender in the physics achievement.

4.5.2 Discussion on Physics Achievement by Gender

The t-tests carried out on PAT post-test scores of the male and female students in the experimental groups indicated a statistically non-significant difference. This implies that the IMSAO teaching approach had an equal positive impact on physics achievement in both boys and girls. Further results analysis using t-test showed a significant statistical difference in physics achievement post-test mean scores between the male students in the experimental groups and female students in the control groups. This indicated that male students exposed to IMSAO approach had significantly better physics achievement post-test mean scores than the female students not exposed to the IMSAO teaching approach. Similar analysis done using a t-test established significant differences in the PAT post-test mean scores between the male students in the control groups and the female students in the experimental groups in favour of the females in the experimental groups. These results revealed that both male and female students exposed to IMSAO outperformed their counterparts in the control groups.

Gender issues have been connected with performance of students in academic tasks in numerous studies but without any definite conclusion. Some findings indicated that significant differences existed between the performance of male and female students, while other findings showed that gender factor had no influence on students' performance. For instance, Annetta, Mangrum, Holmes, Collazo and Cheng (2009) reported that female students used computer more than their male counterparts, and males interacted more with the taught content than females when exposed to forces and motion topic in physics. A research by Anagbogu and Ezeliora (2007) found that girls performed better than boys in science process skills when computer simulations are used. This could be due to the use of innovative gender sensitive instructional methods which appealed to girls making them perform well. On the other hand, Ifamuyiwa and Akinsola (2008), Gambari (2010),Yusuf and Afolabi (2010) and Achuonye (2011) reported that gender has no influence in the academic performance of male and female students exposed to computer-assisted instruction in science subjects. The literature reviewed indicated girls having low physics achievement than boys. In Kenya, the KNEC (2018) report indicated low physics achievement by girls as compared to boys at KCSE. A replication of the same was reported in Nyahururu sub-county (Nyahururu Sub-county Education Report, 2018) where girls' physics achievement was noted to be lower than that of boys'. This might have been due due to use of traditional methods of teaching which favoured boys.

The findings of a study conducted by Kost-Smith, *et al.* (2010) indicated a correlation between students' achievement in physics and their gender. Moreover, their study showed that male students are more successful than their female peers in learning physics. This has been the case in Kenya where boys have posted higher achievement in KCSE physics than girls. This is also supported by Holzinger *et al.* (2009) study, which showed that males generally performed better in the more technically learning conditions with interactive simulations than their female counterparts. Gender stereotypes and use of teacher-centred methods of teaching favourable to boys may have contributed to this trend. However, a gender based comparative study of teaching physics through computer-assisted instruction and ordinary lecture method in secondary schools conducted by Hussain *et al.* (2014)

indicated that female students performed equally like the male students on a physics academic achievement test when computer assisted instruction was used.

The results of the present study on use of IMSAO teaching approach also agrees with the findings of Gambari *et al.* (2014) in Nigerian secondary schools which showed that there is no significant difference in the performance of the boys and girls in the use of computer-based simulation in the teaching of physics. In other words, the use of computer based simulations in the learning process was not discriminative of the student gender. The result of their study also indicated that the use of computer-based simulation in the teaching of physics enhanced the physics achievement of students regardless of their gender, which concurs with the findings of the present study.

The use IMSAO teaching approach equally improved physics achievement in both boys and girls. The lack of statistically significant differences in physics achievement between boys and girls exposed to IMSAO in the present study can therefore be attributed to the treatment (IMSAO), given that both male and female students were homogenous at the beginning of the treatment.

4.6 Difference in Motivation to Learn Physics by Gender of Students Exposed to IMSAO

The fourth objective compared the motivation to learn physics between boys and girls when exposed to IMSAO teaching approach. The analysis of the fourth hypothesis which stated that there is no statistically significant difference in motivation to learn physics between boys and girls exposed to Interactive Multimedia Simulation Advance Organizers (IMSAO) was carried out. The physics motivation questionnaire post-test means between boys and girls were analysed using t-test and ANCOVA.

4.6.1 Difference in Physics Motivation by Gender in Experimental Groups

The physics Motivation post-test mean scores of the male and female students in the experimental groups (E1 & E2) were considered. A t-test was done to establish whether the means score for the male and female students in the experimental groups were significantly different. The results are contained in Table 53.

Table 53:
Comparison of the Students' Physics Motivation Post-test Mean Scores by Gender between the Experimental Groups E1 and E2

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Motivation	Male	43	4.60	0.50	80	2.493	0. 15
	Female	39	4.85	0.37			

Critical values (df = 80, t =1.99, ρ=0.05)
Calculated values (df = 80, t =2.493, ρ=0.15); ρ >.05; not significant

The results in Table 53 indicated that male (M=4.60) and female (M=4.85) students' Physics Motivation Questionnaire (PMQ) post-test mean scores were not significantly different at .05 level (t (80) =2.493, ρ=.15). The results imply that students' motivation to learn physics was not affected by gender when IMSAO teaching approach was used. Both boys and girls in the experimental groups had the same level of motivation when exposed to IMSAO teaching approach. Additional analysis on the Physics Motivation Questionnaire post-test means score of the male and female students in the experimental groups was done to establish whether the results of the t-test were not significantly different due to any initial differences between boys and girls at their primary school level. Since students' motivation to learn had not been measured at that level, the KCPE scores, which indirectly indicated the level of motivation to learn, were used as covariate. Comparison of Physics Motivation post-test mean scores of boys and girls was done using the ANCOVA test with the KCPE scores as the covariate. The adjusted mean scores with KCPE as the covariate are in Table 54.

Table 54:
Students Exposed to IMSAO Adjusted Physics Motivation Post-test Mean Scores with KCPE as the Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Motivation	Male	43	4.510	0.016
	Female	39	4.547	0.017

The results in Table 54 reveals that the adjusted male students mean scores on Physics Motivation post-test (M = 4.510) were not very different from those of the female students (M = 4.547). Both boys and girls indicated high level of motivation on a Likert scale of 1 to 5. The result of ANCOVA analysis with KCPE scores as covariates is given in Table 55.

Table 55:
Differences between Physics Motivation Adjusted Post-test Mean Scores of Male Students Exposed to IMSAO and that of their Female Counterparts

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Motivation	Contrast	0.025	1	0.025	2.425	.123
	Error	0.823	79	0.010		

Critical values (df = 1, 79; F =3.96; ρ=0.05)
Calculated values (df = 1, 79; F =2.425, ρ=0.123); ρ >.05; not significant

The results of the ANCOVA test showed that the difference between the mean scores of the male and female students on Physics Motivation Post-test was not statistically significant at .05 level, ($F(1, 79) = 2.425$, $p = .123$). This is a signal that IMSAO teaching approach had the same effect on both boys' and girls' motivation to learn physics.

Based on these results, the null hypothesis (Ho4) which stated that there is no statistically significant difference in motivation to learn physics between boys and girls exposed to IMSAO teaching approach was accepted at .05 level of significance. This implies that IMSAO teaching approach enhances student motivation to learn physics in both boys and girls.

To fully establish that it is the IMSAO approach that resulted to equal enhancement of motivation to learn physics in boys and girls, additional comparative tests were carried out on males and female students in the control groups. A t-test analysis was carried out to determine whether the Physics Motivation post-test mean scores were significant for the male and female students in the control groups. The result is as shown in Table 56.

Table 56:

Comparison of the Students' Physics Motivation Post-test Mean Scores by Gender between the Control Groups (C1 and C2 combined)

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Motivation	Male	44	2.67	.167	84	0.418	0.677
	Female	42	2.66	.149			

Critical values (df = 84, t =1.984, ρ=0.05)
Calculated values (df = 84, t =0.418, ρ=0.677); ρ >.05; not significant

Male students' Physics Motivation post-test mean scores in the control groups (M= 2.67, SD=.167) was found not to be significantly different from that of female students' (M= 2.66, SD=.149) at .05 level (t (84) =0.418, ρ=.677). The physics motivation post-test mean scores were however lower than those of the experimental groups. Additional comparison of post-test mean scores by gender for students in the control groups was done using the ANCOVA with the KCPE scores as the covariate to establish whether the low physics motivation post-test means for both male and female students in the control group was influenced by their entry behaviour. The adjusted mean scores with KCPE as the covariate are in Table 57.

Table 57:
Students Not Exposed to IMSAO Adjusted Physics Motivation Post-test Mean Scores with KCPE as the Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Motivation	Male	44	2.68	.024
	Female	42	2.65	.025

The physics post-test mean scores for the male students in the control groups (M=2.68) was found not to be very different with the Physics Motivation post-test mean scores of their female counterparts (M=2.65).The Physics Motivation post-test mean scores of the control groups were however found to be lower than the means of the experimental groups in the Likert scale of 1 to 5. The ANCOVA test was done to establish whether there was any statistical significant difference in the PMQ adjusted post-test mean scores between boys and girls in the control group. The results are as indicated in Table 58.

Table 58:
Differences between Physics Motivation adjusted Post-test Mean Scores of Male Students Not Exposed to IMSAO and that of their Female counterparts

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Motivation	Contrast	0.011	1	0.011	.422	.518
	Error	2.069	83	0.025		

Critical values (df = 1, 83; F =3.95; ρ=0.05)
Calculated values (df = 1, 83; F =0.422, ρ=0.518); ρ >.05; not significant

The results from Table 58 indicated non-significant difference in Physics Motivation post-test mean scores between the male students and female students in the control groups, (F (1, 83) =

0.422, p= .518). The physics motivation post-test means scores of the control group were also found to rank very low in comparison with the experimental groups PMQ post-test means scores for both genders. This indicated that gender did not affect the Physics Motivation for the control groups and that KCPE scores had insignificant influence on the Physics Motivation as a covariate. This implies that both male and female students in the control groups were equally poorly motivated to learn physics.

To further establish the effect of IMSAO teaching approach on the Physics Motivation, difference in Physics Motivation by gender between male students in experimental groups and female students in control groups were analysed using a t-test and the results given in Table 59.

Table 59:
Comparison of the Students' Physics Motivation Post-test Mean Scores by Gender between Males in Experimental Groups and Females in Control Groups

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Motivation	Male (E1 & E2)	43	4.507	0.114	83	64.332	0.000*
	Female (C1&C2)	42	2.657	0.149			

Critical values (df = 83, t =1.984, ρ=0.05)
Calculated values (df = 83, t =64.332, ρ=0.000); ρ <.05; *significant

A keen examination of the results in Table 59 indicates a significant difference between the Physics Motivation post-test mean scores of the male students in the experimental (E1 &E2) groups (M= 4.507, SD=0.114) and of female students in the control (C1&C2) groups (M= 2.657, SD=0.149) at .05 level (t (83) =64.332, ρ<.05). The male students in the experimental groups had a significantly higher Physics Motivation post-test means score than their female counterparts in the control groups. This indicated that the IMSAO teaching approach affected positively the Motivation to learn physics. To find out whether the entry behaviour had an effect on the difference between the Physics Motivation post-test mean scores for the compared groups, ANCOVA test was done with the KCPE scores as a covariate. The adjusted Physics Motivation post-test mean scores with KCPE as the covariate are in Table 60.

Table 60:
Adjusted Physics Motivation Post-test Mean Scores by Gender between Males in Experimental Groups and Females in Control Groups with KCPE as a Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Motivation	Male	43	4.503	0.021
	Female	42	2.661	0.021

The adjusted physics post-test mean scores for the male students in the experimental groups (M=4.503) was found to be higher in comparison with the adjusted Physics Motivation post-test mean scores of the female students in the control groups (M=2.661). The ANCOVA test results confirmed this difference as shown in Table 61.

Table 61:

Differences between Physics Motivation Adjusted Post-test Mean Scores of Male Students in Experimental Groups and Female Students in the Control Groups

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Motivation	Contrast	68.86	1	66.86	3801.36	.000*
	Error	1.442	82	0.18		

Critical values (df = 1, 82; F =3.95; ρ=0.05)
Calculated values (df = 1, 82; F =3801.36, ρ=0.000); ρ <.05; *significant

The results in Table 61 showed a statistically significant difference in Physics Motivation post-test mean scores between the male students in the experimental groups and female students in the control groups in favour of male students in the experimental groups; (F (1, 82) = 3801.36, p <.05).This indicated that male students exposed to IMSAO approach had significantly better Physics Motivation post-test mean scores than the female students not exposed to the IMSAO teaching approach. KCPE scores had insignificant effect on the Physics Motivation post-test mean scores as a covariate.

Additional analysis was further done using a t-test to establish whether there were significant differences in the post-test mean scores between the male students in the control groups and the female students in the experimental groups. This was done to rule out any perception that male students' motivation was high due to gender other than the teaching approach. The results are contained in Table 62.

Table 62:
Comparison of the Students' Physics Motivation Post-test Mean Scores by Gender between Males in Control Groups and Females in Experimental Groups

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics Motivation	Male (C1&C2)	44	2.67	0.167	81	63.208	0.000*
	Female (E1 & E2)	39	4.55	0.087			

Critical values (df = 81, t =1.984, ρ=0.05)
Calculated values (df = 81, t = 63.208, ρ=0.000); ρ <.05; *significant

The results in Table 62 indicates a significant difference between the Physics Motivation post-test mean scores of the male students in the control (C1 & C2) groups (M= 2.67, SD=0.167) and of female students in the experimental (E1& E2) groups (M= 4.55, SD=0.087) at .05 level (t (81) = 63.208, ρ<.05) in favour of the female students in the experimental groups. The female students in the experimental groups had a significantly higher Physics Motivation post-test means score (M=4.55) than their male counterparts (M=2.67) in the control groups. This indicated that the IMSAO teaching approach affected positively the Physics Motivation in both boys and girls. To find out whether their initial entry behaviour influenced the differences between the Physics Motivation post-test mean scores in the compared groups, ANCOVA test was done with the KCPE scores as a covariate. The adjusted Physics Motivation post-test mean scores with KCPE as the covariate are in Table 63.

Table 63:
Adjusted Physics Motivation Post-test Mean Scores by Gender between Females in Experimental Groups and Males in Control Groups with KCPE as a Covariate

Scale	Gender	N	Adjusted Mean	Standard Error
Physics Motivation	Male	44	2.678	0.020
	Female	39	4.543	0.021

The adjusted physics post-test mean scores for the female students in the experimental groups (M=4.543) was found to be higher than the adjusted Physics Motivation post-test mean scores of the male students in the control groups (M=2.678). The ANCOVA test was used to establish whether the difference was statistically significant as shown in Table 64.

Table 64:
Differences between Physics Motivation adjusted Post-test Mean Scores of Female Students in Experimental Groups and Male Students in the Control Groups

Measure	Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Physics Achievement	Contrast	68.933	1	68.933	3946.94	.000*
	Error	1.397	80	0.017		

Critical values (df = 1, 80; F =3.96; ρ=0.05)
Calculated values (df = 1, 80; F =3946.94, ρ=0.000); ρ <.05; *significant

The results from Table 64 indicated a significant difference in Physics Motivation post-test mean scores between the male students in the control groups and female students in the experimental groups, ($F (1, 80) = 3946.94$, $p < .05$) in favour of the female students in the control groups. This indicated that female students exposed to IMSAO approach had significantly better Physics Motivation post-test mean scores than the male students exposed to CTM. KCPE scores as a covariate did not significantly affect the Physics Motivation post-test mean in the compared groups. The results indicate that the IMSAO teaching approach affected positively the Physics Motivation post-test mean scores in both boys and girls.

Further analysis was conducted to establish whether there were significant differences in the mean gains in the Physics Motivation by gender between male and female students exposed to IMSAO teaching approach. The gain made by students in the Physics Motivation test was obtained by getting the differences between the pre-test and post-test mean scores of the male and female students in group E1.This indicated the relative effects of IMSAO teaching approach on the student motivation to learn Physics in experimental group E1 by gender. The results are summarized in Table 65.

Table 65:
Students' Physics Motivation Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains in the Experimental Group E1 by Gender

Stage	Scale	Gender	
		Male N = 18	Female N = 19
Pre-test	Mean	2.722	2.624
	Standard Deviation	0.181	0.204
Post –test	Mean	4.521	4.540
	Standard Deviation	0.106	0.094
	Mean Gain	**1.799**	**1.916**

The results in Table 65 shows a higher mean gain in the Physics Motivation test for both male and female student exposed to IMSAO teaching approach. The male students mean score rose from 2.722 (SD=0.181) in the pre-test to 4.521 (SD=0.106) in the post-test while the female students mean score rose from 2.624 (SD=0.204) in the pre-test to 4.540 (SD=0.094) in the post-test. To find out whether the mean gains in the Physics Motivation by gender were statistically significantly different, a t–test was carried out and the results given in Table 66.

Table 66:
Comparison of Students' Physics Motivation Mean Gain by Gender in Group E1

Gender	N	Mean Gain	SD	df	t-value	ρ-value
Male	18	1.799	0.226	35	1.779	0.084
Female	19	1.916	0.174			

Critical values (df = 35, t =2.021, ρ=0.05)
Calculated values (df = 35, t =1.779, ρ=0.084); ρ >.05; not significant

The results of the t-test indicate there was non-significant difference between the mean gain (M = 1.799) of male students in the Physics Motivation and that of female students (M =1.916), $t(35) = 1.779$, $\rho > 0.05$. The results therefore indicate that IMSAO teaching approach positively affected the mean gain for both boys and girls in the Physics Motivation post-test. To fully establish whether it was the treatment that resulted to no significant differences in the Physics Motivation by gender, similar tests were carried out on the control group (C1) that was subjected to pre-test and post-test. The gain made by students in the Physics Motivation test was obtained by getting the differences between the pre-test and post-test mean scores of the male and female students in group C1. The results are contained in Table 67.

Table 67:
Students' Physics Motivation Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains in the Control Group C1 by Gender

Stage	Scale	Gender	
		Male N = 18	Female N = 18
Pre-test	Mean	2.654	2.668
	Standard Deviation	0.173	0.166
Post –test	Mean	2.656	2.654
	Standard Deviation	0.168	0.148
	Mean Gain	**0.002**	**-0.014**

The results in Table 67 indicated a marginal mean gains in the Physics Motivation for the male students and a drop in Physics Motivation for female for the female students in the control group. The male students mean score rose from 2.654 (SD=0.173) in the pre-test to 2.656 (SD=0.168) in the post-test while the female students mean score dropped from 2.668 (SD=0.166) in the pre-test to 2.654 (SD=0.148) in the post-test. To find out whether the mean gains in the Physics Motivation by gender were significantly different in the control group C1, a t–test was carried out and the results given in Table 68.

Table 68:
Comparison of Students' Physics Motivation Mean Gain by Gender in Group C1

Gender	N	Mean Gain	SD	df	t-value	ρ-value
Male	18	0.002	0.263	34	0.179	0.859
Female	18	-0.014	0.268			

Critical values (df = 34, t =2.021, ρ=0.05)
Calculated values (df = 34, t =0.179, ρ=0.859); ρ >05; not significant

The results of the t-test indicate there was no significant difference between the mean gain (M = 0.002) of male students in the Physics Motivation and that of female students (M =-0.014), t (34) = 0.179, ρ > 0.05 in the control group C1.The mean gains were however less in comparison with the mean gains in the experimental group E1. Since earlier results had indicated a significant difference in Physics Motivation by gender between students exposed to IMSAO teaching Approach and those exposed to CTM, the results therefore asserts that the significant difference in the Physics Motivation between the experimental and the control groups was purely due to the treatment. The results therefore indicate that IMSAO teaching approach positively affected their mean gain for both boys and girls in the Physics Motivation.

4.6.2 Discussion on Motivation to Learn Physics by Gender

The results indicated that students' motivation to learn physics was not affected by gender when IMSAO teaching approach was used. These results also revealed that the IMSAO teaching approach affected positively the Motivation to learn physics in both gender in comparison to the Conventional Teaching Methods.

A research by Osborne and Collins (2010) stressed the importance of making physics an enjoyable subject for all students to study regardless of their gender even when it is envisaged that they will or will not continue with the subject in post-secondary institutions. Girls need to be encouraged to learn the subject as they too have the potential to acquire and apply physics knowledge in life. As such they need to be exposed to learning approaches that motivate them to do physics and which boost their self-efficacy According to Reid (2003), the teaching methods used by teachers influence the student motivation and attitudes toward physics. According to him, girls are significantly less likely to enjoy their physics lessons than boys, feel they are less able to discuss and experiment with ideas, more likely to feel bored, not pay attention in class, find physics less interesting and feel less confident (have a lower self-concept in physics) when expository strategies of teaching are used. Such issues indicate that there is a problem with how some teachers engage girls given that girls also report that, despite liking their physics teachers as much as boys do, these teachers have, on average, lower expectations of what they can learn, are less interested in them as people, are less good at explaining physics to them, are less likely to want them to understand physics and are less likely to explain how physics is applicable to different situations. The IMSAO teaching approach provided an enjoyable and interactive physics learning environment to both boys and girls. All Students, regardless of their gender, were interested in learning how to carry out physics experimental activities virtually using interactive simulations which provided hints whenever the students were stuck. On the other hand conventional methods of teaching disengage girls making them dislike physics. A possible way to overcome this would be to have pedagogies that allow for greater students involvement that allow for greater student autonomy and creativity (Reiss, 2004). The use of IMSAO teaching approach could be one of the ways in which teachers could make physics attractive to girls and make them compete fairly with boys in physics related fields.

The findings of the present study on the effect of IMSAO teaching approach on motivation to learn physics in boys and girls are in agreement with studies carried out by Sandhya, Smitha and Asha (2016) which indicated the existence of a positive relationship between computers simulated assisted instruction and motivation towards physics irrespective of gender. The findings also agrees with another study carried out by Hussain *et al.,* (2014) which showed that computer assisted instruction method of teaching was better than the traditional lecture method in maintaining the motivation of students in physics at the secondary level in both gender.

Other Studies have also showed a relationship between motivation to learn physics and the methods of instruction (Eridemir, 2009) for both boys and girls. In this study it was observed that boys and girls who have negative attitude towards physics have lack of motivation for class engagement, and that boys and girls who have positive attitudes towards physics have motivation for class engagement. Cracker (2006) also established that motivation towards learning in sciences change with exposure to science, the learning environment, and teaching method. Effective instructional strategies have therefore a potential of increasing students' motivation to learn in both boys and girls. In the present study IMSAO teaching approach was found to enhance the students' motivation to learn physics in both gender in comparison to the CTM.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1. Introduction

The main aim of this study was to determine the effects of Interactive Multimedia Simulations Advance Organizers teaching approach on students' achievement and motivation to learn secondary school physics with particular reference to the physics topic Measurement. This chapter presents the summary of the findings of the study, the conclusions reached, the implications, the recommendations, and suggestions for further research.

5.2 Summary of the Findings

The first objective compared students' Physics achievement between those exposed to IMSAO teaching approach and those exposed to Conventional Teaching Methods (CTM). Results generated by the analysis revealed that students exposed to IMSAO teaching approach achieved highly in physics than those exposed to CTM.

The second objective compared students' motivation to learn Physics between those exposed to IMSAO teaching approach and those exposed to CTM. Results analysed revealed that students exposed to IMSAO teaching approach were more motivated to learn physics than those exposed to CTM.

The third objective compared the achievement in physics between boys and girls when they are exposed to IMSAO teaching approach. The results of the study revealed that IMSAO teaching approach resulted to high physics achievement for both boys and girls.

The fourth objective compared motivation to learn physics between boys and girls when they are exposed to IMSAO teaching approach. The study found out that when IMSAO teaching approach was used, it resulted to improved motivation to learn physics in both boys and girls.

5.3 Conclusions

Based on the findings of the study, the following conclusions were made:

i. IMSAO teaching approach was found to be more effective in enhancing students' physics achievement as compared to the CTM. This was due to the interactive nature of the simulation, which helped to conceptualize and retain the physics concepts taught.

ii. IMSAO teaching approach resulted to increased students' motivation to learn physics than the CTM. The use of IMSAO teaching approach captured learners' attention and made learning interesting and enjoyable.
iii. IMSAO teaching approach enhanced the physics achievement equally in both boys and girls. The IMSAO teaching approach appealed to both boys and girls. The self-paced learning using an interactive simulation ensured that even girls, who are sometimes shy in manipulation skills, had time to experiment with the apparatus virtually without fear of failure.
iv. IMSAO teaching approach resulted to increased students' motivation to learn physics equally in both boys and girls. The approach therefore, reduced gender disparities in motivation to learn physics.

5.4 Implications of the Study

From the study, it is explicitly evident that IMSAO teaching approach improves achievement and motivation to learn physics in secondary schools as compared to the CTM. Further, when this approach is used in teaching boys and girls, the physics achievement and motivation to learn physics improves in both genders with no significant differences. This is in contrast to the CTM methods, which have resulted to significant differences in physics achievement and motivation to learn physics in favour of boys. When IMSAO teaching approach is used, achievement and motivation to learn Physics is not affected by the students' gender. The approach is therefore likely to improve the physics achievement and motivation to learn physics at KCSE level. This could results to many students passing in physics examination and taking up STEM courses in the universities. Consequently, such people would play a transformative role in the Kenyan society and globally through scientific developments and innovations.

Another implication of the finding is that the IMSAO teaching approach appeals to both boys and girls, and improve their physics achievement and motivation to learn physics equally. In a long time, physics has largely been perceived as a preserve of boys and most of physics related courses at the universities have been male dominated. This is clearly indicated by the low enrolment and achievement at the KCSE over the past years. Girls have always lagged behind in achievement and their enrolment has been lower than that of boys. The IMSAO teaching approach is therefore a game changer, which if applied, would see the number of girls enrolling for physics as a subject increasing and their achievement in physics matching or being better than that of boys. This would break the long held myths and stereotypes that science oriented courses are meant for men. Women will equally have a role to play in scientific developments and innovations in the 21st century.

5.5 Recommendations

The findings of this study have revealed that the IMSAO teaching approach has an effect of enhancing the achievement in physics and improving their motivation to learn physics. The following recommendations are made based on the findings of the study.

The Kenya Institute of Curriculum Development (KICD) may need to develop a physics curriculum incorporating the IMSAO teaching approach for secondary schools in Kenya. This could involve rolling out of a digital curriculum, with integrated interactive multimedia simulation software programs for all topics in physics. This could help the students to learn physics in a self-paced mode, interact with the perceived “difficult” physics content in a more appealing context and enable them to do self-assessment as they learn. This would translate to improved physics achievement and motivation to learn physics at KCSE.

The teacher educators’ institutions such as universities and teachers training colleges may need to incorporate IMSAO teaching approach as part of their teacher-training curriculum. The publishers and authors of physics textbooks should give insights and illustrations on how the IMSAO teaching approach may be used to supplement the content in the textbooks by giving suggestion to the teacher on how to conduct simulations in the teaching of different topics in physics and the open education resources where such simulations may be found. This would help in motivating learners to take physics regardless of their gender.

The government, through the Ministry of Education may need to conduct in-service training and seminars for practicing teachers on skills about use of interactive computer simulations in the teaching process. The Ministry of Education may also endeavour to fast track their plan of establishing well-equipped computer laboratories in all public secondary schools, with fast internet connectivity, to facilitate the use of free online interactive multimedia simulations in the teaching to boost achievement and motivation to learn physics in Kenyan secondary schools.

5.6 Recommendations for Further Research

The findings of the study indicate that IMSAO teaching approach is effective in enhancing physics achievement and student motivation to learn physics. However, the following areas may form the basis for further researches in future:

i. A study on how IMSAO teaching approach would affect the acquisition of science process skills in physics practical.

ii. A study on how IMSAO teaching approach in physics could affect the student choices of careers in the university and other institutions of higher learning.

iii. A study to investigate the effects of IMSAO teaching approach on achievement and motivation in learn other science subjects.

iv. A study to investigate the effects of IMSAO teaching approach on retention of content taught.

v. A study to investigate the effects of IMSAO teaching approach on achievement and motivation in Primary school science.

vi. A study to investigate the level of computer literacy skills in secondary school teachers and their readiness to embrace IMSAO teaching approach in their teaching.

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APPENDICES

APPENDIX A: PHYSICS ACHIEVEMENT TEST (PAT)

Score [ ]

School…………………………Admission No.…………………………Class……………..

Gender: Male [ ] Female [ ] (tick appropriately). Time: 1 hour

INSTRUCTIONS

This paper consists of 20 questions. ANSWER ALL questions in the spaces provided. Read the questions carefully before writing your answer.

1. List the seven *basic physical quantities* and give their S.I units (7mks)

2. Give two reasons why measurements are taken in physics (2mks)

3. State one limitation of using a micrometre screw gauge to measure (1mk)

4. List any two measurements on objects that can be accurately measured using a Vernier callipers (2mks)

5. What is the function of the ratchet in a micrometre screw gauge? (1mk)

6. Which instruments would you use to measure accurately: (4mks)

a) The thickness of a mobile phone scratch card

b) The width of your desk

c) The Diameter of s thin copper wire

d) The diameter of a cylindrical water pipe

7. Differentiate between the Main scale and a Vernier scale in a Vernier callipers (2mks)

8. Define the tem *Pitch* as used in micrometre screw gauge (1mk)

9. What is the meaning of the term *Least count* as used in Vernier callipers (1mk)

10. Describe how the least count in a Vernier callipers is calculated (1mk)

11. What is zero error as used in measurements? (1mk)

12. Illustrate the following zero errors on a diagram (2mks)

(i) A zero error of -0.24 on a Vernier callipers

(ii) A zero error of +0.17 on a micrometre screw gauge

13. Compare and contrast the thimble scales of two micrometre screw gauge with a pitch of 0.5mm and 1.0mm (2mks)

14. List down two advantages of using micrometre screw gauge over the Vernier callipers in measurement (2mks)

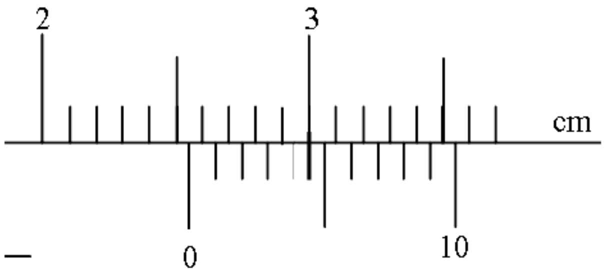
15. Sketch a micrometre screw gauge scale reading:

a) 0.23 (1mk)
b) 5.05 (1mk)

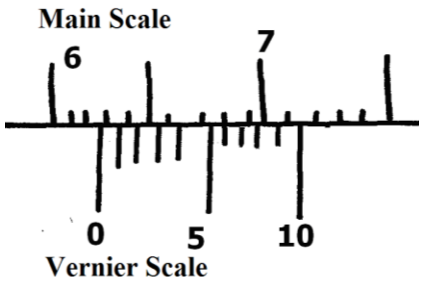
16. Describe how you would measure the internal diameter of a $100cm^3$ beaker using Vernier callipers (2mk)

17. Write down the Vernier callipers readings in the figures below if the callipers had a negative zero error of 0.01:

a) (1mk)



b) (1mk)



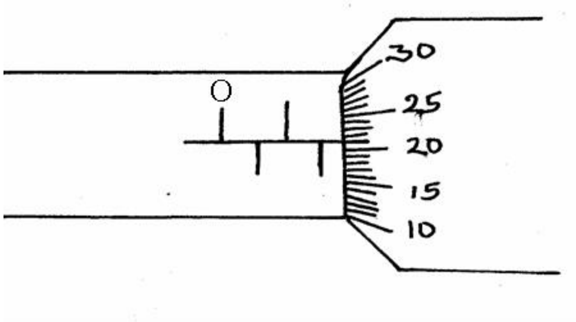
18. A student used a Vernier callipers to measure the internal diameter of a glass tube. The student repeated the experiment four times and recorded the results as shown in the Table.

Experiment	**Diameter in cm**
1	2.3661
2	2.3
3	2.36
4	2.36619

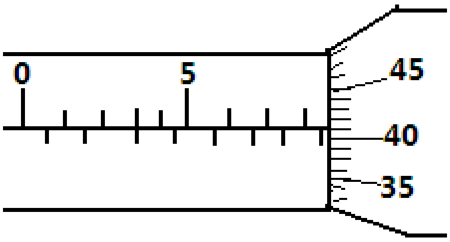
Which of the readings was accurately taken? (1mk)

19. Write down the readings on the micro meter screw gauge shown in the figures below

a) (1mk)



b) (1mk)



20. A Vernier callipers with a negative zero error of 0.03 was used to measure the diameter of a spherical object and the measurement recorded as 3.25cm. Calculate the correct volume of the sphere in cubic meters (taker ∏= 3.142) (2mks)

APPENDIX B: PHYSICS ACHIEVEMENT TEST (PAT) MARKING SCHEME

1. List the seven *basic physical quantities* and give their S.I units (7mks)

a) Length	***Meter***
b) Mass	***Kilogram***
c) Time	***Second***
d) Temperature	***Kelvin***
e) Electric current	***Ampere***
f) Luminous intensity	***Candela***
g) Amount of substance	***Mole***

2. Give two reasons why measurements are taken in physics (2mks)
   - ***For comparison***
   - ***For communication between scientists***
   - ***For precision in measurement***
3. State one limitation of using a micrometre screw gauge to measure (1mk)
   - ***Cannot measure depth***
   - ***Cannot measure internal diameter***
4. List any two measurements on objects that can be accurately measured using Vernier callipers. (2mks)
   - ***Length***
   - ***Depth***
   - ***Internal and external diameter***
5. What is the function of the ratchet in a micrometer screw gauge? (1mk)
   - ***Prevents one from exerting undue pressure on an object when using the micrometer screw gauge.***
6. Which instrument would you use to measure accurately: (4mks)

   a) The thickness of a mobile phone scratch card
   - ***Micrometre screw gauge.***

   b) The width of your desk
   - ***Meter rule***

   c) The Diameter of s thin copper wire
   - ***Micrometre screw gauge.***

   d) The diameter of a cylindrical water pipe

- ***Vernier calipers.***

7. Differentiate between the Main scale and a vernier scale in a vernier calipers (2mks)

MAIN SCALE	**VERNIER SCALE**
- ***Measures in 1dp***	- ***Measures in 2dp***
- ***The smallest division is 0.1cm***	- ***The smallest division is 0.09cm***
- ***It is fixed***	- ***It is movable***

8. Define the tem *Pitch* as used in micrometer screw gauge (1mk)

- ***This is the distance moved by the spindle in one complete rotation***

9. What is the meaning of the term *Least count* as used in vernier calipers (1mk)

- ***The difference in length between the main scale division and the vernier scale division.***

10. Describe how the least count in a vernier calipers is calculated (1mk)

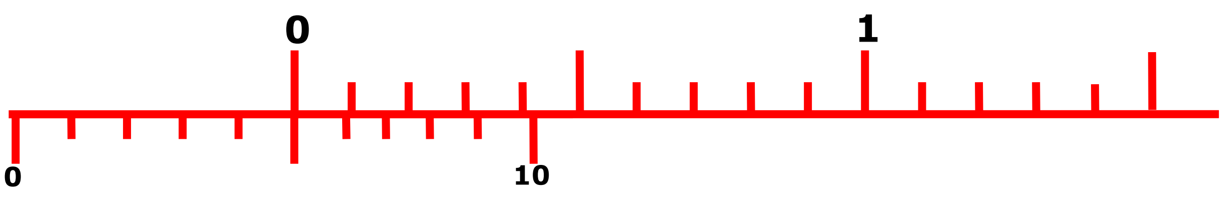
- ***Smallest main scale division minus the smallest vernier scale division. Ie*** **0.1 − 0.09=0.01cm**

11. What is zero error as used in measurements? (1mk)

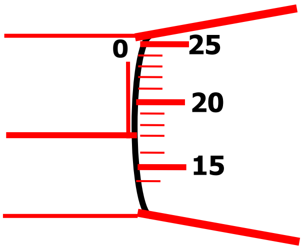
- ***This is the measurement recorded on an instrument when it is closed without any object.***

12. Illustrate the following zero errors on a diagram (2mks)

a) A zero error of -0.05 on a vernier calipers



b) A zero error of +0.17 on a micrometer screw gauge



13. Compare and contrast the thimble scales of two micrometer screw gauge with a pitch of 0.5mm and 1.0mm (2mks)

COMPARE

0.5mm	1.0mm
- *Each division is* **0.01mm**	- *Each division is* **0.01mm**

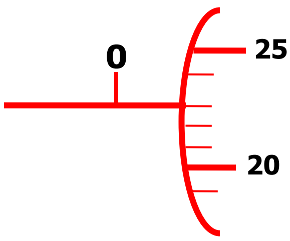
CONTRAST

0.5mm	1.0mm
- *Has 50 division*	- *Has 100 division*

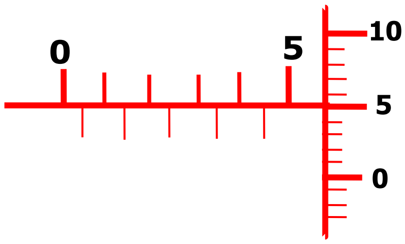
14. List down two advantages of using micrometer screw gauge over the vernier calipers in measurement (2mks)

- ***Micrometer screw gauge is more accurate***
- ***Can measure very small lengths***

15. Sketch a micrometer screw gauge scale reading:
a) 0.23 (1mk)



b) 5.05 (1mk)

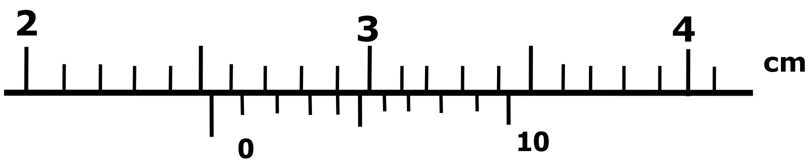


16 Describe how you would measure the internal diameter of a $100cm^3$ beaker using vernier calipers (2mk)

- ***Adjust the internal jaws of the vernier calipers in to the beaker'***
- ***Record the reading on the main scale and the vernier scale mark and add them together.***

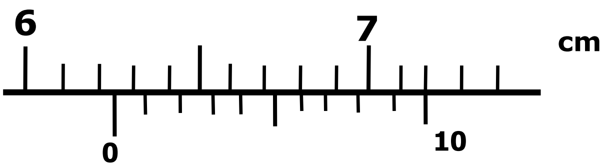
17. Write down the Vernier callipers readings in the figures below if the callipers had a negative zero error of 0.01:

a) (1mk)



$$\begin{array}{r} 2.50 \\ +\ 0.04 \\ \hline 2.54 \end{array} \qquad \begin{array}{r} 2.54 \\ +\ 0.01 \\ \hline 2.55 \end{array} = \mathbf{2.55cm}$$

b)



$$\begin{array}{r} 6.20 \\ +\ 0.06 \\ \hline 6.26 \end{array} \qquad \begin{array}{r} 6.26 \\ +\ 0.01 \\ \hline 6.27 \end{array} = \mathbf{6.27cm}$$

18. A student used a Vernier callipers to measure the internal diameter of a glass tube. The student repeated the experiment four times and recorded the results as shown in the Table.

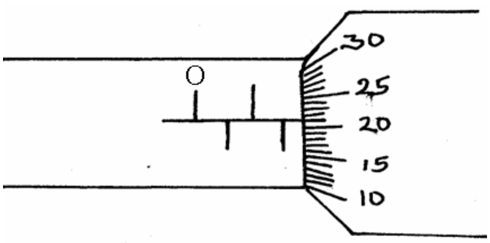
Experiment	**Diameter in cm**
1	2.3661
2	2.3
3	2.36
4	2.36619

Which of the readings was accurately taken? (1mk)

= 2.36cm

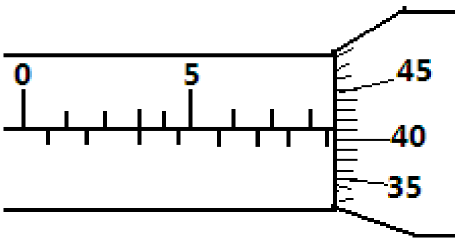
19. Write down the readings on the micro meter screw gauge shown in the figures below

a) (1mk)



$$\begin{array}{r} 1.50 \\ +\ 0.21 \\ \hline 1.71 \end{array} = 1.71\text{mm}$$

b) (1mk)



$$\begin{array}{r} 8.50 \\ +\ 0.41 \\ \hline 8.91 \end{array} = 8.91\text{mm}$$

20. A Vernier callipers with a negative zero error of 0.03 was used to measure the diameter of a spherical object and the measurement recorded as 3.25cm. Calculate the correct volume of the sphere in cubic meters (taker ∏= 3.142) (2mks)

$$\begin{array}{r} 3.25 \\ +\ 0.03 \\ \hline 3.28 \end{array} \quad = 0.00328\text{cm}$$

$$V = \frac{4}{3} x \frac{22}{7} \text{ x } \left(\frac{0.00328}{2}\right)^3$$

$= 1.848 \times 10^{-5}\ m^3$

APPENDIX C: PHYSICS MOTIVATION QUESTIONNAIRE (PMQ)

Directions for students

The purpose of this Questionnaire is to find out what you think about the Physics course. Information given in this questionnaire will be treated confidentially for research purposes only. This questionnaire contains statements about your willingness in participating in the physics course. You will be asked to express your agreement on each statement. There are no “right “or “wrong” answers. Your opinion is what is wanted. Think about how well each statement describes your willingness in participating in the physics course.

Draw a circle around the number that best describes your willingness to participate in a physics course.

1. If you strongly disagree with the statement
2. If you disagree with the statement
3. If you have no opinion on the statement
4. If you agree with the statement
5. If you strongly agree with the statement

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another. Some statements in this questionnaire are similar to other statements. Do not worry about this. Simply give your opinion about all statements.

\

School…………………………**Admission No**…………………………**Class**……………..

Gender: Male ☐ **Female** ☐ **(tick appropriately).**

	A. Self-efficacy	**Strongly disagree**	**disagree**	**No opinion**	**Agree**	**Strongly Agree**
1	Whether the physics content is difficult or easy, I am sure that I can understand it.	**1**	**2**	**3**	**4**	**5**
2	I am not confident about understanding difficult physics concepts. (−)	**1**	**2**	**3**	**4**	**5**
3	I am sure that I can do well on physics tests.	**1**	**2**	**3**	**4**	**5**
4	No matter how much effort I put in, I cannot learn physics. (−)	**1**	**2**	**3**	**4**	**5**
5	When physics activities are too difficult, I give up or only do the easy parts. (−)	**1**	**2**	**3**	**4**	**5**
6	During physics activities, I prefer to ask other people for the answer rather than think for myself. (−)	**1**	**2**	**3**	**4**	**5**
7	When I find the physics content difficult, I do not try to learn it (−)	**1**	**2**	**3**	**4**	**5**
	B. Active learning strategies	**Strongly disagree**	**disagree**	**No opinion**	**Agree**	**Strongly Agree**
8	When learning new physics concepts, I attempt to understand them.	**1**	**2**	**3**	**4**	**5**
9	When learning new physics concepts, I connect them to my previous experiences.	**1**	**2**	**3**	**4**	**5**
10	When I do not understand a physics concept, I find relevant resources that will help me.	**1**	**2**	**3**	**4**	**5**

11	When I do not understand a physics concept, I would discuss with the teacher or other students to clarify my understanding.	**1**	**2**	**3**	**4**	**5**
12	During the learning processes, I attempt to make connections between the concepts that I learn.	**1**	**2**	**3**	**4**	**5**
13	When I make a mistake, I try to find out why.	**1**	**2**	**3**	**4**	**5**
14	When I meet physics concepts that I do not understand, I still try to learn them.	**1**	**2**	**3**	**4**	**5**
15	When new physics concepts that I have learned conflict with my previous understanding, I try to understand why.	**1**	**2**	**3**	**4**	**5**
	C. Physics Learning Value	**Strongly disagree**	**disagree**	**No opinion**	**Agree**	**Strongly Agree**
16	I think that learning physics is important because I can use it in my daily life.	**1**	**2**	**3**	**4**	**5**
17	I think that learning physics is important because it stimulates my thinking.	**1**	**2**	**3**	**4**	**5**
18	In physics, I think that it is important to learn to solve problems.	**1**	**2**	**3**	**4**	**5**
19	In physics, I think it is important to participate in inquiry activities.	**1**	**2**	**3**	**4**	**5**
20	It is important to have the opportunity to satisfy my own curiosity when learning physics.	**1**	**2**	**3**	**4**	**5**

	D. Social Persuasion Performance Goal	Strongly disagree	disagree	No opinion	Agree	Strongly Agree
21	I participate in physics courses to get a good grade. (−)	**1**	**2**	**3**	**4**	**5**
22	I participate in physics courses to perform better than other students. (−)	**1**	**2**	**3**	**4**	**5**
23	I participate in physics courses so that other students think that I am smart. (−)	**1**	**2**	**3**	**4**	**5**
24	I participate in physics courses so that the teacher pays attention to me. (−)	**1**	**2**	**3**	**4**	**5**

	E. Achievement Goal	Strongly disagree	disagree	No opinion	Agree	Strongly Agree
25	During a physics course, I feel most fulfilled when I attain a good score in a test.	**1**	**2**	**3**	**4**	**5**
26	I feel most fulfilled when I feel confident about the content in a physics course.	**1**	**2**	**3**	**4**	**5**
27	During a physics course, I feel most fulfilled when I am able to solve a difficult problem.	**1**	**2**	**3**	**4**	**5**
28	During a physics course, I feel most fulfilled when the teacher accepts my ideas.	**1**	**2**	**3**	**4**	**5**
29	During a physics course, I feel most fulfilled when other students accept my ideas.	**1**	**2**	**3**	**4**	**5**

	F. Teaching approach	Strongly disagree	disagree	No opinion	Agree	Strongly Agree
30	I am willing to participate in the physics course taught using Interactive Multimedia Simulation Advance Organizers because the content is exciting and changeable.	**1**	**2**	**3**	**4**	**5**
31	I am not willing to participate in the physics course because Interactive Multimedia Simulation Advance Organizers approach made me feel quite tense, comparing to the traditional way of learning physics. (−)	**1**	**2**	**3**	**4**	**5**
32	I am willing to participate in the physics course because Interactive Multimedia Simulation Advance Organizers improved my understanding of the basic principles of physics	**1**	**2**	**3**	**4**	**5**
33	I am not in favour of learning with Interactive Multimedia Simulation Advance Organizers approach because it is just another step toward depersonalized instruction. (−)	**1**	**2**	**3**	**4**	**5**
34	I am willing to participate in the physics course because Interactive Multimedia Simulation Advance Organizers approach improved my ability to learn independently	**1**	**2**	**3**	**4**	**5**
35	I am willing to participate in the physics course because Learning of physics using Interactive Multimedia Simulation Advance Organizers is fun	**1**	**2**	**3**	**4**	**5**

Note: (−) represent reverse items.

APPENDIX D: PHYSICS ACHIEVEMENT TEST (PAT) MARK-SHEET

SCHOOL:……………………………………………..

SN	ADM No	KCPE Marks	PAT Score
1.			
2.			
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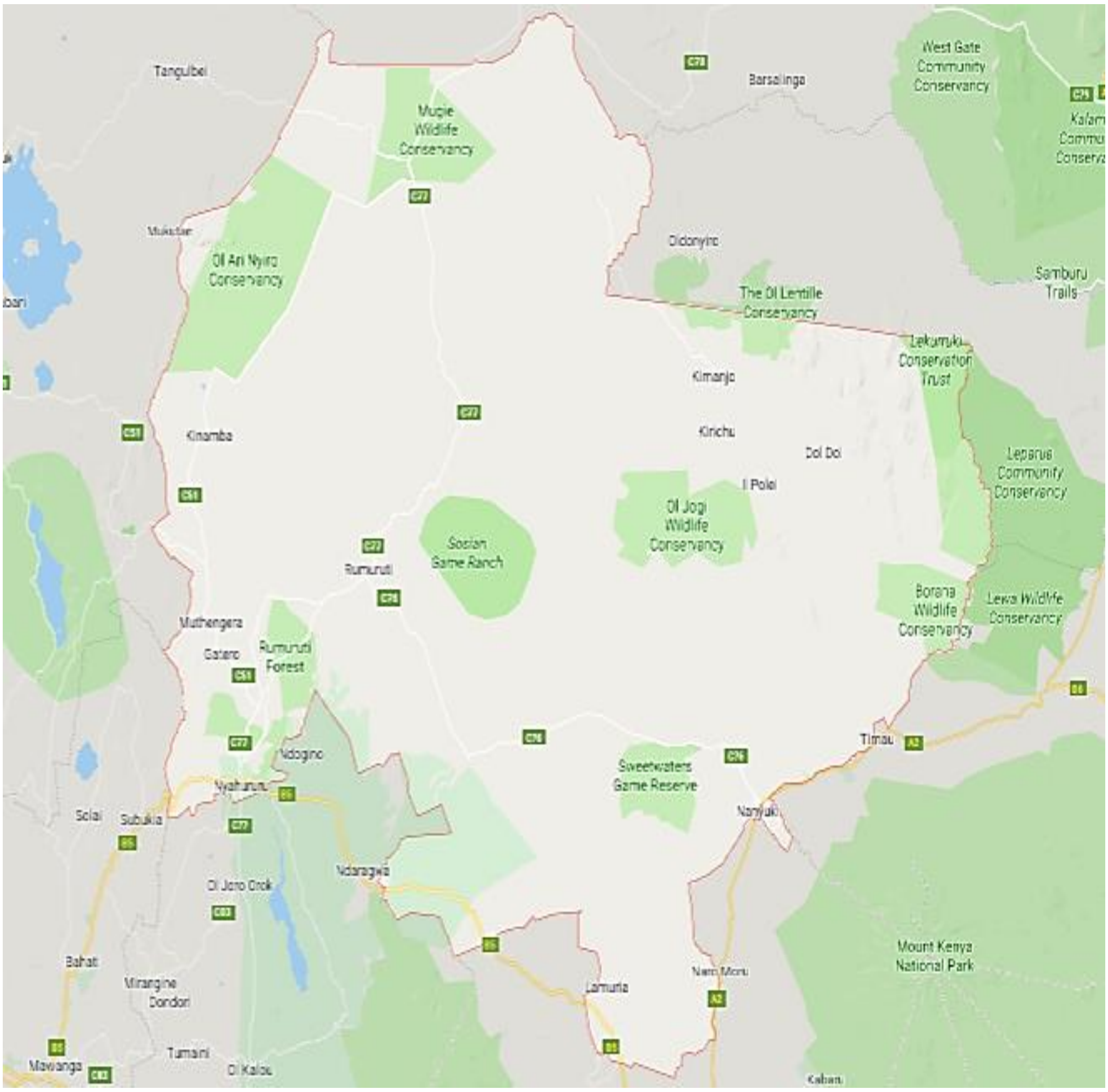
APPENDIX E: MAP OF LAIKIPIA COUNTY



SOURCE: https://www.google.com/maps/place/Laikipia County. Map Retrieved from Google Maps on 4th September 2019

APPENDIX F: INTERACTIVE MULTIMEDIA SIMULATIONS ADVANCE ORGANISERS (IMSAO) TRAINING MANUAL

The purpose of this manual is to help the physics teacher plan and implement the teaching-learning programme based on Interactive Multimedia Simulations Advance Organizers (IMSAO) approach. This approach integrates the interactive multimedia simulations advance organizers in the teaching of topic Measurement in the secondary school physics syllabus.This will include use of computer-based technology integrating some, but not necessarily all, of the following: text, graphics, animation, sound, and video. Audio-visual material can provide useful aids for learning when integrated into computer based teaching systems. However, a teaching system is only useful if the learner remains active and motivated. To learn, students must want to learn and must be involved and active. IMSAO instructional approach puts emphasis on the involvement of learners in the learning process by use of multisensory media.

The manual aims at explaining the basics of IMSAO. The manual content is divided into:

1. Instructional objectives
2. Planning for the IMSAO
3. Teaching using IMSAO

1.0 Instructional Objectives

An instructional objective is a statement of the performance to be demonstrated by each student in the class, stated in measurable and observable terms.

1.2 Reasons for Stating Objectives

a) Give direction to teachers in the selection of instructional methods and instructional resources.

b) Inform students why any content is to be learnt and to what extent.

c) Provide scope for the question paper setter in the construction of tools for evaluation of students' achievement.

Learners should be made aware of the instructional objectives in the teaching learning process.

1.3 Rules for stating instructional Objectives

a) Instructional Objectives should be stated in terms of student's performance and not teacher's performance. The Objective should specify what the student will be able to do at the end of the lesson and not what the teacher had intended to do.

b) The mere description of subject matter should be avoided. An Objective should specify both the kind of behaviour expected and the subject or context to which that behaviour applies.

c) Use action verbs. Use verbs that refer to any observable activity displayed by a learner.

d) State in terms of learning outcomes instead of the learning process. Describe in detail the final outcome of learning (End product) and not the process of learning itself.

e) An Objective should not consist of more than one learning outcome.

1.4 Taxonomy of Instructional Objectives

Instructional objectives are broadly categorized into three**:**

a) Cognitive domain
b) Affective domain
c) Psychomotor domain

a) Cognitive Domain – These objectives deal with mental or intellectual capabilities of the learners and have six levels.

i. Knowledge – remembering previously learned material
ii. Comprehension – grasping the meaning of the material
iii. Application – ability to use learned material in new situations
iv. Analyse – breaking down material into its parts
v. Synthesis – putting parts into a whole.
vi. Evaluation – judging the value of a thing for a given purpose using definite criteria.

b)Affective Domain:

These are objectives, which deal with feelings and emotions in learners. They include:

i. Receiving: willingness of learners to receive a stimuli
ii. Responding: Learners reacts to an idea or activity
iii. Valuing: The learners put worth or value to what they are taught.

iv. Organization: the learners put together the value or worth of learnt knowledge or skills and organize them.
v. Characterization by value: the learners develop a character out of the organized value system he has acquired.

In this study, the affective domain will be measured using Physics Motivation Questionnaire.

c) Psycho-motor domain

These objectives deal with skills that require physical abilities in learner. Most science process skills fall under this domain

i. Perception: use of senses in learning
ii. Set: Being ready to engage in a physical activity
iii. Guided response: ability to perform an activity under guidance
iv. Mechanism: learners can make manipulative movements
v. Complex overt response – degree of proficiency and confidence in the manipulative movements increases.
vi. Adaptation – Learners can use the acquired skills in other related activities
vii. Origination – Learners becomes innovative and tries out other skilled physical activities.

2.0 Planning for teaching

The following are the reasons that necessitate planning for teaching:

a) To ensure the right allocation of teaching time to each topic and to avoid running out of material.

b) To prevent unnecessary overlapping of courses, lessons and repetitions for information.

c) To teach the topics in a logical sequence.

d) To select the suitable instructional methods and instructional resources (materials and media) for the students of a particular class.

e) To budget for the instructional resources (materials and media) required and to procure/prepare them.

f) To revise the instructional resources (materials and media) in the light of the feedback obtained during the previous year/course.

g) To provide a variety of activities (learning experiences for the students).

h) To enhance teacher's self confidence in his/her ability to teach in an interesting and effective way by designing a number of tactical alternatives.

3.0 Teaching using IMSAO

The researcher provided the teachers with pictorial, graphics and videos materials showing the use of Vernier callipers and micrometre screw gauge in real life situations. These were used as the advance organizers in this module.

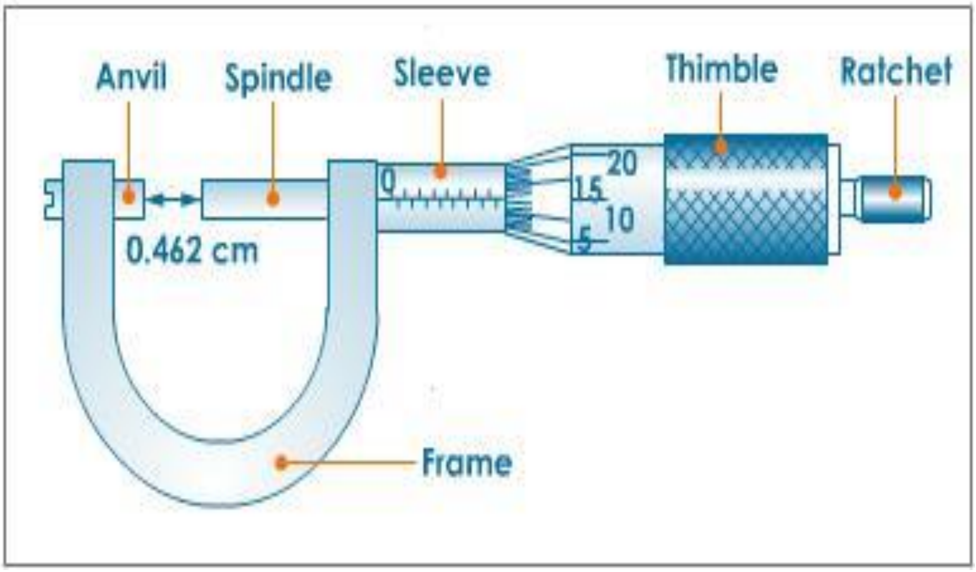
An advance organizer is a tool used to introduce the lesson topic and illustrate the relationship between what the students are about to learn and the information they have already learned. By using an advance organizer to link the new information to old information, the new information can be remembered more easily. There are three basic purposes of advance organizers. First, they direct students' attention to what is important in the upcoming lesson. Second, they highlight relationships among ideas that will be presented. Third, they remind students of relevant information that they already have.

Teachers to be trained by the researcher on how to put the advance organizers on a computer and project it on a Smart Board or in a Power-Point presentation format. The teachers will incorporate video, pictures, and other kinds of visuals and graphics provided. This will make students to have easy visual access to the advance organisers. The interactive advance organisers can also be used in a computer lab where student will interact personally with the materials using their computers.

The researcher to provide the teachers with interactive multimedia simulation programs on use of Vernier callipers and micrometre screw gauge in taking of measurement in physics that will be installed in the computers or projected on a white board. The teacher will guide the learners on how to use them. Learners will be expected to interact with the programs and change parameters and make measurements using the Vernier callipers and micrometre screw gauge.

a) The Micrometre screw gauge

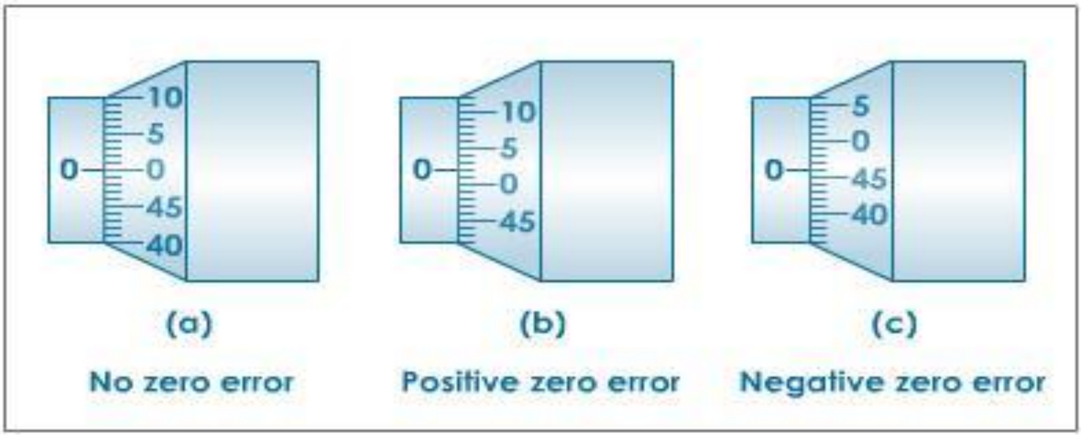
Micrometre screw-gauge is an instrument used for measuring accurately the diameter of a thin wire or the thickness of a sheet of metal .It consists of a U-shaped frame fitted with a screwed spindle that is attached to a thimble as shown in the figure below.



Micrometre screw gauge

The screw has a known pitch such as 0.5 mm. Pitch of the screw is the distance moved by the spindle per revolution. Hence, in this case, for one revolution of the screw the spindle moves forward or backward 0.5 mm. This movement of the spindle is shown on an engraved linear millimetre scale on the sleeve. On the thimble, there is a circular scale which is divided into 50 or 100 equal parts.

When the anvil and spindle end are brought in contact, the edge of the circular scale should be at the zero of the sleeve (linear scale) and the zero of the circular scale should be opposite to the datum line of the sleeve. If the zero is not coinciding with the datum line, there will be a positive or negative zero error as shown in figure below.



Zero error in case of micrometre screw gauge

While taking a reading, the thimble is turned until the wire is held firmly between the anvil and the spindle.

The least count of the micrometre screw gauge can be calculated using the formula given below:

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}$$

$$= \frac{0.5\ \text{mm}}{50}$$

= 0.01 mm

Types of error in micrometre screw gauge reading

Every micrometre prior to its use should be thoroughly checked for backlash error or zero error.

- Backlash error: Sometimes due to wear and tear of the screw threads, it is observed that reversing the direction of rotation of the thimble, the tip of the screw does not start moving in the opposite direction immediately, but remains stationary for a part of rotation. This is called back lash error.
- Zero error: If on bringing the flat end of the screw in contact with the stud, the zero mark of the circular scale coincides with the zero mark on base line of the main scale, the instrument is said to be free from zero error. Otherwise, an error is said to be there. This can be both positive and negative zero error.

Calculating micrometre screw gauge reading:

Total observed reading = main scale reading + (circular scale division coinciding the base line of main scale) x least count

True diameter = observed diameter – zero error

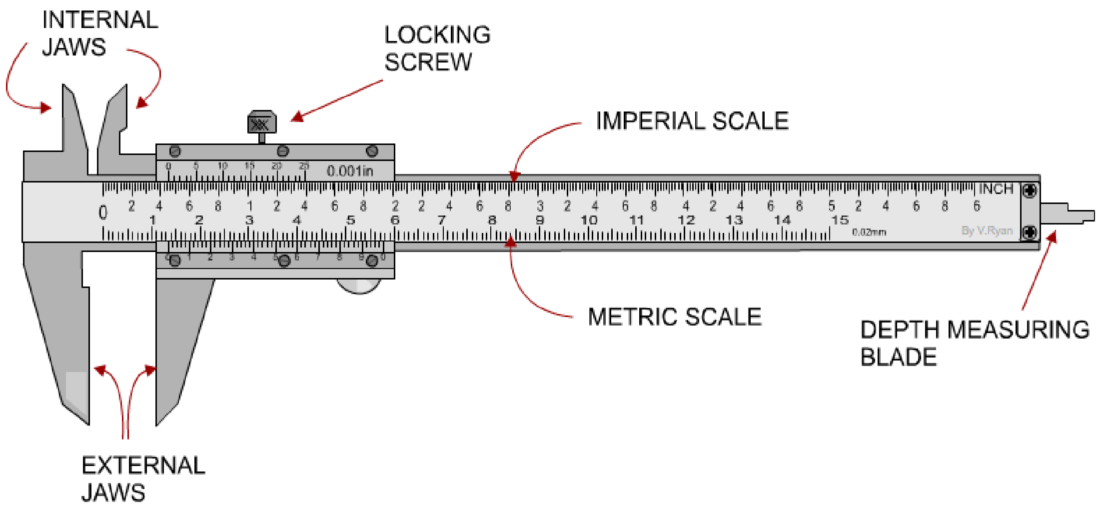
Example, main scale reading = 2mm or 0.2cm

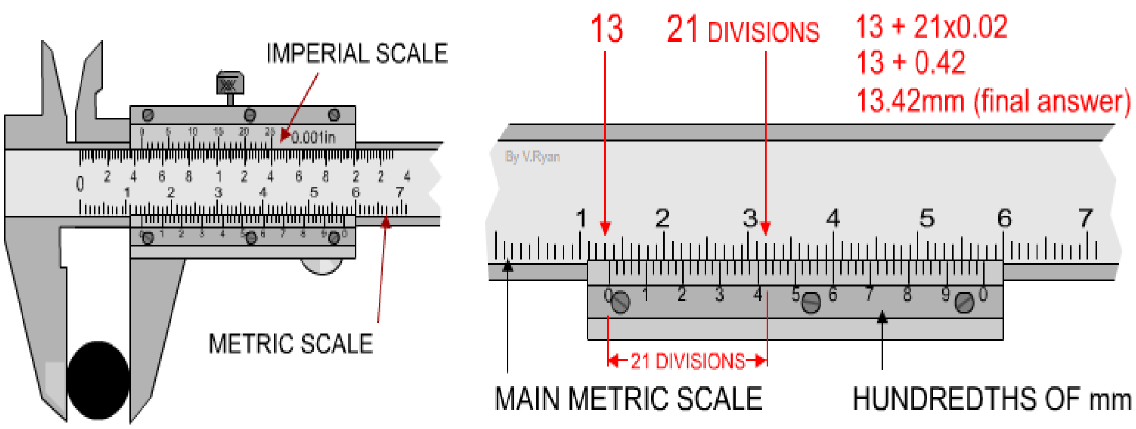
Circular scale reading = 56, so 56 x 0.001 = 0.056cm

So observed reading = 0.2 + 0.056 = 0.256cm

b) The Vernier Calliper

The Vernier calliper is a precision instrument that can be used to measure internal and external distances extremely accurately. The user interprets measurements from the scale. Some Vernier callipers have both an imperial and metric scale. The figure below illustrates a Vernier callipers





a) The main metric scale is read first and this shows that there are 13 whole divisions before the 0 on the hundredths scale. Therefore, the first number is 13.

b) The' hundredths of mm' scale is then read. The best way to do this is to count the number of divisions until you get to the division that lines up with the main metric scale. This is 21 divisions on the hundredths scale.

c) This 21 is multiplied by 0.02 giving 0.42 as the answer (each division on the hundredths scale is equivalent to 0.02mm).

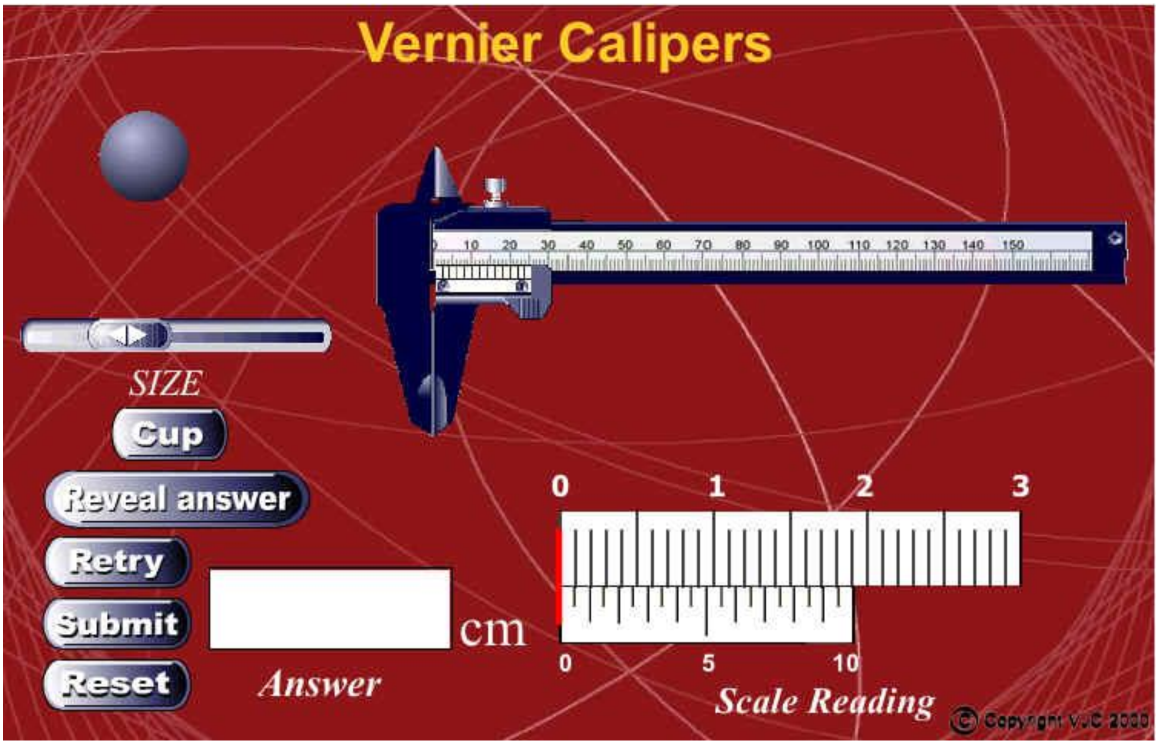
d) The 13 and the 0.42 are added together to give the final measurement of 13.42mm (the diameter of the piece of round section steel)

The teachers will use the following expository advance organizers to acquaint the students with the concepts of measurement using Vernier callipers and micrometre screw gauge.

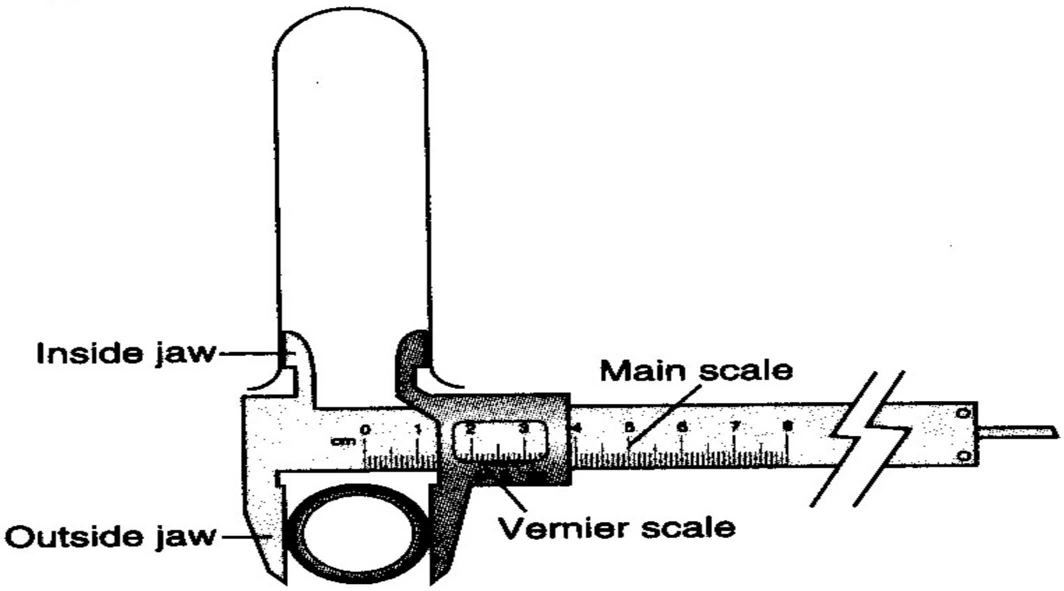
<u>Measuring Instruments</u>

Vernier Calliper

A Vernier calliper is used to measure an object with dimensions up to 12 cm with an accuracy of 0.01 cm.

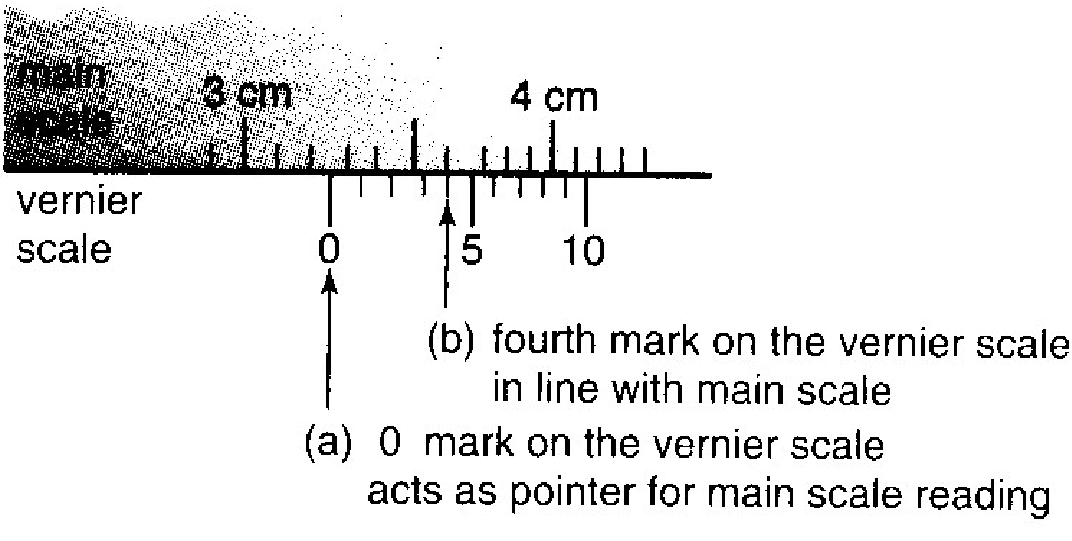


There are two pairs of jaws; one is designed to measure linear dimensions and **external diameters** while the other is to measure **internal diameters**.



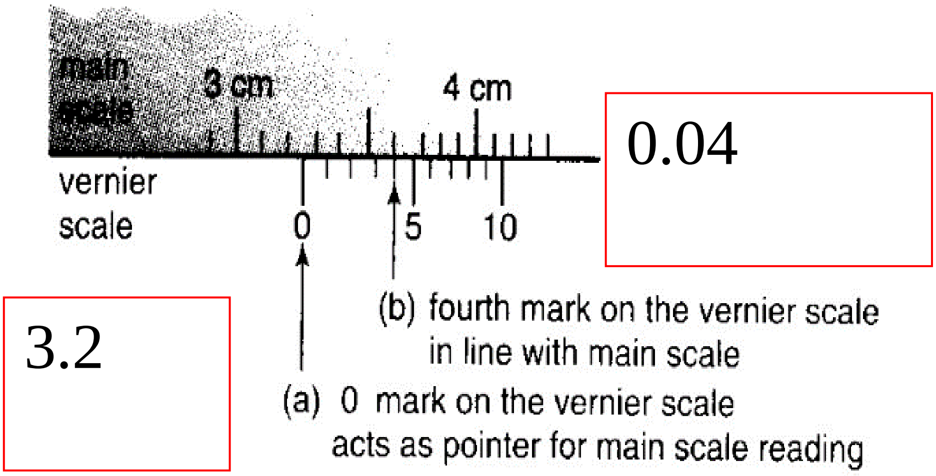
To measure with a Vernier calliper, slide the Vernier scale along the main scale until the object is held firmly between the jaws of the calliper. The subsequent steps are as follows.

(a)The reading on the main scale is determined with reference to the `0' mark on the Vernier scale. The reading to be taken on the main scale is the mark preceding the '0' mark on the Vernier scale. In the figure below, the measurement lies between 3.2 cm and 3.3 cm. The reading to be taken on the main scale is 3.2 cm (the `0' mark on the Vernier scale acts as a pointer).



(b) The reading to be taken on the Vernier scale is indicated by the mark on the Vernier scale, which is exactly in line or **coincides** with any main scale division line. The figure below shows that the **fourth mark** on the Vernier scale is exactly in line with a mark on the main scale. Thus the second decimal reading of the measurement is:

Vernier scale reading = 4 x 0.01 cm = 0.04 cm



(c) The reading of the Vernier calliper is the result of the addition of the reading on the main scale to the reading on the Vernier scale.

Calliper reading = Main scale Reading + Vernier scale reading

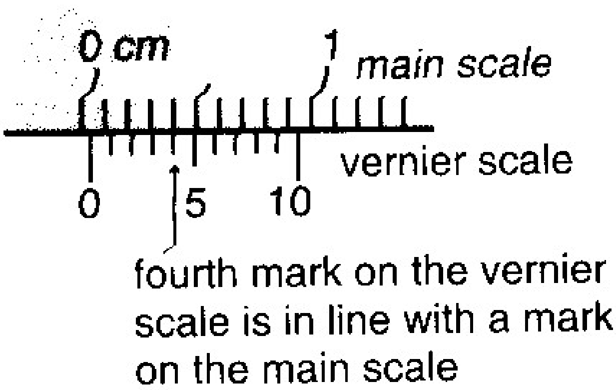
Thus the reading of the Vernier calliper in the figure below is

= 3.2 + 0.04 = 3.24 cm

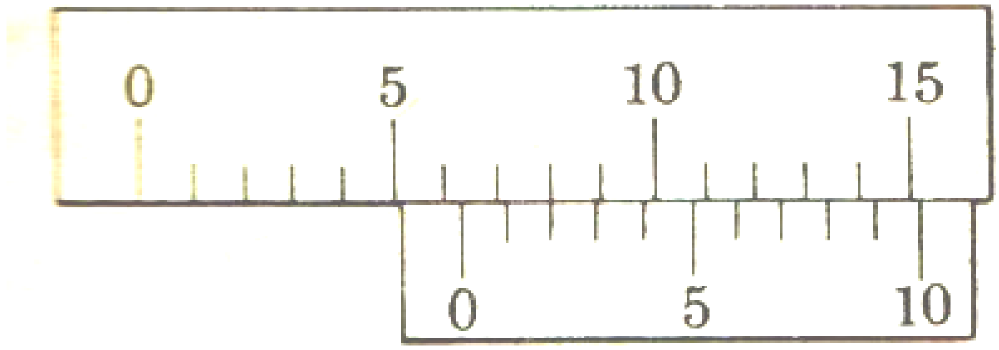
A Vernier calliper has a zero error if the `0' mark on the main scale is not in line with the '0' mark on the Vernier scale when the jaws of the calliper are fully closed.

Positive and negative zero error

A positive zero error is subtracted from the reading while a negative zero error is added to the reading. The figure below show a positive zero error = +0.04 cm.



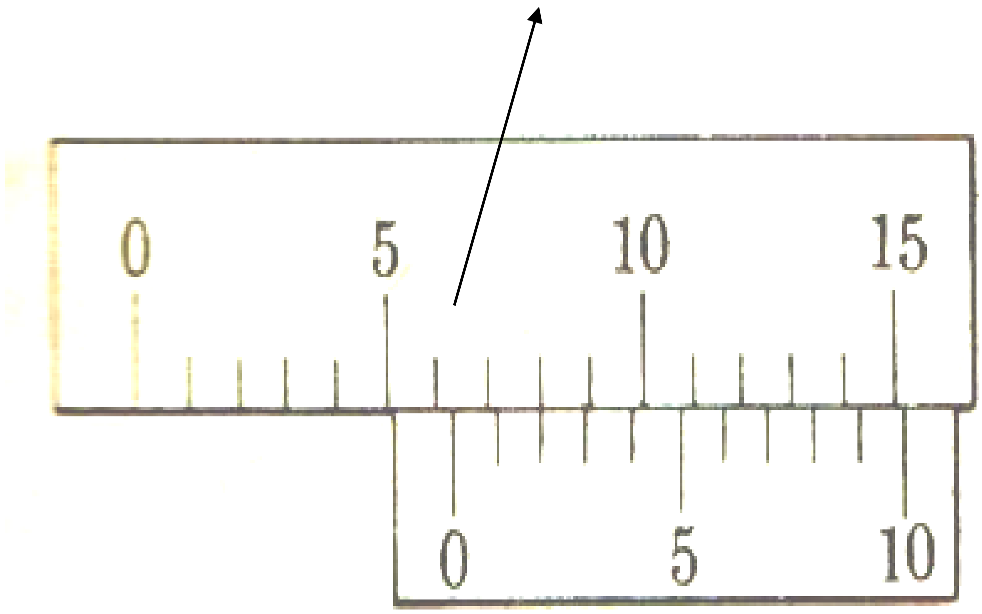
Student activity 1

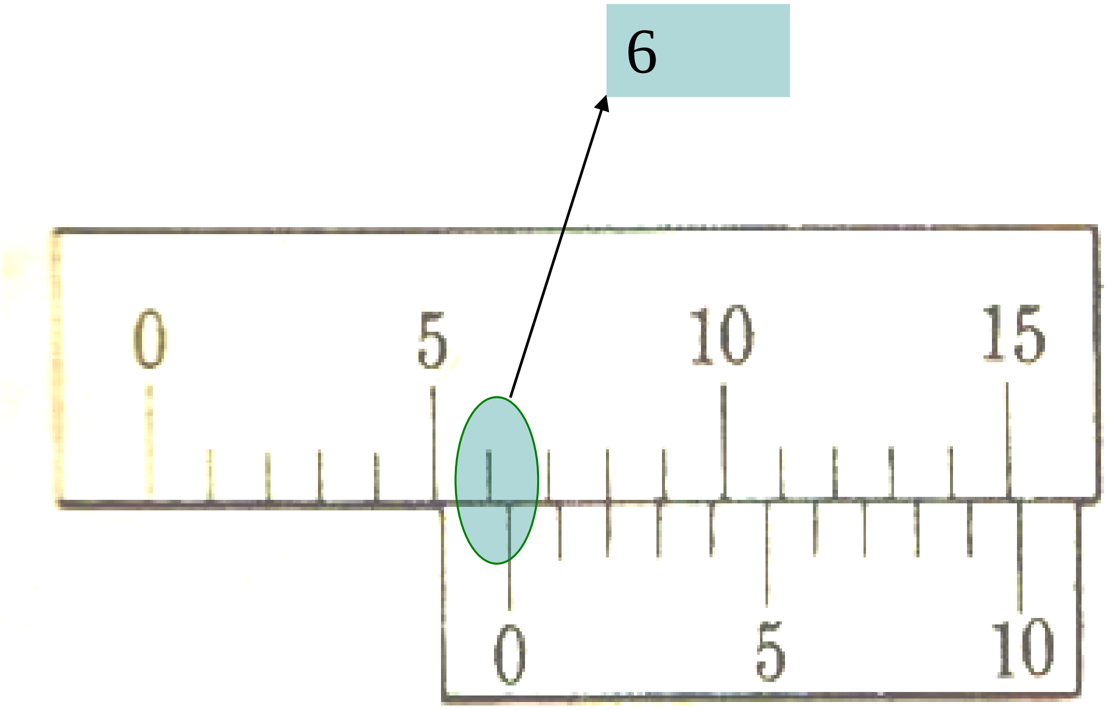


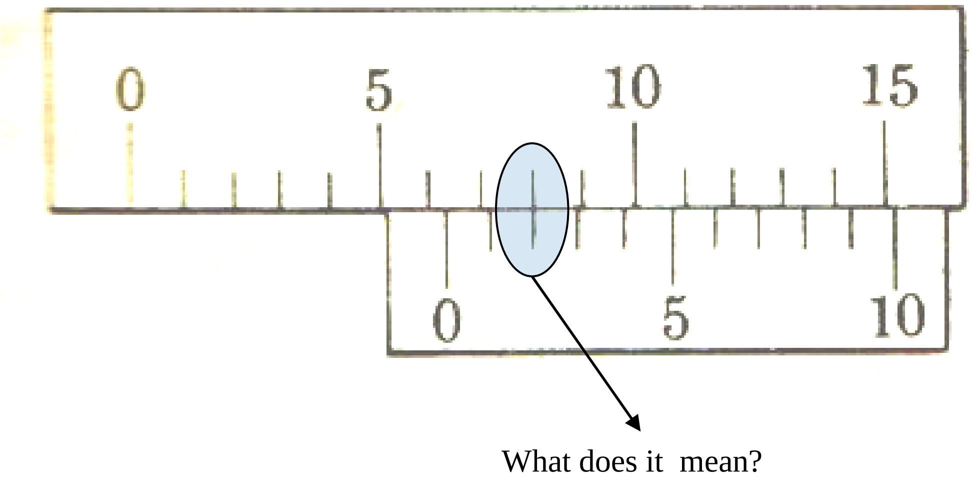
What is the reading of the caliper?

Steps to the solution

What does it mean?




6
0
5
10
15
0
5
10


0
5
10
15
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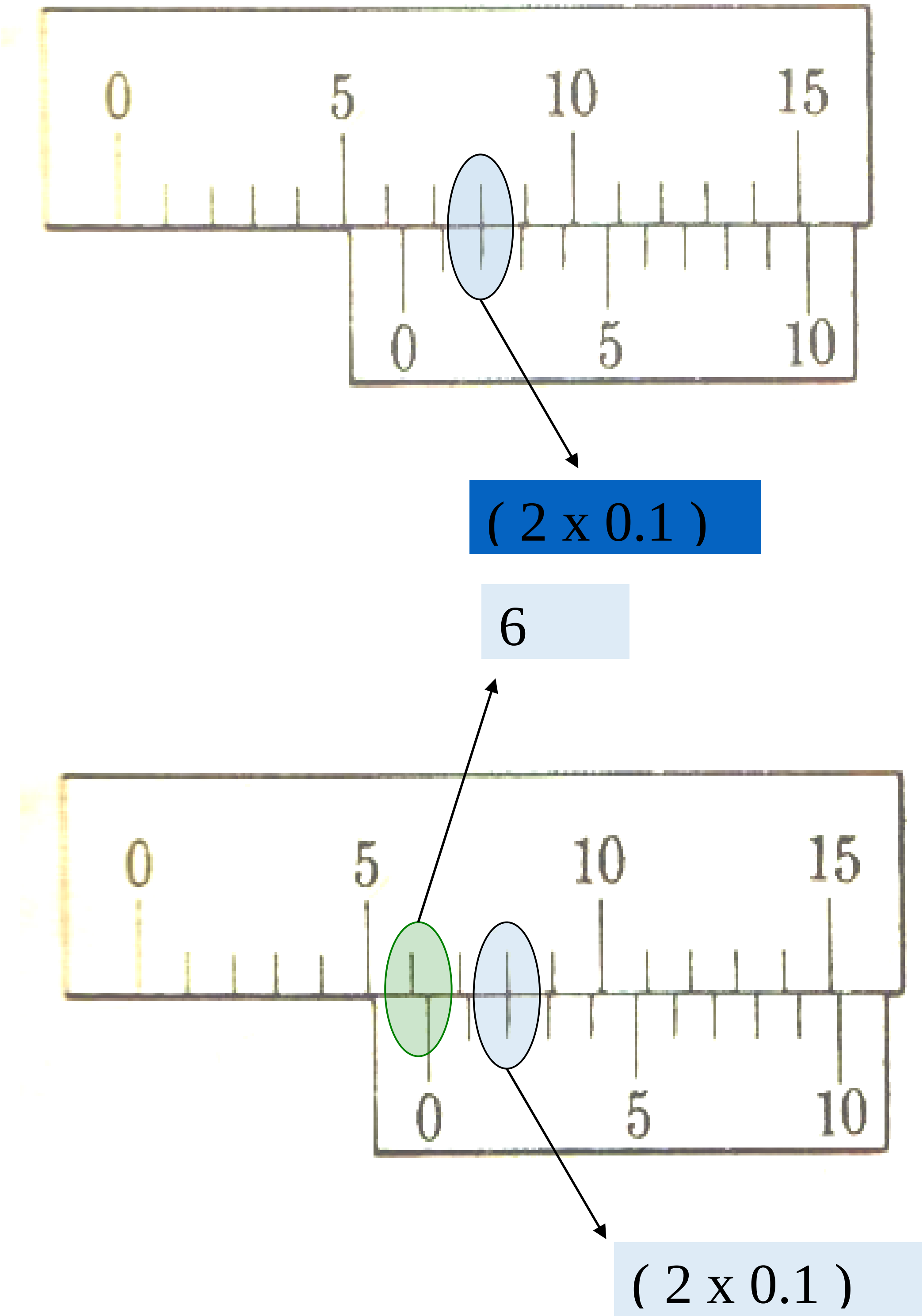
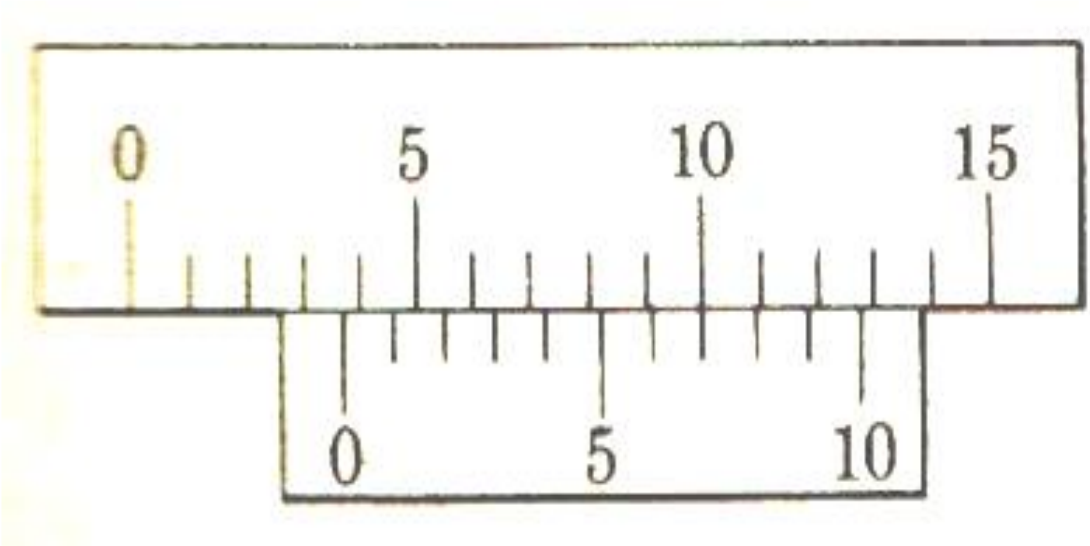
5
10
What does it mean?



The reading is therefore (6 mm+ 0.2 mm) = 6.2 mm

Student activity 2



What is the reading of the caliper?

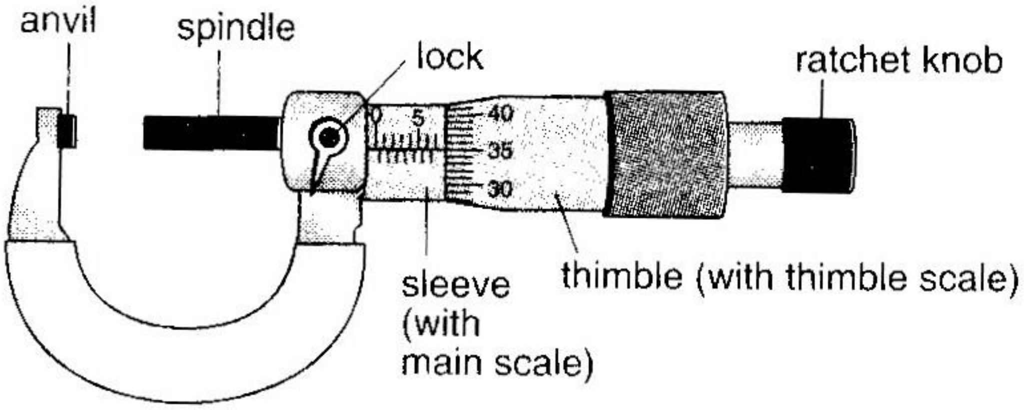
The result of measuring is:

(3 mm + (7 x 0.1) mm) = 3.7 mm

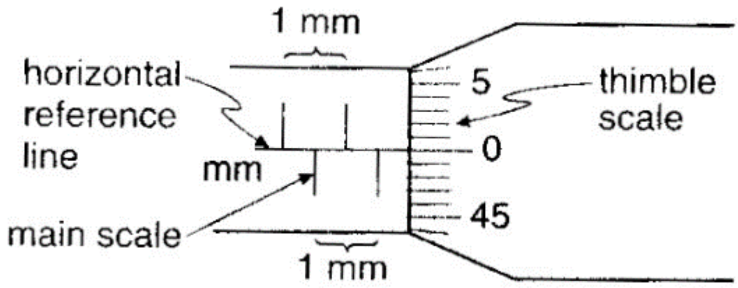
Micrometre Screw Gauge

-A micrometre screw gauge is used to measure small lengths ranging between 0.10 mm and 25.00 mm.

-This instrument can be used to measure diameters of wires and thicknesses of steel plates to an accuracy of 0.01 mm.



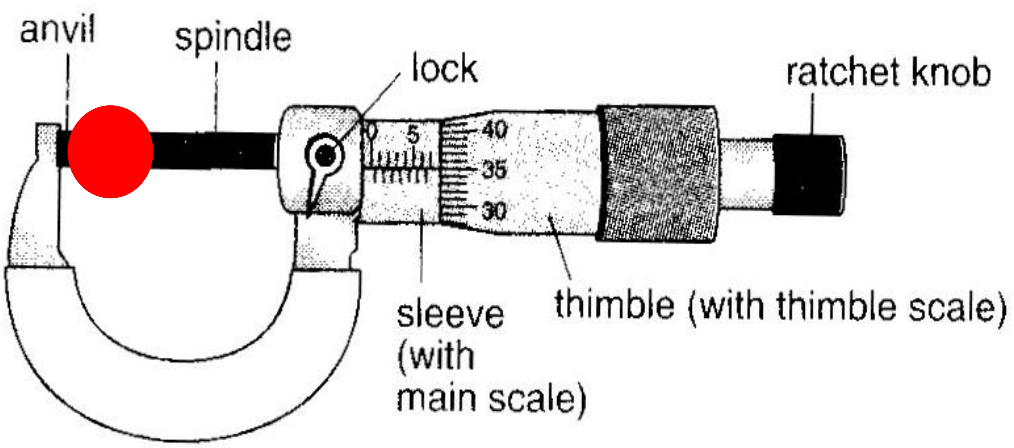
-The micrometre scale comprises a **main scale** marked on the sleeve and a scale marked on the thimble called the **thimble scale**.



-The difference between one division on the upper scale and one division on the lower scale is 0.5 mm.
-The thimble scale is subdivided into 50 equal divisions. When the thimble is rotated through one complete turn, i.e. 360°, the gap between the anvil and the spindle increases by 0.50 mm.
-This means that one division on the thimble scale is

$$\frac{0.5mm}{50} = 0.01mm$$

-When taking a reading, the thimble is turned until the object is gripped very gently between the anvil and the spindle.

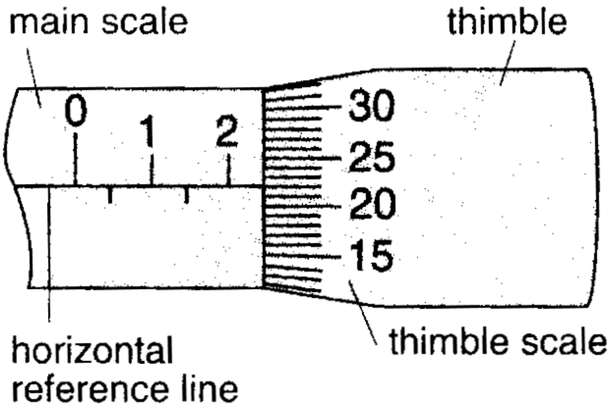


-The ratchet knob is then turned until a `click' sound is heard.
- The ratchet knob is used to **prevent the user from exerting undue pressure**.

- The grip on the object must not be excessive as this will affect the accuracy of the reading.

Taking readings on a micrometre screw gauge

Readings on the micrometre are taken as follows:



(a) The last graduation showing on the main scale indicates position between 2.0 mm and 2.5 mm. Thus, the reading on the main scale is read as 2.0 mm.

(b) The reading on the thimble scale is the point where the horizontal reference line of the main scale is in line with the graduation mark on the thimble scale. In the Figure this is the 22nd mark on the thimble scale, thus giving a reading of 22 x 0.01 mm = 0.22 mm.

(c) The reading of the micrometre screw gauge is the sum of the main scale reading and the thimble scale reading which is: 2.0 + 0.22 =2.22 mm

(d) Just like in Vernier callipers, positive zero error is subtracted from the reading while negative zero error is added.

The students will be taken through the procedures of measuring using the Vernier callipers and the micrometre screw gauge with the help of the advance organizers provided and the interactive simulation. They will be taken through concepts such zero errors and the least count in the measurement scales for both the micrometre screw gauge. The students will then be given simulated tasks, which require them to take measurement of various items interactively using the simulation.After the exposure and interaction with the advance organizers and the simulations on Vernier callipers and the micrometre screw gauge, the learners will be provided with actual instruments and given various items to measure the diameters using the micrometre screw gauge and the Vernier callipers.

APPENDIX G: NACOSTI RESEARCH AUTHORISATION LETTER

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

NACOSTI/P/16/27875/11923

Date:

6th July, 2016

David Gachiu Ngatia
Egerton University
P.O Box 536-20115
EGERTON.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Effects of interactive multimedia simulations advance organizers teaching approach on students' achievement and motivation to learn secondary school physics in Laikipia County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Laikipia County** for the period ending **5th July, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Laikipia County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Laikipia County.

The County Director of Education
Laikipia County.

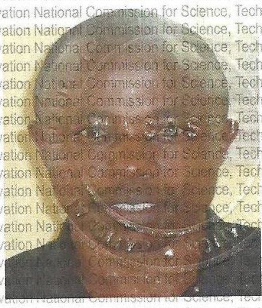
APPENDIX H: NACOSTI RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. DAVID GACHIU NGATIA
of EGERTON UNIVERSITY, 0-20100 NAKURU,has been permitted to conduct research in *Laikipia County*

on the topic: *EFFECTS OF INTERACTIVE MULTIMEDIA SIMULATIONS ADVANCE ORGANIZERS TEACHING APPROACH ON STUDENTS' ACHIEVEMENT AND MOTIVATION TO LEARN SECONDARY SCHOOL PHYSICS IN LAIKIPIA COUNTY, KENYA*

for the period ending:
5th July,2017

Permit No : NACOSTI/P/16/27875/11923
Date Of Issue : 6th July,2016
Fee Recieved :Ksh 2000



....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County 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 without 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) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 10008

APPENDIX I: ABSTRACT OF IJERN JOURNAL ARTICLE

International Journal of Education and Research *Vol. 7 No. 1 January 2019*

IMPACT OF INTERACTIVE MULTIMEDIA SIMULATIONS ADVANCE ORGANIZERS TEACHING APPROACH ON STUDENTS' ACHIEVEMENT IN SECONDARY SCHOOL PHYSICS

David G. Ngatia[1]*, Assistant Lecturer, University of Kabianga, Kenya, dgachiu@yahoo.com, +254725620042 (*corresponding author)

Prof J. Changeiywo[2], Professor, Egerton University, Kenya, jchangeiywo@yahoo.com +254722858563

Dr. Patricia W. Wambugu[3] Senior Lecturer, Egerton University, Kenya, patriwa2010@gmail.com, +254722433741

Abstract

This study investigated the effect of Interactive Multimedia Simulations Advance Organizers (IMSAO) teaching approach on physics achievement in the topic Measurement in Kenyan secondary school Physics. IMSAO approach integrates interactive multimedia simulations and advance organizers in the teaching learning process. Solomon-four, quasi-experimental research design was used. Four schools were purposefully sampled from the 24-mixed day public secondary schools in Nyahururu Sub-County of Laikipia County, Kenya. The sampled schools were randomly assigned to experimental and control groups.168 students from the sampled schools were involved in the study. A Physics Achievement Test (PAT) was developed, validated and pilot tested for use in data collection. The reliability coefficient of PAT was 0.83. A training manual on IMSAO was developed. Thereafter, the teachers in the experimental schools were trained on how to use IMSAO. A pretest was administered to students in one control and one experimental group and after the treatment a posttest PAT was administered to students in all the four groups. Data was then scored and analyzed using Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA) and t-tests at α level of 0.05. The findings indicated that students taught using IMSAO approach demonstrated significant improvement in PAT when compared to those taught through Conventional Teaching Methods (CTM). On the basis of the findings, the study advocates for the use of IMSAO on effectiveness and improved academic achievement in secondary school physics.

Key Words: Advance Organizers, Conventional Teaching Methods, Interactive Multimedia Simulation, Students Physics Achievement

APPENDIX J: ABSTRACT OF IJSRIT JOURNAL ARTICLE

ISSN: 2313-3759 *www.ijsrit.com*

THE EFFECTS OF INTERACTIVE MULTIMEDIA SIMULATION ADVANCE ORGANISERS TEACHING APPROACH ON STUDENTS' MOTIVATION TO LEARN SECONDARY SCHOOL PHYSICS

David G. Ngatia[1], University of Kabianga, dgachiu@yahoo.com, +254725620042
- Corresponding author

Dr. Patricia W. Wambugu[2], Egerton University, patriwa2010@gmail.com,+254722433741

Prof J. Changeiywo[3], Egerton University, jchangeiywo@yahoo.com,+254722858563

Abstract

The study of physics is important for technological development of any society. Despite its crucial role as a catalyst to great innovations, enrolment of students in the subject has been low at Kenya Certificate of Secondary Education (KCSE).There are many factors that might cause students to have low motivation towards physics. One among the factors is employment of ineffective teaching methods that are not interesting and enjoyable to the learners. Interactive Multimedia Simulation Advance Organizers (IMSAO) is one of the approaches that could enhance students' motivation to learn physics. The approach allows students to create models of real situations, manipulate, and get feedback immediately .This study investigated the effects of using the approach on students' motivation to learn physics topic measurement in Nyahururu Sub-County in Laikipia. The study also investigated and compared the level of motivation to learn physics between boys and girls when exposed to IMSAO. Solomon's Four Non-Equivalent Control Group design was specifically used. A physics Motivation Questionnaire (PMQ) was developed and used for data collection. A total population of 168 form two students, drawn from the four sampled schools, took part in the study. Experimental groups were taught using IMSAO teaching approach while the control groups were taught using Conventional Teaching Methods (CTM). Data was analysed using t-test and ANOVA. The findings of the study showed that IMSAO teaching approach affected students' motivation to learn physics positively when compared toCTM. The results also revealed that the IMSAO teaching approach affected positively the motivation to learn physics in both gender. The researchers recommends the integration of the IMSAO teaching approach in the teaching of physics to make the learning of physics interesting and to reverse the trend of low enrolment in physics in secondary schools.

Key Words: Interactive Multimedia Simulations Advance Organisers (IMSAO), Conventional Teaching Methods (CTM), Student Motivation, Secondary School Physics.

26