# EFFECT OF VIRTUAL PHYSICS PROGRAMS ON STUDENTS' LEARNING OUTCOMES WITHIN PUBLIC SECONDARY SCHOOLS IN KAKAMEGA SOUTH SUB-COUNTY

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**A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Education in Educational Management and Policy Studies of Masinde Muliro University of Science and Technology**

**November, 2024**

## DECLARATION

This thesis is my original work, prepared with no other than the indicated sources and support, and has not been presented elsewhere for a degree or any other award.

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## APPROVAL BY THE SUPERVISORS

This thesis entitled "*Effect of Virtual Physics Programs on Students' Learning Outcomes within Public Secondary Schools in Kakamega South Sub-County*" has been submitted to Masinde Muliro University of Science and Technology for examination with the approval of the following supervisors:

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## COPYRIGHT

## DEDICATION

I dedicate this thesis to my dear wife, who has been a professional colleague and my rock through life's journey.

To my mother Janet, and the late Aunt Gladys Kamonya who taught me resilience, perseverance and how to nurture big dreams.

To my children, Ryan, Kelly Talia, and Tania who have made my life complete and given me reason to be happy appreciating God's faithfulness.

## ACKNOWLEDGEMENTS

Writing this thesis has been defined by many people who have played a critical role in assisting me in the course of my study. I am particularly indebted to my supervisors, Dr. Caroline Wekullo and Dr. Paul Ogenga, who were directly involved through their guidance and support during the course.

I cannot forget my colleagues and other Department of Education Planning and Management members at MMUST for their advisory roles and encouragement. I have to say this; you are a great team, and I enjoyed working with you, the collaboration and teamwork shown during my study cannot match any other.

I also thank the Kakamega South Sub-County Director of Educational for allowing me to carry out this research in schools under his jurisdiction. I appreciate the principals of schools for giving me a chance to partake the study in their schools and respective physics teachers and the students for participating in the study actively.

I wish to thank my wife, Audrey Lumasia, my mother Janet, my late Aunt Gladys Kamonya, and our children; Ryan, Kelly Talia, and Tania, for their understanding, encouragement, and support in urging me to soldier on, even when I was about to give up. I unreservedly want to say thank you. Your patience and kind words meant a lot to me. I will forever be grateful.

## ABSTRACT

Virtual learning programs have been used in different parts of the world but their impact on learning outcomes varies from subject to subject. In Kenya, it was only at the onset of Covid-19 that academic institutions embraced it as one of the alternative ways of instruction. This study investigated the effect of virtual Physics programs on students' learning outcomes in physics within public secondary schools in Kakamega South sub-county. The study was guided by three objectives: to determine the effect of physics virtual programs on students' achievement in physics within public secondary schools in the Kakamega South sub-county; to establish the effect of virtual Physics programs on students' attitude towards physics in public secondary schools in the Kakamega South sub-county, and to examine the effect of virtual programs on students' motivation in physics within public secondary schools in the Kakamega South sub-county. The study adopted the quasi-experimental research design, using treatment and control group model. The independent variable was mode of teaching and learning physics virtually while the dependent variables were; students' achievement in physics, attitude in physics and motivation in physics. The target population was 4000 form two students in public secondary schools in Kakamega south sub-county, from which a sample of 351 form two students were selected through multistage sampling, including: purposive, stratified and simple random sampling techniques. I analyzed the data using difference in difference. The results of the analysis showed that students' achievement in physics was increasing by 1.34 point over time and the increase was statistically significant. Also, the results of the analysis showed that students' attitude towards physics increased by .494 points over time and the increase was statistically significant. Lastly the analysis results on students' motivation showed a positive increase over time due to the intervention and were statistically significant ( ). These research findings showed that the virtual physics offer flexible, accessible and interactive alternative to traditional face to face. The findings would provide widespread benefits that extend to individual student by enhancing their understanding hence improved learning outcome, impact to teachers by enhancing their teaching tools, being cost effective and infrastructure flexibility to schools, policy makers would have scalable education models and data driven insights, and bring social equity and work force development to parents and society as a whole. Consequently, the study recommends that the government through KICD rolls out full integration of virtual physics programs in secondary education curriculum, incorporating teacher professional development and blended teaching and learning in schools.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| CAK | Communication Authority of Kenya |
| CDE | County Director of Education |
| CS | Cabinet Secretary |
| DiD | Difference in Difference |
| FTF | Face-to-face |
| KBC | Kenya Broadcasting Cooperation |
| KCSE | Kenya Certificate of Secondary Education |
| KICD | Kenya Institute of Curriculum Development |
| KIE | Kenya Institute of Education |
| MMUST | Masinde Muliro University of Science and Technology |
| MOEST | Ministry of Education Science and Technology |
| PAT | Physics Achievement Test |
| SAQ | Students Attitude Questionnaire |
| SCDE | Sub-County Director of Education |
| SMQ | Students Motivation Questionnaire |
| STEM | Science, Technology, Engineering, and Mathematics |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Overview

This chapter presents the background of the study, the statement of the problem, the purpose of the study, the objectives of the study, and the research hypothesis. The chapter also presents the significance of the study, limitations of the study, assumptions of the study, scope of the study. It would also include the theoretical framework and conceptual framework.

## 1.2 Background of the study

The role of science, technology, engineering, and mathematics (STEM) subjects in achieving sustainable global development cannot be underestimated, given that scientific breakthroughs are at the centre of progressive development (Rull, 2014). This explains why some STEM-based economies report a high rate of employment, better wage rates, and increased patent rights than non-STEM economies (Mallory, 2018; Rothwell, 2013). Physics is one of the STEM subjects that is mandatory for students to pursue courses related to Engineering and Technology. With this realization, many countries, including developing economies, are using advancements in technology to increase the accessibility of Physics at secondary school level. In particular, virtual teaching of Physics and other STEM subjects in secondary schools is being implemented in various developing countries. The use of virtual learning in Physics subjects is expected to address the shortage of Physics trainers in less developed countries.

Most developed countries embraced virtual learning long ago and are far more advanced. For instance, in North America, radio is not widely used in virtual learning. However, there is the active use of television for remote learning purposes (Fabregas, 2019; Miguel &Alejandro, 2019). For instance, Mexico has been using television for virtual learning in lower secondary schools found in remote communities since 1968 for what is termed as Telesecundaria (Fabregas, 2019; Miguel & Alejandro, 2019). The television programs run on a scheduled basis from 8 am to 8 pm in Telesecundaria every school day, carrying the same high school curriculum found in other ordinary secondary schools in the country. Therefore, the learning timetable in those schools is aligned with television programs throughout the day. However, the program is supplemented by teachers present during the airing of programs to engage learners in their assignments.

Secondary schools in the United States and Canada have a more advanced form of virtual learning that does not involve radio and television (Pregowska et al., 2021). Each high school has an online learning platform that mostly uses the internet. Therefore, it is a form of online learning where students can interact with the instructors, set their learning timetable, and directly interact with other learners even though they are not meeting physically. Therefore, each student is required to have digital devices such as a computer and access to the internet.

Whereas students' progress on virtual learning is tested conventionally using continuous assessment tests and final term exams in both the US and Canada, studies on its effect reported contradictory results. For example, a meta-analysis study done in the United States reported no significant difference between the learning outcomes of students in online classes and those in face-to-face classes (Cavanaugh et al., 2004). However, another study conducted by the US Department of Education indicated that K-12 students in online learning programs performed better than their counterparts in face-to-face classes (Patrick & Powell, 2009).

Virtual learning through radio and television is widely used in Asian countries. In China, 44 of its universities use radio and television broadcasts to reach their huge student population (UNESCO, 2020). In addition to virtual broadcasting, the universities provide print materials and audio cassettes to students.

The Open University of Japan (formerly known as the University of the Air) has various courses whose mode of teaching incorporates TV and radio lessons, face-to-face instructions, print materials, and online lessons (David &Amey, 2020). The university has its TV and radio stations exclusively broadcasting its educational content. A study done on the learning outcomes of students in Japan [though in higher education] revealed no significant difference between students taking online and offline classes (Tateyama, 2015).

A recent survey reported in Mainichi (2021), one of the leading Japanese dailies, showed that 70% of the universities were switching back to the face-to-face model of learning due to its effect compared to online learning. A recent webinar held in Japan organized by Awaji Youth Federation concluded that virtual learning could not be equated to face-to-face learning (Singh, 2021). This conclusion corroborates what the National Federation of University Co-operative Associations reached after an online survey showed that 44.7% of students were not satisfied with online classes (Singh, 2021). Consequently, the effect of online learning is in question despite its widespread adoption.

UNESCO (2020) revealed that 70% of African countries were using either radio or television for virtual learning. The study also indicated that 34% of the countries combined radio and television. Before COVID-19, many countries blended radio lessons with normal classroom lessons. This happened under the supervision of the subject teacher. The effect of radio lessons on students' learning outcomes was not monitored and evaluated since it was done alongside face-to-face learning.

During COVID-19, many African countries used television and radio lessons to keep learners busy as they waited for the situation to normalize (Monitor, 2020). This was the case in Libya, Liberia, Morocco, and South Africa (World Bank, 2020). Therefore, not many countries thought about evaluating the effect of radio and television lessons on students' learning outcomes in any subject. Evaluation could not have been possible, given that some students could neither access radio nor television (Monitor, 2020).

In Egypt, distance learning did not rely on radio and television. Instead, an interactive website called Egyptian Knowledge Bank was developed with learning content for all grades from preparatory to secondary schools (World Bank, 2020).

Through the virtual guidance of their teachers, students could access the website, access the right lessons, and ask questions as though there are in an actual classroom (World Bank, 2020). To assess students' learning outcomes on the virtual platform, the Egyptian Ministry of Education asked parents to ensure that kindergarten and grades 1-2 students finish the curriculum on the website (World Bank, 2020). In addition, students in grades 3-7 were assessed through a research project in each subject done on the learning website.

At the same time, students in tenth grades were evaluated through a pilot test taken at home from tablets supplied by the ministry of education. Accordingly, unlike many other African countries, Egypt had an elaborate way of assessing the learning done virtually during COVID-19.

Regionally, countries like Uganda and Rwanda have also been using radio and television lessons before COVID-19 (World Bank, 2020). Like most African countries, virtual learning through radio and television was done in the physical classroom under the supervision of a teacher. Extensive use of radio and television was during the outbreak of COVID-19, and its impact on student learning outcomes was not assessed, despite the long closure of schools in Uganda and Rwanda (Monitor, 2020).

Radio lessons in Kenya have been in place even before COVID-19 (Weru, 2018). These lessons were aired during class time under the teacher's supervision to enable students to implement the instructions given over the radio (Nyambeki, 2016). At that time, radio lessons were simply supplementing face-to-face learning with their teacher. However, this only used to happen in primary schools, and practice was not widespread in rural schools without the required infrastructure. When COVID-19 broke out, the government of Kenya, through the Kenya Institute of Curriculum Development (KICD), rolled out virtual learning through radio and television in both primary and secondary schools (Government of Kenya, 2020). All the STEM subjects including Physics were covered in these lessons. While the government conducted a rapid survey and discovered that many students were listening to radio and television lessons, the impact of such a mode of learning on students' learning outcomes, particularly in Physics, has not been evaluated (Ministry of Education and KICD, 2020). This puts the effect of virtual learning in question, despite being the alternative mode of learning adopted by the Ministry of Education moving forward.

In Kakamega County, Kakamega South Sub-County, several schools have continued with virtual learning even after in-person learning resumed. Out of the 31 secondary schools in the sub-county (Araptoo, 2020), 10 secondary schools with a functional computer laboratory have used the KICD virtual learning program. Nevertheless, none of the schools has evaluated the program's impact, specifically on student learning outcomes in Physics subjects. Based on this background, this study would seek to assess the effect of KICD virtual Physics programs on students' learning outcomes in the subject within public secondary schools in Kakamega South Sub-County.

### 1.3 Statement of the Problem

The Kenyan Ministry of Education adopted physics virtual learning program done through television and radio as the only alternative to face-to-face learning going forward (Ministry of Education Science and Technology [MOEST], 2020), its effect and student need-appropriateness of such program are not known. Without establishing the effect of the virtual learning program, it is practically impossible to improve and make it learner-oriented.

While there was an improvement learning outcomes in KCSE 2020 compared to 2019, it is impossible to attribute this difference in performance to KICD virtual learning despite its dominance as a form of learning in that period (Cheruiyot, 2021; Manyibe, 2021; MOEST, 2020). Additionally, due to the flexibility and convenience of online learning, several studies (Aditya et al., 2021; Lockee, 2021) indicate that the number of students in secondary schools enrolling in virtual learning programs is going to increase post-COVID-19. However, the effect of such learning arrangements is not known. Furthermore, failure to establish the effect of the KICD virtual learning program could also lead to wastage of resources, given that the ministry of education spent over Kshs.577,430,000 million to finance television, radio, and KICD cloud programs in 2020 alone (MOEST, 2020).

Various studies have been carried out to establish the impact of virtual learning [television and radio lessons] on reading, writing, and listening skills among preschool-going children and adults (Sanusi et al., 2021). Other studies (Balakamakshi & Savithri, 2021; Gopal et al., 2021; Toong et al., 2021) focused on the impact of online learning on students'learning outcomes in colleges and universities, but not secondary schools. Studies (Ahmed, 2016; Nyambeki, 2014; Weru, 2018) done in Kenya about e-learning in secondary schools largely focused on factors affecting its adoption and not its effect on students'learning outcomes in secondary schools. Consequently, there is a research gap regarding the effect of virtual learning programs on students'learning outcomes in physics in secondary schools. Against this backdrop, this study established the effect of physics virtual programs on students' learning outcomes in physics within public secondary schools in Kakamega South Sub-County

## 1.4 Purpose of the study

The general purpose of this study was to assess the effect of using virtual Physics programs on students' learning outcomes in physics within public secondary schools in the Kakamega South sub-county.

## 1.5 Objectives of the study

i. To determine the effect of virtual physics programs on students' achievement in physics within public secondary schools in Kakamega South sub-county;
ii. To establish the effect of virtual physics programs on students' attitude towards physics in public secondary schools in Kakamega South sub-county,
iii. To examine the effect of virtual physics programs on students' motivation in physics within public secondary schools in Kakamega South sub-county.

## 1.6 Research Hypotheses

**:** Virtual physics programs have no statistically significant effect on students' achievement in physics within public secondary schools in Kakamega South sub-county;

**:** Virtual physics programs have no statistically significant effect on students' attitude towards physics within public secondary schools in Kakamega South sub-county;

: Virtual physics programs have no statistically significant effect on students' motivation in physics within public secondary schools in Kakamega South sub-county.

### 1.7 Significance of the study

For many years, television and radio lessons have been used in Kenya but never regarded as a viable alternative form of learning to in-person learning. This is exhibited by the sheer lack of studies in Kenya, particularly examining its effect in achievement, attitude and motivation of learners in physics subject at the high school level. Therefore, the findings of this study are invaluable in shaping the virtual learning policy and the teaching practice of physics in a virtual learning environment.

The study identified the minimum prerequisite factors needed to facilitate an effective physics virtual learning program in secondary schools in Kenya. In addition, this study provides a deeper understanding of virtual learning in Kenya, enabling the formulation of a virtual learning policy, which has been lacking, despite the widespread adoption of e-learning in universities.

The study also provides a basis for further discourse on the effect of virtual learning on learning outcomes in physics. Over recent years, student learning outcomes in the subject has been declining, specifically since 2014. Similarly, the number of students selecting the subject at the high school level has been dwindling. Some teachers have been accused of discouraging students they consider academically weak not to specialize in STEM areas instead of encouraging them (Wanzala, 2017). This was revealed by a study conducted by the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) (Wanzala, 2017). With poor learning outcomes in physics and the reducing number of students taking the subjects, Kenya's sustainable industrialization vision of 2030 may be in jeopardy. This study highlights the role of virtual learning in enhancing students' learning outcomes in physics.

This study is among the first to examine virtual learning from the theoretical lenses of transactional distance theory to the body of knowledge. The transactional theory identifies that at least three factors are important for effective distance learning. These are dialogue, course structure, and learner autonomy. By examining virtual learning through television and radio, this study validates the theory's major assertions by adding relevant literature to the body of knowledge.

**1.8 Limitation of the study**

The Physics virtual program was rolled out to cover most parts of the country, if not the whole country. EDU TV and EDU Radio have partnered with the national broadcaster and other community radio to ensure that the virtual programs reach most learners. However, it is not clear the extent to which schools have embraced them. The researcher conducted a baseline study beforehand, to get the required information.

Secondly, the use of virtual programmes for teaching highly dependent on steady supply of electricity. It was however not guaranteed whether there would be steady supply of electricity in the schools that would be used, for effective blended learning, hence some schools would have advantage over others.

This being a quantitative study calls for random sampling of respondents, so as to make a valid conclusion. However, random sampling was not be possible in this study, due to the static nature of classes and ethical issues that go along with random sampling.  The researcher however assigned schools into various treatment groups in random manner.

Lastly, teacher education, efficacy, experience, school laboratories, and institutional infrastructure limited the research methodology.

### 1.9 Assumptions of the study

The study assumed that the respondents would provide the required information. The study also assumed that no students in schools that had adopted KICD virtual learning programs nor those that had not affected each other's learning outcomes, leading to independent observations. Lastly, the study assumed that the variance among schools in physics virtual learning programs and face-to-face schools was equal. The study also assumed that no student would be in the control and treatment groups at the same time.

### 1.10 Scope of the Study

The study was carried out in Kakamega South Sub-County. It focused on secondary schools which used face to face learning and those that implemented physics virtual learning. The purpose of this study was limited to the effect of the KICD virtual learning program on learning outcomes in the subject. It also focused on achievement, attitude and motivation as the learning outcomes. Additionally, only form two students were used in this study, because they have a foundation of understanding of basic science principles as compared to from 1 class who focus on introductory science. Also form 2 is a transitional period where students begin to engage with more specialised physics topics but not preparing for high stakes examinations as of form 3 and 4, making them ideal to introduce to them virtual physics interventions that could build deeper understating. The study was limited by specific topics to be covered since findings could constraint generalisation on physics overall.

## 1.11 Theoretical Framework

This study was guided by transactional distance theory. Transactional distance theory was postulated by Michael Moore (1990), and it is one of the key theories in virtual or distance learning, though it was found relevant even in face-to-face learning. The theory argues that there is always a distance in any form of educational relationship (Moore, 2013); hence critical to consider three key factors 1) dialogue, 2) structure, and 3) student autonomy. According to Moore (1997), the amount of dialogue between the teacher and the student determines the transactional distance in education. To this end, Moore (1997) argued that greater transactional distance occurs when there is less dialogue between the instructor and the students. Giossoset (2009) elaborated on the aspect of dialogue, stating that it goes beyond two-way communication to incorporate all kinds of interactions within the set educational goals, whose result is solving students' problems. Whereas the frequency of dialogue is important, Moore (2013) emphasizes the quality of communication towards addressing the needs of the virtual learner. Physics virtual program may provide a strong dialogue enhancing learning outcome by addressing students' misconceptions and promoting deeper understanding and support problem solving.

The second factor Moore (2013) deemed important in distance learning is the course structure. Moore (1997) describes course structure in terms of its rigidity or flexibility regarding course goals; teaching techniques, course assessment, and the extent to which each student's needs are accommodated. Virtual physics programs may improve learning outcome by providing students with clear and organised approach and helping them focus on key concepts in physics.

The third factor, learner autonomy, is the sense of self-direction and interdependence perceived by the learner as they go through the program. Moore (1990) developed the concept of transactional distance because he believed that greater transactional distance was detrimental to student academic learning outcomes. The objective of transactional distance theory in online and distance learning was to inform the designing and implementation of distance and virtual learning programs to optimize educational outcomes. High learner autonomy in virtual physics programs may be an asset for students who are self-motivated and disciplined, autonomy can lead to enhanced engagement and deeper learning.

The physics virtual learning program utilizes TV and radio broadcasts, is affected by transactional distance. Students do not have the opportunity to interact with the course instructor on television or radio; these platforms do not provide such interaction. While this is done, bearing in mind that students would be able to engage their subject instructor after lessons, some schools might not have as qualified and motivated teachers as one on the television or radio program. Consequently, transactional distance can be greater due to the lack of effective dialogue (Moore, 2013). Similarly, the students do not have much control over the virtual course design, the timing of the radio program, and the ability to forward, pause, and course assessment, as argued in transactional distance theory. Therefore, based on this theory, this study would seek to validate whether transactional distance must be reduced for education outcomes in terms of good scores to be achieved, as argued by Moore (1997).

## 1.12 Conceptual Framework

Based on the transactional distance theory and the empirical literature review, this study conceptualizes that physics virtual program and face-to-face learning affect students' learning outcomes in physics. Physics virtual learning programs through television and radio broadcast is the independent variable under the treatment group. Physics virtual learning blended with face-to-face schools would form the treatment groups. Form two students in schools sampled for physics virtual programs would be subjected to teaching and learning using virtual learning program in Physics. Therefore, instructors teaching the virtual lessons would be the same across all the schools that had adopted it. This would also be supplemented by face-to-face learning by the respective teachers for the subject Physics in the sampled Schools. On the other hand, face-to-face (F2F) learning was the independent variable for the control group. The control group comprises form two students' sample in public secondary schools within Kakamega South Sub-County schools that used face to face learning programs. Therefore, the teachers teaching Physics in face-to-face classes across these schools were the same. However, the student learning outcomes in Physics were measured using their scores in the three research instruments that were used for data collection in this study.

The independent variable was the mode of learning which was inclusive of virtual and face-to-face, while the dependent variable was student's learning outcomes which was broken down into achievement, attitude and motivation in Physics forming the three objectives. Therefore, the expected interaction between the independent, dependent and control variables as predicted by the researcher is as illustrated in figure 1.

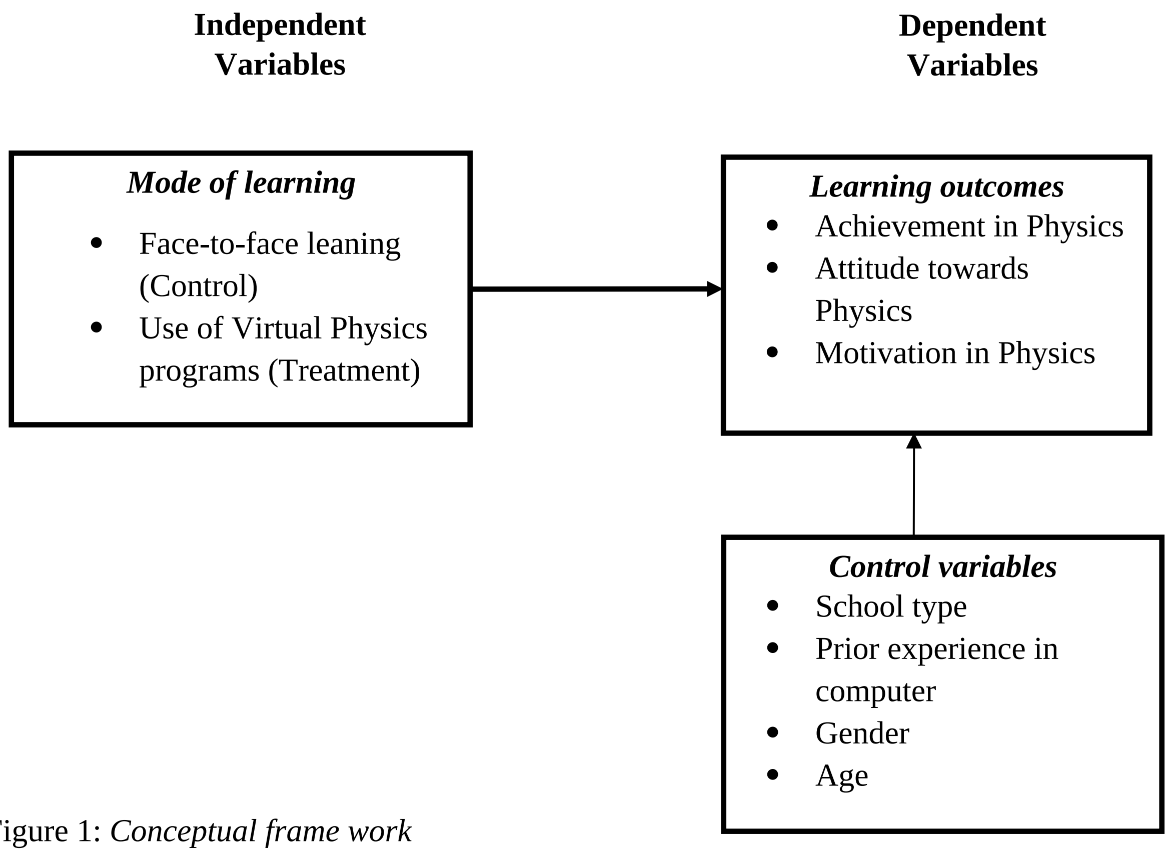


Figure 1: *Conceptual frame work*

The control variables were gender, age, school type, and prior experience to computer which ensured dependent variable and independent variables are accurately represented. The school status was not controlled to yield results that mirror diversity of education environments giving insights into how the program performs across public and private schools without adjusting the existing differences.

The researcher controlled for novelty by the use of familiarisation of the constructs for a short time before measuring the outcomes. This allowed novelty to wear down so that initial excitement does skew the data.

### 1.13 Operational definition of key Terms

For the purpose of conducting this study, the following terms were conceptualized as follows;

**Academic Achievement**: The term achievement refers to the extent to which instructional objectives are attained by learners in physics. Standardized tests with structured questions were used to assess extend of instructional objectives attainment where scores attained were recorded as percentages

**Attitude**: in this study attitude refers to the extent to which a leaner likes Physics as a subject. A survey with items that capture learners likes in physics was administered, responses were quantified using a Likert scale (1=strongly disagree to 5 = strongly agree).

**Learning outcomes**: In this study the term learning outcomes are Students' academic test achievement in Physics, attitude towards Physics and motivation in the subject.

**Motivation** In this thesis the term motivation means the extent to which a leaner is interested in Physics now and in future. A survey with items that capture learners' interest in physics was done, responses were quantified using a Likert scale (1=strongly disagree to 5 = strongly agree).

**Virtual Learning Programs**: These are Physics lessons for form two students as aired on EDU TV platform, Computers or mobile devices. The presence of virtual physics programs was indicated by binary coding (1= access to virtual programs and 0 = no access)

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Overview

This chapter discusses the historical development of virtual learning in Kenya, the importance of STEM subjects, and the effect of virtual learning on student learning outcomes. It also presents the research gaps identified from the extant literature.

## 2.2 Virtual Learning in Kenya

In Kenya, the concept of virtual learning programs was started after independence and was carried out by the national broadcaster Voice of Kenya (VOK) (GOK, 1964). In 2001, the World Space project took over the broadcast (which was essentially done via the radio) before it was reverted to the national broadcaster. The national broadcaster took over the program because of its nationwide reach, hoping to reach most of the schools in the country (Kenya Institute of Education, 2005). Through the Session paper No. 1 of 2005, KICD was mandated to ensure the delivery of educational media programs through radio and television channels (Weru, 2018).

The Kenya Institute of Curriculum Development (KICD) has been in existence since 2013 (KICD, 2021). It was established through an Act of Parliament. KICD succeeded the Kenya Institute of Education (KIE), which had been in existence since 1968. KICD has many roles, one of them being disseminating education programs via a third channel (Kenya Institute of Curriculum Development, 2021). In Kenya, radio lessons were established in the 1960s, whereas televised lessons only started in 2010 (KICD, 2021). The concept of out-of-classroom learning was enhanced during the lockdowns necessitated by the ravaging Covid-19 pandemic (MOEST, 2020). KICD was up to the task in Kenya and revamped its radio and television programs. In responding to a question on KICD and its e-learning programs from a Member of Parliament, the Cabinet Secretary (CS) in charge of education indicated that the e-learning initiated by the government through KICD was meant to ensure that virtual learning lessons were delivered to over 15 million students during the lockdown period (Parliament of Kenya, 2020). The CS further indicated that KICD used the EDU TV to transmit the virtual lessons targeting primary and secondary school learners (Parliament of Kenya, 2020). The government has ensured that EDU TV is a must-carry channel. The Communication Authority of Kenya (CAK) has mandated all TV distributors to carry the channel. This means that even the Pay TV signal distributors have EDU TV in their channel lists.

Besides the EDU TV channel, KICD has also ensured that radio lessons are broadcasted to learners. KICD partnered with the national broadcaster, KBC Radio, to broadcast its virtual lessons. In addition, KICD has also partnered with other FM radio stations to disseminate the virtual lessons to ensure that it attains 100% cumulative coverage across the country (Parliament of Kenya, 2020). Therefore, schools with the necessary infrastructure incorporate these lessons into their timetables. To add to the program, Teachers Service Commission (TSC) in January 2022 started piloting an online teaching program called Secondary Education Quality Improvement Project among select 12 schools within the country (Mitty, 2022). The pilot program, which lasted for two months, involved teachers from Machakos Boys and Alliance Girls High School to share lessons with understaffed schools in 10 counties in the country. The lessons shared from the two schools covered Chemistry, Biology, Physics, Mathematics, and English (Mitty, 2022). The program aimed to advance online learning among Secondary schools in Kenya and address teachers' shortages in the country. The counties involved in the pilot program were Isiolo, Kisii, Taita Taveta, Kilifi, and Bomet, targeting form two students (Mitty, 2022). Consequently, virtual learning in secondary schools in Kenya is still at an infant stage, where continuous monitoring and evaluation of its implementation and effect cannot be ignored.

### 2.3 STEM education in Kenya

The role of science, technology, engineering, and mathematics (STEM) training in achieving sustainable global development cannot be underestimated, given that scientific breakthroughs are at the centre of progressive development (Rull, 2014). This explains why STEM-based economies report a high rate of employment, better wage rates, and increased patent rights than non-STEM economies (Mallory, 2018; Rothwell, 2013). Furthermore, countries focused on STEM training, like China and India, have benefited significantly with year-on-year growth in the gross domestic product (Baruah, 2021; Hong, 2018). Similarly, the solution to climate change, global healthcare system vulnerability to health pandemics such as coronavirus 2019, and depletion of natural resources are inbred in effective STEM training (Kirkland and Poppleton, 2021; Mpofu, 2019) at the secondary school level.

One of the significant benefits of enhancing the teaching of STEM subjects at the secondary school level is its ability to provide 21st-century competence (Ismail, 2018). The 21st century has seen an increase in globalization, contributing to the digitalization of almost every aspect of life. For this reason, developed countries under Organisation for Economic Cooperation and Development (OECD) have created 21st Century skills and competence frameworks based on STEM subjects to equip millennium learners with the right competencies to succeed in the 21st century and beyond. Specifically, the 21st century would require information, technological, and ICT literacy competencies. Information literacy is the competency that enables millennials to access and evaluate information efficiently, while ICT literacy is the competency that facilitates the use of digital communication devices to create and share information on a digital platform. On the other hand, technology literacy is the skill of using technology to solve real-world problems such as pollution and racism (Voogt& Robin, 2012). Furthermore, apart from technology-based skills, millennials must be creative, innovative, collaborative, agile, and wounding to experiment with various ideas in such solutions to unprecedented life happenings (Ismail, 2018).

STEM subjects have also gained emphasis due to their ability to supply much-needed workplace skills. For example, a recent study revealed a shortage of five million scientists and engineers (Ismail, 2018). Furthermore, out of the predicted 600 million jobs by 2030 by the World Bank (2020), 80% would require a high level of competence in science and technology (Macdonald, 2021). Therefore, STEM subjects can balance the demand and supply of skills. In addition, according to Macdonald (2021), an investment in STEM subjects can be used to solve the unemployment problem.

Secondary schools, particularly in developing countries, are used to lay the foundation for further specialization in STEM subjects (Tikly et al., 2018). Consequently, an effective STEM teaching methodology in secondary schools is critical for increasing enrolment in science-related courses at the university level (Tiklyet al., 2018). For example, in Kenya, despite the recognized role of STEM subjects in future economies, the number of students and learning outcomes in STEM subjects has been declining over the years (Aineah, 2019; Kiptum, 2016).

Learning outcomes in STEM subjects in Kenya has been declining for more than six consecutive years. For example, in Biology, 1% of 2018 KCSE candidates got a grade of A in the subject, while in 2017, only 10 students got a grade of A. In 2016, 18% of students who sat for the Biology KCSE exams managed to get a grade of C and above (Aineah, 2019). This significantly dropped from 40% in 2015 to 38% in 2014 (Aineah, 2019). To put this into perspective, 48% of candidates in 2016 scored D- and below, meaning that about half failed in the subject (Aineah, 2019). Thus, the number of students enrolling in medicine and medical-related courses has been decreasing due to dismal learning outcomes in Biology. This implies that the country cannot effectively respond to the global health pandemic due to a shortage of healthcare workers.

The same trend is observed in Mathematics, Chemistry, and Physics. The learning outcomes in mathematics has been the worst over the years, with half of the candidates scoring an E in 2016; the mean grade for Chemistry in 2016 dropped to D, with more than 75% of candidates scoring D- and E (Aineah, 2019). For more than seven years consecutively, half of the candidates have scored grades D and below in Physics. The poor learning outcomes in STEM subjects at the secondary school level has resulted in fewer and fewer students enrolling for STEM degrees at the university level (Kiptum, 2016).

## 2.4 Influence of Virtual learning on learners' academic achievement in Physics

Earlier studies by Clark (1983) and Kozma (1994) compared online versus face-to-face learning and revealed conflicting results. The main argument of these studies was that there should be no effect on student's learning outcomes across the different mediums of instruction. On the other hand, Clark (1983) explains that a different effect can only be found when a course instructor changes to a new medium, affecting how the lessons are delivered. In the same vein, Kozma (1994) acknowledges that the attributes of each medium of learning may affect learning outcomes. This makes their conclusion that there is no effect questionable and premature, with the probability that earlier studies did not consider the effect of instructors switching from one medium to another on student learning outcomes. With this conclusion in place, studies (Coates &Humpries, 2001; Merwe, 2011) that followed moved away from comparing to examining the effect of blending online and face-to-face learning on student learning outcomes. Many of these studies found that augmenting online and face-to-face learning significantly improved students' outcomes (Coates & Humphries, 2001; Merwe, 2011). However, with technological advancements and acknowledging the differences that come with each instructional delivery medium, recent comparative studies have been done on online and face-to-face students' learning outcomes.

Paul and Jefferson (2019) conducted a comparative analysis of student learning outcomes in an online versus a traditional class in an environmental science course. The purpose of the study was to determine the teaching methodology that had the highest impact on student's learning outcomes in a science course at the university level. The study's target population was 1st and 2$^{nd}$-year students enrolled in an Environmental

Science class where a sample of 548 respondents was drawn using the convenience sampling technique. The final course grades were used to compare the learning outcomes of online teaching against that of face-to-face teaching. Chi-Square, independent sample t-test, and DiD were used in inferential data analysis. The study found that the number of students scoring grade A in an online class was more (10.9%) than in face-to-face classes (6.9%). However, the Chi-Square statistics revealed no statistically significant difference in students' learning outcomes between online and face-to-face teaching. Although the findings of Jefferson are very critical in helping to understand the relationship between academic learning outcomes and virtual learning, the study focused on university students whose level of interest and self-initiative in learning can be significantly different from that of high school students. Consequently, it is impossible to generalize these findings to students' learning outcomes in Physics at the high school level.

Helms (2014) conducted a census survey study comparing students' learning outcomes in an online versus face-to-face class in a Psychology course at the university level in the United States. The study involved a target population of 105 psychology students in their first year at Kennesaw University, achieving a 91.43% participation rate. Primary data was collected through a documentary review of students' transcripts from the university database, and independent sample t-tests were used to analyse data. The study revealed a statistically significant difference between the learning outcomes of face-to-face and online students, with the former scoring higher final grades than those in the latter. These findings contradict Paul and Jefferson (2019), who reported no significant differences in student learning outcomes between online and face-to-face classes. However, Helm's (2014) findings corroborate with those of Arias, Swinton, and Anderson (2018), who reported that students in face-to-face classes had statistically significantly higher exam scores than those in online classes. Although Helm's (2014) study richly contributes to the literature on virtual versus face-to-face learning, the study was done in a higher education context, making it unreliable to generalize their results to the secondary school level.

Arias et al. (2018) conducted a randomized study to compare students' learning outcomes in an online class against those in a face-to-face class in a macroeconomics class. The study involved a target population of 37 students, where 17 were randomly assigned to face-to-face classes while fifteen attended online classes. The study employed an ordinary least square model to analyse the data. Arias et al. (2018) reported that students in face-to-face classes scored better grades than those in online classes. Arias and colleagues (2018) findings are very important given that participants were randomly assigned, hence eliminating the self-selection bias, and the same instructor taught and examined both classes. This makes the findings reliable. Nonetheless, given that this study focused on a single class, their generalization to other classes is limited. Therefore, this study seeks to overcome this methodological gap by comparing form 2 students' learning outcomes in different schools in the area of study.

A study by Alpert, Couch and Harmon (2015) added another dimension by comparing students' learning outcomes in face-to-face, blended and online classes. The study found that students in face-to-face learning performed better than those in blended and online learning. Particularly, students in online learning got five to ten marks less than those in traditional and blended classrooms. The study further showed that students with special needs in online learning did worse than their counterparts in face-to-face learning. This finding validates those reported by Helm (2014) and Arias et al. (2018) that students' learning outcomes in online learning was relatively low compared to face-to-face learning.

Smith (2013) is among the few scholars who have conducted comparative in-person learning and blended learning in secondary schools. The study adopted the experimental research design to explore the impact of the physical classroom and blended learning in a secondary school in New Zealand. Standard assessment grades of the students in the two classes were used as the primary data in the study. The study used the same teacher across the control and experimental classes to control instructor biases. Smith (2013) reported no significant difference between students' learning outcomes in blended and face-to-face classes. Smith (2013) concluded that the lack of significant difference indicated that blended learning was as effective as traditional learning.

On the other hand, Smith (2013) also stated that the non-significant differences imply that blended learning was not better than in-person learning. However, the study reported that students in blended learning reported high levels of learning than their counterparts in traditional classes. Nevertheless, unlike the present study, Smith's (2013) discussions were not based on any theory or model. The current study aims to investigate the effect of virtual learning on students' learning outcomes in physics through the lenses of transactional distance theory.

The extant literature has paid considerable attention to the effect of gender differences on the learning outcomes of students in an e-learning environment. A study by Almasri

(2022) investigated the effect of gender differences on the learning outcomes of undergraduate biology students. The study was carried out in Kuwait, consisting of 1375 undergraduate students. The study differed from the current study by comparing the differences in learning outcomes in an e-learning environment when the genders were mixed and separated. The study found no significant difference in male and female students' learning outcomes in e-learning biology classes.

Another study by Hsiao and Shiao (2018) also investigated the effect of gender differences on the learning outcomes of university students in digital learning in Taiwan. The study found that female students performed better in an e-learning environment than male students. Therefore, it concluded that e-learning is suitable for female students and can be used to ensure that all female students access education. Hsiao (2021), under the context of COVID-19, carried out another study in Taiwan to examine the mode of learning (face-to-face and distance learning) that is suitable for each gender (male and female). The study found that male students performed well in face-to-face classes while female students outperformed in the distance online classes. However, given that this study was carried out at a university, a study must be carried out at the secondary school level since the motivation for learning is different among undergraduate and high school students.

While e-learning is increasingly being used in schools, very few studies have examined the category of students most suited to this form of learning. Cacault*et al.* (2021) conducted a randomized experiment to examine the effect of distance learning on the learning outcomes of high-ability and low-ability students in higher education. The study found that attending virtual classes lowered the academic learning outcomes of low-ability students but increased the achievement of high-ability students. Another study by Kofoed, Gilmore, Gebhart, and Moschitto (2021) found online learning reduces student learning outcomes by a 0.215 standard deviation. The study found that the reduction was very large among low academic ability students than high academic ability students. Kofoed *et al.* (2021) explained these findings stating that students in online or virtual classrooms struggled to concentrate and felt less connected to their instructors and peers. The study thus concluded that the shift to online learning resulted in poor academic learning outcomes.

**2.5 Influence of Virtual learning on learners' attitude towards Physics**

The disposition of students towards online learning is a crucial factor in the educational environment enabled by online resources (Maio & Haddock, 2009). Individuals' attitudes are linked to their cognitions, emotions, and actions about an attitude object (Triandis, 1971). Strong attitudes can affect behavior, and positive attitudes towards learning can improve the effective use of learning resources (Maio & Haddock, 2009). A study conducted by Yue (2013) investigated Australian university students' perspectives of online learning within a blended course in Australia. The elements, such as previous attitudes, past experiences, and motivation, were examined concerning the participants' online learning attitudes at the course's conclusion. The study consisted of two phases: Phase One included pre- and post-testing and course participation, based on students' weekly reports and online forum transcripts, while Phase Two involved interviews. The students demonstrated heightened enthusiasm towards online learning by the end of the course. Their prior online learning attitudes were the predictors of their attitudes towards online learning after the course's conclusion.

Previous research has demonstrated the influence of motivation on students' perceptions of online learning (Mullen & Tallent-Runnels, 2006; Paechter, Maier & Macher, 2010). Students displaying heightened motivation showed a stronger propensity for a positive attitude towards learning in an online environment. Despite extensive research on students' attitudes toward online learning, numerous contradicting and ambiguous findings persisted. Furthermore, identifying and acquiring precise responses from absent students may prove difficult; thus, the investigation into the attitude shifts of enrolled students can illuminate implications for course design, instructional practices, and support in online courses, while also offering insights for future research on student attrition from online courses.

Joolingen et al. (2012) examined visual and interactive elements of virtual programs have an effect on students who may struggle with traditional face to face learning. The study was guided by technological pedagogical content knowledge, mixed methodology research design was employed with a sample of 310 students. The study found out improvement in content delivery using virtual programs.

Derrah et al. (2014) studied on perceived challenges leading to anxiety and resistance among students. Virtual labs were employed to 224 university students using 3-D simulation, brief video and laboratory experiments for hands on labs versus control group. He found out that virtual programs can reduce these negative perceptions by offering more exploratory and less demeaning learning approach.

Esther et al. (2014) examined student perceptions on distant education within the setting of a mid-sized state university in the Mid-Atlantic region. The data sources were journal entries authored by 36 teacher candidates enrolled in the course, Teaching English

Language Learners PreK-12. Findings were classified based on Course Characteristics; for instance, students possess distinct viewpoints regarding the utilization of the discussion forum, some of which are unfavourable. Instructor Characteristics, such as the necessity for interaction and synchronous communication, along with successful evaluation, and Learner Characteristics, including the suitability of distance education based on student learning styles and practical considerations. The findings indicated a substantial impact of online training on students' attitudes toward the subject matter.

### 2.6 Influence of Virtual learning on learners' Motivation in Physics

Dyer (2005) conducted a study revealing that participants' trust in online learning before the course did not forecast their motivation and attitude toward online learning following the physics course. Students might be intrinsically motivated by interest, enthusiasm, self-assurance, and the learning process itself. Conversely, they may also be extrinsically motivated by many external stimuli, like pressures, rewards, or acknowledgment from others (Deci & Ryan, 1985; Ryan & Deci, 2000).

Pekrun et al. characterized "motivation" as feelings intrinsically connected to either the experiences during activities or their outcomes, encompassing a range of scenarios. Their research revealed a substantial association between academic motivation and students' enthusiasm, academic performance, self-regulation, cognitive resources, learning strategies, classroom experiences, and character traits. Positive feelings included pride, hope, and enjoyment, whilst negative emotions consisted of rage, anxiety, despair, shame, and ennui. Public opinion views positive emotions as producing advantageous results and negative emotions as leading to detrimental impacts; yet, each category of emotions has its unique benefits.

Positive emotions expand the scope of human cognition, fostering creativity, curiosity, and interpersonal connections; facilitating the exploration of social viewpoints and relationships; and enhancing both physical and social competencies. Conversely, negative emotions serve as motivational catalysts for self-defence, foster cooperation (through guilt), drive the pursuit of justice (by anger), provide valuable insights (such as sadness over inadequacy), and facilitate learning. Negative emotions signify an issue and hence drive us to address that issue.

(Jense & Nadelson, 2012) found out that virtual physics programs may input motivation across gender and learning methodology helping reduce motivation gaps. Interactive simulation and virtual labs can enhance motivation more effectively for uninterrupted groups in physics particularly female students by providing them with explanatory approach and collaboration that goes with their preferred learning.

Cheong et al. (2014), found out that incorporating physics programs in gaming can increase extrinsic motivation. Gamification elements can make learning of physics more involving by providing short term goals and rewards that can encourage students to engage with physics content.

A distinct study indicated that good emotions predicted future academic success (mathematics test scores and final grades), while academic success also predicted these feelings, including students' family socioeconomic level, intellect, and gender. Conversely, unpleasant emotions negatively predicted achievement, and achievement adversely affected these feelings. Sakiz et al. contend that the influence of perceived teacher affective support on behavioural engagement was analogous to that of students' perceived academic self-efficacy beliefs in science.

## 2.7 Summary of Research Gaps

While studies compare the effect of online/virtual learning and face-to-face learning, most were carried out in very different contextual conditions. As exposed in the extant literature, the studies were done in college and university settings where participants had other priorities apart from learning, such as work and family commitments. This is not the case in secondary schools in Kenya, where learning is the priority of most students. In addition, the existing empirical evidence presents findings on online learning, which has features that are not available in physics virtual learning programs. For instance, online learning in the reviewed studies (Helm, 2014; Paul & Jefferson, 2019) has interactive features between students and instructors and among students themselves. Consequently, these differences in settings create a contextual research gap, which this study seeks to fill by examining the effect of the virtual physics learning program on students' learning outcomes in Physics in secondary schools in Kenya.

Although the studies reviewed gave empirical evidence on the learning outcomes of Environmental science classes (Paul and Jefferson, 2019) and psychology courses (Helm, 2014), the effects of virtual learning in Physics subjects were not covered. In addition, although Paul and Jefferson (2019) found no significant difference in learning outcomes between online and face-to-face students, Helm's (2014) earlier study found statistically significant results. Thus, the results from existing literature are inconclusive and contradictory, necessitating the need for further studies in this area. Therefore, this study aims to fill the gap, especially in Physics, and provide data to address the contradiction exhibited by the Paul and Jefferson (2019) and Helm (2014) studies.

Also, many comparative studies (Paul & Jefferson, 2019; Arias et al., 2018; Helm, 2014; Smith, 2013) conducted on students' learning outcomes in virtual and face-to-face classes were not based on any theory. This study seeks to fill this gap by examining the effect of virtual vis-à-vis face-to-face classes based on the transactional distance theory.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 Overview

This chapter presents the research methodology. It also presents the research design of the study, the study location, target population, sample size, and sampling procedure. The chapter also presents the data sources, data collection procedure, data analysis methods and ethical considerations.

## 3.2 Research Design

Using the difference-in-differences (DiD) research technique, the study embraced the Solomon four group quasi-experimental research design. The design was fit to measure the effect of the virtual physics intervention while controlling for pretest and experimental effect. Despite its origins in epidemiology (Snow, 1855), the DiD technique has found widespread application in econometrics, public policy, and the social sciences as a means of estimating causal effects. The DiD method is a perfect statistical tool since it allows us to examine the changes in an outcome over time between the intervention and control groups. In addition, this study's non-randomized intervention design allowed for the use of the Difference-in-differences analysis to accurately estimate group-level decisions affecting outcomes within the intervention group. The approach offered a practical means of enhancing the efficiency of data analysis. The DiD was particularly useful in reducing the bias caused by missing variables. In order to ensure that the estimates were free from bias, the unobserved components were removed from the model using the DiD. Public secondary school students in the Kakamega south sub-county were the subjects of this study, which employed the DiD approach to assess the influence of virtual physics program intervention on learning outcomes while controlling for inference variables within group characteristics. Figure 2 shows the model of the non-randomized pretest posttest of experimental group with a control group.

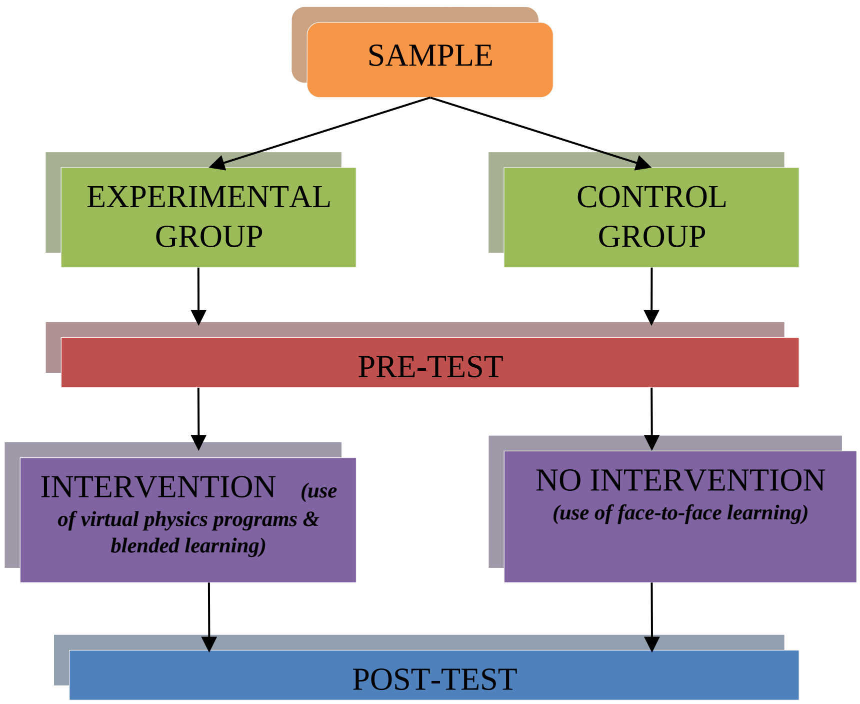


Figure 2: *Research design*

As demonstrated in Figure 2, the sample was divided into two treatment groups—one for the experimental and one for the control—in order to carry out this study design. Following pre-tests in all three dependent variables (motivation, achievement, and attitude), the experimental groups got blended learning and virtual physics instruction, while the control group continued with face-to-face instruction alone. The three dependent variables were then post-tested for both treatment groups, as Figure 2 further demonstrates.

A pre-test was employed to determine if the sampled students exhibited uniform entry behavior for the study's dependent variables; absence of this assessment would render the study deficient in internal validity (George & Mallery, 2003). The post-test was employed to compare the treatment groups regarding the study's dependent variables, with the objective of assessing whether the intervention administered to students in the experimental groups significantly improved their academic performance in physics. The comparison between the experimental and control groups concluded the quasi-experiment.

This research design was deemed optimal for this study because (i) it included control groups, enhancing the study's internal validity, and (ii) it utilized pre-testing, allowing the researcher to determine the homogeneity of the selected sample, a crucial requirement for inferential analysis, especially when using parametric tests (DeRue, 2012).

## 3.3 Study location

The study was conducted in the Kakamega South sub-county. From the insights of pilot study, Kakamega South sub-county was used since some schools had significant virtual physics resource platform including access to devices like computer, T.V and trained teachers and others had limitation the virtual physics program, providing the same contextual background for performing a comparative study. It was also selected because of consistent poor learning outcomes in physics in 2018 and 2019 (Aineah, 2019), hence the need to examine the effect of the physics virtual program introduced in 2020 by MOEST in partnership with KICD, when the KCSE performance in physics improved.

Furthermore, conducting the study in the sub-county allowed for better control over control and experimental groups and ability to tailor the program to the local needs.

The sub-county has thirty-one secondary schools falling into five categories: boarding schools, day schools, boarding mixed schools, boarding/day mixed schools, and mixed schools. There are three boarding schools, one for boys and two for girls. There are two-day schools exclusively for girls and one mixed boarding school for boys and girls. There are two boarding/day mixed schools that also accommodate both genders of students. There are also three boarding/day schools; one for boys and two for girls. The mixed day school category has 20 schools accommodating female and male students. Out of the 31 secondary schools, 25 have the infrastructure for physics virtual learning program. The remaining schools had no the virtual learning program due to the lack of required infrastructure such as television screens, computer laboratories, virtual learning halls, and radios.

### 3.4 Target Population

The study's target population were form two students in all the 31 public secondary schools in Kakamega South Sub County, who were 4000 in number (CDE, 2023). Students in the form two classes were selected because form 2 marks a transition period where students begin to interact with more specialised topics but not yet preparing for high stakes in examinations as may be the case of form 3 and 4. In contrast to form 1 physics content may focus more on introductory topics making the targeted intervention less impactful.

### 3.5 Sample Size and Sampling Procedures

The multi-stage sampling technique was employed to get the necessary sample, as illustrated in Table 1, which provides a concise overview of the principal steps involved.

Purposive sampling, as shown in Table 1, was employed to pick just those schools from the accessible population that had infrastructure for virtual physics programs and blended learning.

Table 1: Sampling frame

| Sampling Procedure | Population | Sample |
|---|---|---|
| Purposive sampling of schools that had infrastructure for virtual Physics programs and blended learning | 31 | 25 |
| Purposive sampling of schools whose average mean in KCSE for the last 3 years ranges from 3.5 to 5.5 | 25 | 15 |
| Proportionate stratified random sampling from the purposively selected school types as the strata | 15 | 8 |
| Simple random sampling of form two students from the 8 schools meeting the previous criteria, by selecting one intact stream in each | 4000 | 351 |
| Purposive sampling of Physics teachers who were hitherto teaching the selected form 2 students | 50 | 24 |

The intervention of this study regarding blended learning was a prerequisite for participants in the experimental group. Purposive sampling was employed to choose schools from the resultant list, specifically those with an average mean score in KCSE ranging from 3.5 to 5.5 points over the past three years, to ensure equitable competition and a sample with comparable admission behaviour. The heterogeneity of participating schools was a requisite for fulfilling the initial aims of the study; thus, this range was considered optimal, since research indicates it is the most heterogeneous (Mulavu,2019).

The precise quantity of form two students selected as respondents was calculated using the Krejcie and Morgan (1970) formula, as illustrated in Figure 3. Utilizing 4000, the study's target population, as the value of N in the calculation yields 351 as the calculated sample size, denoted as S.

The study therefore used 351 students in schools from the research area that met the inclusion/exclusion criteria.

S =

Where: s= required sample size
X = z-value, 1.96 at 0.05 alpha
N = population size
P = population proportion
d = degree of accuracy expressed

Figure 3: *Formula used to select respondents* *Source: Delice, (2010)*

Subsequently, Table 1 indicates that proportionate stratified random sampling was employed to pick the requisite types of schools, namely co-educational, boys' only, and girls' only, to guarantee equitable data representation. Figure 4 illustrates the methodology employed to calculate the proportions or precise quantities required for each category of school.

Figure 4 demonstrates that four coeducational institutions, in addition to two female-only schools and two male-only schools, were proportionately chosen for this study.

Mixed Schools Needed = × 8 = 4

Girls' Schools Needed = × 8 = 2

Boys Schools Needed = × 8 = 2

Figure 4: *Computation of the number of schools used in the study*

As a result, this selection criterion sufficiently reflected each type of institution. Simple Random Sampling (SRS) was utilized to select the individual schools, as demonstrated by the calculations in Figure 4. Simple Random Sampling (SRS) was utilized to select one form two stream among schools with several form two streams. In schools with a single class consisting of two streams, the entire stream was employed in the study. The SRS was executed utilizing the balloting approach, wherein unique random numbers were assigned to all schools selected for participation in the study according to the specified criteria. The numerals were engraved on separate little sheets of same size and colour. Each paper was then folded to conceal the numbers and placed into three separate bags: one for mixed schools, one for girls' schools, and one for boys' schools. Thereafter, all the bags were sealed and thoroughly shaken to combine their contents.

A blindfolded individual was directed to select eight pieces of thesis from the sacks, with four pieces from the mixed schools' bag, two from the girls' schools' bag, and two from the boys' schools' bag. Only eight schools were required. The paper was selected one at a time, without any replacement. The institutions that were ultimately selected for the study were identified by the numbers on the papers that were retrieved from the bags. In cases where institutions had multiple form two streams, the same methodology was implemented to select a single form two stream. This approach ensured that all eligible schools and pupils were given an equitable opportunity to be selected for participation in this study.

In order to mitigate interaction, which is acknowledged as a potential threat to the internal validity of a study (Pearl, 2015), distinct institutions were employed as experimental and control groups. The eight intact streams of form two students, which were previously reported, were randomly assigned into two groups and designated as BL-1, BL-2, BL-3, BL-4, FTF-1, FTF-2, FTF-3, and FTF-4. The experimental group was composed of participants with the prefix "BL," while the control group was composed of individuals with the prefix "FTF." In order to facilitate the identification of each research group according to the type of intervention administered, these prefixes were deliberately and strategically implemented. The terms "BL" and "FTF" are abbreviations for "Blended Learning" and "Face-to-Face" learning, respectively, and are used to designate the two methods that were examined in this study. Prior to the commencement of this investigation, the purposive sample strategy was implemented to select all pertinent physics instructors who teach the selected form two students in the designated institutions. This was an effort to prevent any scheduling complications that could have resulted from the random sampling of teachers, which could have caused some institutions to be hesitant to participate in the study.

Table 2: Table of sample assigned to the study

| Group Type | Label | Total No. of Students | No. of Teachers |
|---|---|---|---|
| Experimental | BL-1 | 37 | 1 |
| | BL-2 | 46 | 1 |
| | BL-3 | 44 | 1 |
| | BL-4 | 48 | 1 |
| | Sub-total | 175 | 4 |
| Control | FTF-1 | 45 | 1 |
| | FTF -2 | 47 | 1 |
| | FTF -3 | 43 | 1 |
| | FTF -4 | 41 | 1 |
| | Sub-total | 176 | 4 |
| Whole Sample | TOTAL | 351 | 8 |
| BL=Blended learning | FTF=Face to face | | |

Source: Pearl, (2015)

Table 2 shows the total number of participants for each study group. Clearly, there were a range of group sizes, with the smallest consisting of 37 students and the largest 48. Both the experimental and control groups were approximately the same size, as seen in Table 2.

### 3.6 Sources of Data

Data for the study came from the students who took part in it, both in the control and experimental groups.

### 3.7 Research Instruments and Measurement Scale

Following a thorough examination of the existing literature and discussions with several educational research specialists, the researcher, driven by the three research objectives, created three instruments to gather data. Two surveys and one achievement test were part of it. The sections that follow provide more information about each tool.

### 3.7.1 Physics Achievement Test (PAT)

The PAT was designed to ascertain the level of students' proficiency in Physics, as its name implies. All of the students in the sample took the PAT (Appendix 2), an hour-long achievement test with 40 points, both before and after the intervention of a period of one month. Since the questions on the PAT were based on those on Physics papers 1 and 2, which were administered by KNEC examiners, they were all considered standard. Using questions from the Physics curriculum for both Form 1 and Form 2, the researcher created a number of items for it. It was divided into two parts, A and B, with the former including questions on demographics and the latter on physics.

The PAT score of an individual student was calculated by dividing their total marks by their percentage. The PAT had a maximum achievement score of 100% (for students who got maximum marks in all 14 items) and a minimum score of 0% (for students who got zero marks in all 14 things). The quantitative data gathered by the PAT was utilized to accomplish the primary goal of this research.

### 3.7.2 Students' Attitude Questionnaire (SAQ)

The Students' Attitude Questionnaire (SAQ) in Appendix 3 was a closed-ended survey designed to gather data on students' attitudes toward physics. All items included were standard, having been adopted and changed by Masinde (2018), who utilized them to assess students' attitudes towards chemistry; thus, the researcher adjusted them to be applicable to Physics. The quantity of goods in the SAQ was as advised by Suzuki and Malone (2001). The item was administered to all sampled Form Two students both prior to and following the intervention of a period of one month to gather data pertinent to the second purpose of this study.

The SAQ consisted of three sections: Part A provided an overview, Part B collected pertinent student demographics, and Part C had 18 closed-ended statements utilizing a five-point Likert-type scale. Some statements were articulated positively, while others were expressed negatively. A composite score for all statements in the SAQ was calculated and expressed as a percentage by dividing it by 90, the maximum possible composite score, and multiplying the result by 100.

The maximum achievable score for a student was 100% (for the individual who attained 5 in each of the 18 statements), whilst the minimum attainable score was 20% (for a student who received 1 in each statement).

### 3.7.2 Students' Motivation Questionnaire (SMQ)

The SMQ (Appendix 4) assessed students' motivation to learn physics prior to and following the intervention of a period of one month. The motivating elements contained within were derived and adjusted from Keller's (2010) motivational variables. The quantity of items included were as proposed by Suzuki and Malone (2002); hence, the SMQ comprised three sections: Part A provided an overview, Part B collected pertinent student information, and Part C assessed students' motivation in physics. This section consisted of 12 closed-ended items utilizing a five-point Likert scale. Some statements were phrased positively, while others were phrased negatively, although all aimed to gather information regarding students' motivation in physics.

All SMQ items were standardized, as they were developed based on several of Keller's (2010) motivational variables: attention (the degree to which students perceived virtual physics as engaging), relevance (the importance students attributed to physics content for their future pursuits), confidence (the extent to which physics content enhanced their academic self-efficacy), and satisfaction (the degree to which students believed knowledge of physics would fulfil their future requirements).

The maximum attainable score for a student was 100% (for the individual who achieved 5 in each assertion), whilst the minimum feasible score was 20% (for a student who scored 1 in each statement).

### 3.8 Pilot Study

A pilot study was carried out two weeks before the main study in two secondary schools in Kakamega South sub-County that had introduced blended learning. In order to avoid duplication and the halo effect, the pilot schools were removed from the study's sample frame before the actual study began (Long-Crowell, 2015). To ensure the research instruments were valid and reliable, they were tested using data collected from the pilot study.

#### 3.8.1 Validity of the Research Instruments

According to Pearl (2015), an instrument is regarded valid if it accurately measures the variables it purports to measure. This was found using the Rasch Model. A grading scale and scoring guide for the PAT, SAQ, and SMQ were delivered to three experts from the Department of Educational Planning and Management at Masinde Muliro University of Science and Technology (MMUST) by the researcher. Phase and content validity to ensure the instruments developed measured the outcome required in virtual learning. Phase validity for PAT was achieved through expert review, item identification, piloting and item analysis, for SAQ, it was achieved through item development, piloting, expert review and factor analysis. For SMQ, phase validity was achieved through item development, piloting, factor analysing and expert review.

Content validity for PAT, SAQ and SMQ was achieved through definitions of constructs, expert review and revisions based on feedback.

The researcher also consulted an experienced KNEC examiner of KCSE in physics over the PAT, providing them with a rating scale. The researcher utilized expert feedback to refine the tools, enhancing their suitability and precision for data collection in the real study.

### 3.8.2 Reliability of the Research Instruments

A research instrument is deemed reliable if it produces consistent results with repeated administration to the same subjects (Aziz, 2010). The research instruments for this study were assessed for reliability before the major investigation, employing data from the pilot study. The test-retest reliability analysis was conducted utilizing Cronbach's alpha coefficients. This method calculated the Pearson Product Moment Correlation Coefficient (PPMCC) for each instrument. This reliability assessment approach was employed due to its requirement of a single test administration, hence minimizing annoyance to the selected schools by not excessively occupying their time. An instrument with a determined alpha coefficient of 0.7 or above was considered suitable for this study, as it satisfied the criterion established by George & Mallery (2003). The results demonstrated PPMCC values of 0.759, 0.832, and 0.779 for the PAT, SAQ, and SMQ, respectively. As all three results above 0.7, this indicated their reliability, and they were utilized in the actual study without alteration. This achievement was ascribed to the utilization of standardized items.

### 3.9 Data Collection Procedures

The researcher gained a research permission from the National Commission for Science, Technology and Innovation (NACOSTI) after the Director of Post graduate Studies (DPS) approved the research plan. Each Sub-County Director of Education, as well as the County Director of Education for the study region, was given a copy of the permit. The schools that were going to be included in the study were contacted beforehand to let the principals and department heads of the scientific programs know about it.

While on this pre-visit, the researcher obtained approval from the principals and, with their help, arranged for two physics teachers to meet with the department chairs to discuss the study's specifics.

Subsequently, all sampled students completed the pretest physics achievement test, the student attitude questionnaire, and the student motivational questionnaire. The researcher gathered all completed instruments, assigned codes, and oversaw the marking of the PAT, following the coordination of the marking scheme. The 'conveyor belt' marking system was utilized to mitigate the halo effect and reduce subjectivity, whereby each examiner assessed only their designated portion of all scripts. Following a four-week period of physics instruction, the posttest PAT, SAQ, and SMQ were administered sequentially to all sampled students in accordance with the research design.

### 3.10 Data Analysis

Prior to the actual data analysis, the raw data was encoded utilizing STATA tool version 17.0 to assess the missing data. Summary statistics were generated, encompassing the means, standard deviation, maximum, and minimum. The quantitative data obtained from the PAT, SAQ, and SMQ was evaluated by regression analysis DiD. Before conducting descriptive and inferential analyses, multiple measures were implemented to ensure the correctness and quality of the research data.

The data was examined to evaluate any absent values. The data was analysed by descriptive statistics and by assessing the range of values for all variables. This technique uncovered some inaccurately entered data. Consequently, all values in the data sets were juxtaposed with the values on the hardcopy instruments. Any instance in the dataset exhibiting a value above the permissible range for a certain variable was thoroughly examined to identify the inaccuracies.

The data was scrutinized for consistency checks to verify logical correlations among variables, such as the absence of male students in a "girls' only" institution and vice versa. Variables with dubious values were selected for further scrutiny by analysing the completed hardcopies of the instruments. The values on the physical copies of equipment were juxtaposed with the values recorded in the data file. All discrepancies were ultimately recognized and corrected appropriately.

Finally, diagnostic tests were performed for sensitivity checks and modelling decisions prior to the actual data analysis. The data set was examined to determine whether it satisfied the three causal assumptions. The following are difference in difference (DiD) models employed to evaluate the three hypotheses.

The DiD model in regression was employed to assess the impact of virtual physics programs on student achievement as follows:

Where  represents the outcome of interest, which is students' achievement in physics, , is the intercept representing the baseline level of achievement in control group in pre-treatment. The coefficient  represents the measures of the impact of the  treatment before and after the treatment occurred,  represent whether the sample was in the treatment group or control group. The coefficient  is measure of the effect between the treatment and control group before treatment occurred,  represent the difference before and after program (intervention),  represents the interaction of, the difference between before and after intervention in the treatment group.  is the coefficient of the interaction, which is the pure effect of the treatment on the outcome ruling out other inferences experienced by other groups. It is the estimate for the average treatment effect (ATE). It accounts for the inferences as if they were included in the model. In this study, the unobserved factors could affect the treatment and control group in the way, violating the parallel trend assumption, since the two groups were not similar.  is the coefficient of triple interaction. The control variables were represented by  , they were included in the model to account for the difference in the observed characteristics between the two groups that are not due to the treatment. The symbol  represents the residual variables, which satisfies the assumption of parallel trend, by making the outcome more robust.

The DiD model in regression was used to estimate the effect of virtual physics programs on students' attitude as follows:

Where represents the outcome variable, which was students' attitude in physics, is the intercept, represents the coefficient measures of the impact of the treatment versus post variables. represent whether the sample was in the treatment group, is the coefficient measure of the effect between the treatment and control group. represent the difference before and after program(intervention), represents the interaction of that is, the difference between before and after intervention in the treatment group, and is the coefficient of the interaction, which is the pure effect of the treatment on the outcome ruling out other inferences experienced by other groups. It is the estimate for the average treatment effect (ATE), it accounts for the inferences as if they were included in the model. In this study, the unobserved factors could affect the treatment and control group in the way, violating the parallel trend assumption, since the two groups were not similar. is the coefficient of triple interaction, the control variables represented by were included in the model to account for the difference in the observed characteristics between the two groups that were not due to the treatment. The term epsilon () represents the residual variables, which satisfies the assumption of parallel trend, by making the outcome more robust.

DiD model in regression to estimate the effect of virtual physics program on students' motivation was fitted as follows.

Where  is the measure of students' motivation in physics,, is the intercept,  represents the coefficient measures of the impact of the treatment versus post variables.   represent whether the sample is in the treatment group,    is the change in motivation score between the treatment and control group.  represent the difference before and after program(intervention),    represents the interaction of that is the difference between before and after intervention in the treatment group, and  is the DiD estimate, which is the pure effect of the treatment on the outcome ruling out other inferences experienced by other groups. It is the key coefficient of interest, it is the estimate for the average treatment effect (ATE), and it accounts for the inferences as if they were included in the model.  In this study, the unobserved factors affect the treatment and control group in the way, violating the parallel trend assumption, since the two groups were not similar. The  , is the coefficient of triple interaction, the control variables represented by   were included in the model to account for the difference in the observed characteristics between the two groups that were not due to the treatment.  The term epsilon () represents the error term, which satisfied the assumption of parallel trend, by making the outcome more robust.

### 3.11 Ethical Considerations

Prior to fieldwork, an official overview letter and permits from the institution and the National Commission for Science, Technology, and Innovation (NACOSTI) were obtained. An official introductory letter to the sub-county education officer, who subsequently informed the schools about the research and provided an introductory letter to solicit the necessary assistance. Participation in the study was voluntary; hence, schools that opted out were not compelled. The researcher guaranteed the participants' confidentiality about the acquired information. The study has recognized additional stakeholders who directly or indirectly contributed to the implementation of the research. Among these members were the research supervisor and the principals from the selected schools.

# CHAPTER FOUR

# RESULTS, INTERPRETATION AND DISCUSSION OF FINDINGS

## 4.1 Overview

This chapter delineates the outcomes corresponding to each objective, derived from statistical analyses conducted on the research data, accompanied by their interpretation, and concludes with a discussion of these results in relation to all research objectives.

## 4.2 Statistical Assumptions

First**,** the assumptions of consistency, was checked through validity and reliability of the tests instruments to ensure that well defined causal questions were asked and elicited the expected responses. Cronbach alpha level was relevant in assessing reliability and validity of research findings for accuracy and consistence. The intervention of interest was the option to use the virtual physics programme, and variation in how it is used was not expected to affect its impact on learning outcomes.

Second the assumption of positivity also called overlap was attained by ensuring that all 8 schools in the study were eligible for being selected for either the intervention or control group.

The third assumption of the parallel trends, which specifies that trends in the outcomes over time in the control and treatment group are same in every aspect except that the control group did not receive the treatment, was attained by including the control variables, which included observable features in groups that could influence the outcome. The inclusion of the control variables in the model ensured that the change in outcome scores from the pre-exposure to post-test for the control group is the same as the counterfactual change in scores for the intervention group had the Physics virtual programme exposure not been implemented.

### 4.3 Descriptive Statistics

Data acquired by the three study instruments was subjected to a number of descriptive measures in an effort to identify patterns and trends that could shed light on the findings from the quantitative data analysis.

A total of 351 participants were non-randomly assigned to treatment and control groups. Before the intervention, students were tested to determine their scores in physics achievement, attitude towards Physics, and motivation towards physics. The students assigned to the treatment group were exposed to the intervention (i.e. used blended virtual physics program) in the month of March 2024. After one month of the exposure to the treatment, the students were again tested to determine their scores in achievement, attitude towards physics and motivation in physics. The before and after test were done so as to compare changes in an outcome over time between the treatment and control groups. The one-month period provided sufficient time for students to engage meaningfully with the virtual physics programs, the time allowed for interaction sessions for necessary outcome. The one month-long period helped address the novelty effects, where initial enthusiasm from something new might impact results. The total observation before and after was 702.  The students' demographic characteristics were assessed on various aspects including:  age gender, school type, and prior training in computer. A summary is presented in Table 3.

From Table 3; the results of analysis showed that female respondents were the majority (386) representing 55% of the participants and male were 316 representing 45% of the participants. The age of the students who participated in the study ranged between 13 and 18 years old, with the mean age being 15years and standard deviation of .99. Whereas 50% (350) of the respondents were from mixed public secondary schools, 25.4% (178) were from purely boys' public schools, and 25% (174) were from purely girls' public secondary schools in Kakamega south sub-county.

Table 3: Summary of characteristics and variables in the study

| **Variable** | **N** | **Mean** | **Std.dev** | **Min** | **Max** |
|---|---|---|---|---|---|
| Age | 702 | 14.88 | .99 | 13 | 18 |
| PAT | 702 | 26.78 | 9.25 | 11 | 53 |
| SAQ | 702 | 66.09 | 11.16 | 25 | 99 |
| SMQ | 702 | 66.45 | 13.08 | 25 | 99 |
| **Categorical** | **Code** | **Frequency** | **Percentage** | **Cum** | |
| Gender | | | | | |
| Male | 0 | 316 | 45.01 | 45.01 | |
| Female | 1 | 386 | 54.99 | 100 | |
| **Time** | | | | | |
| Before treatment (March) | 0 | 351 | 50.00 | 50 | |
| After treatment (April) | 1 | 351 | 50.00 | 100 | |
| **Treatment/intervention** | | | | | |
| Control group | 0 | 351 | 50.00 | 50 | |
| Treatment group | 1 | 351 | 50.00 | 100 | |
| **Type of school** | | | | | |
| Boys | 0 | 178 | 25.4 | 25.4 | |
| Girls | 1 | 174 | 24.8 | 50.14 | |
| Mixed | 2 | 350 | 49.9 | 100 | |
| **Prior Computer experience** | | | | | |
| No | 0 | 530 | 76 | 75.5 | |
| Yes | 1 | 172 | 25 | 100 | |

N=702; PAT=Physics Achievement Test; SAQ=Student Attitude Questionnaire, SMQ=Student Motivation Questionnaire

Of the students' participants, only 24% (172) had prior experience in computer and the majority of the participants, 76% (530) had no prior experience in computer.

The students' scores in the PAT ranged between 11 and 53, with the mean score and standard deviation in score being (Mean=27) and SD=9.25. The students' attitude scores ranged between 25 and 99, with the mean score and standard deviation of 66.09 and 11.16 respectively. Similarly, the minimum score for students' motivation in physics was 25 and the maximum score was 99. The mean and standard deviation of motivation score was 66.45 and 13.03 respectively.

### 4.4 The effect of virtual Physics programs on students' achievement in physics

The first objective of this study was to determine the effect of the virtual physics program on students' achievement in physics, a difference in difference model was fitted to estimate the difference in treatment and control group before and after the intervention. The fitted difference in difference model controlled for students' gender, age, school type, and prior experience in computer. The results of the analysis are presented in Table 4.

Table 4: Difference in difference regression estimating the effect of virtual physics program on students' achievement in physics

| Variables | Coeff | SE | T | P | 95% CL LB | UB |
|---|---|---|---|---|---|---|
| Intercept | 25.346 | 4.469 | 5.67 | 0.000 | 16.571 | 34.121 |
| ***Treatment(intervention)*** | | | | | | |
| Treatment | .878 | .812 | 1.08 | 0.282 | -.723 | 2.478 |
| ***Time*** | | | | | | |
| After | 1.341 | .806 | 1.66 | 0.037 | 1.242 | 2.923 |
| Treatment#time Treatmentt#After | 10.865 | 1.141 | 9.52 | 0.000 | 8.624 | 13.106 |
| ***Control variables*** | | | | | | |
| Gender | -.337 | .681 | -0.50 | 0.020 | -1.671 | -.998 |
| Age | -.165 | .297 | -0.56 | 0.579 | -.748 | .418 |
| School type | .223 | .385 | 0.58 | 0.563 | -.534 | .979 |
| Prior Computer Experience | .036 | .768 | 0.05 | 0.036 | .943 | 1.471 |

Note: N= 02; Coeff=coefficient, SE=Standard error, t=Statistic, P = Significance level; $p < .05$, $p < .01$, $p< .001$; CL = Confidence level; LB = lower bound; UB = Upper bound.

The results showed that the intervention effect on the treatment group was increasing over time; however, the effect of virtual physics program on students' achievement in

Physics in the treatment group was not statistically significant when compared to the control group before treatment, .

The results of the analysis also showed that students' achievement in physics was increasing by 1.34 point over time and the increase was statistically significant.

The interaction term, which was the pure effect of the treatment on outcome in the model, was estimated to cause a roughly 11-point increase in students' physics achievement scores in the treatment group, after receiving the virtual physics program lessons, ruling out other inferences experienced by other groups. The treatment effect was positive and statistically significant ( ). This indicates that the virtual physics program itself had a positive effect on students' outcome hence the null hypothesis was rejected for test. The positive effect of physics came from the ability to engage and motivate students, provide personalised and adaptive learning experiences, enhance conceptual understanding through visualisation and interaction. These enabled learners achieve better academic outcome.

Two of the four control variables in the model that is having prior experience in computer and school type had a positive effect on students' achievement in physics. While effect of prior experience in computer was statistically significant (t=0.05; p=0.036) the effect of school type was not statistically significant (t= 0.58; p= 0.563).

Students gender (t= -0.50; $p$=0.02), and age (t= -0.56; $p$=0.579) had a negative influence on the students' achievement in the model.

The discovery that the integration of virtual physics programs with in-person instruction significantly enhanced students' achievement compared to traditional face-to-face learning was notable. Students in all experimental groups of this study, who got physics teaching via virtual programs, attained significantly superior outcomes compared to their counterparts in the control groups, who underwent face-to-face instruction in the physics. A comparative study of the pretest achievement evaluation revealed that all groups demonstrated statistically identical levels of achievement from the outset. The researcher ascribed the variance in posttest performance to the therapy administered to the experimental groups, which encompassed both in-person training and virtual programs.

My findings are in agreement with those of Smith (2013) who have conducted comparative in-person learning and blended learning in secondary schools within New Zealand. The study adopted the experimental research design to explore the impact of the physical classroom and blended learning. Standard assessment grades of the students in the two classes were used as the primary data in the study. The study used the same teacher across the control and experimental classes to control instructor biases. Smith (2013) reported a significant difference between students' achievement in blended and face-to-face classes.

The findings of this study are also in unison with those of Paul and Jefferson (2019) who conducted a comparative analysis of student achievement in an online versus a traditional class in an environmental science course. The purpose of the study was to determine the teaching methodology that had the highest impact on student's learning outcomes in a science course at the university level. The final course grades were used to compare the achievement of online teaching against that of face-to-face teaching. The independent sample t-test was used in inferential data analysis. The study found that the number of students scoring grade A in an online class was more (10.9%) than in face-to-face classes (6.9%). Although the findings of Jefferson are very critical in helping to understand the relationship between academic learning outcomes and virtual learning, the study focused on university students whose level of interest and self-initiative in learning can be significantly different from that of high school students.

The school type had a significant positive effect on student outcome using virtual physics programs due to difference in resources, teacher expertise, students support and overall school culture.

Computer experience positively affected students’ outcome when using virtual program because it reduced the cognitive load associated with learning new technologies, increased confidence in virtual environments and enhanced problem solving.

Gender and age had a negative effect on students’ achievement when using virtual programs due to difference to prior experience, attitude towards technology and learning preferences. Gender challenges stem from self-efficacy stereotypes and varying levels of interest in technology. Age related challenges linked to familiarity to digital tools, resistance to change and flexibility.

### 4.5 The effect of virtual Physics programs on students' attitude towards physics

The second objective of the study was to determine the effect of the virtual physics program on students’ attitude towards the subject, a difference in difference model was fitted to estimate the effect on the treatment and control groups before and after the intervention.  The fitted difference in difference model controlled for students’ gender, age, school type, prior experience in computer training. The results of the analysis are presented in Table 5.

Table 5: Difference in difference regression estimating the effect of virtual physics program on students' attitude towards physics

| **Variables** | **Coeff** | **SE** | **T** | P 95%CL | **LB** | **UB** |
|---|---|---|---|---|---|---|
| Intercept | 62.362 | 4.679 | 13.33 | 0.000 | 53.176 | 71.548 |
| Treatment(intervention) | -.075 | .853 | -0.09 | 0.930 | -1.750 | 1.601 |
| Time After | .494 | .844 | 0.59 | 0.050 | -1.162 | 2.151 |
| Treatment#time Treatment#After | 17.946 | 1.195 | 15.02 | 0.000 | 15.600 | 20.292 |
| ***Control variables*** | | | | | | |
| Gender | .465 | .711 | 0.65 | 0.514 | -.932 | 1.862 |
| Age | -.061 | .311 | -0.20 | 0.845 | -.672 | .550 |
| School type | -.276 | .403 | -0.68 | 0.495 | -1.068 | .516 |
| Prior Computer Experience | .200 | .804 | 0.25 | 0.804 | -1.378 | 1.778 |

Note: N=702; Coeff=Coefficient, SE=Standard error, p = Significance level; $p < .05$, $p < .01$, $p< .001$; CL = Confidence level; LB = lower bound; UB = Upper bound.

The results showed that the intervention effect on the treatment group was reducing by .075 point over time, however, the effect virtual physics program on students' attitude towards Physics in the treatment group was not statistically significant when compared to the control group,.

The results of the analysis also showed that, students' attitude towards physics increased by .494 points over time and the increase was statistically significant.

The interaction term in the model estimates causal effect of roughly 18-point increase in students' attitude towards physics in the intervention group, after receiving the virtual physics program lessons (treatment), controlling for other inferences experienced by other groups. The treatment effect is positive and statistically significant (), indicating that the virtual physics program by itself has a positive effect on students' attitude towards physics leading to rejection of the second null hypothesis.

While both gender and prior computer experience, as control variables, had a positive effect students' attitude towards physics, the effects were not statistically significant represented as ($t= .65$; $p = 0.514$) and ($t= 0.25$; $p= 0.804$). In the model, students age and school type as control variables negatively influenced students' attitude towards physics, represented as ($t= -0.20$; $p= 0.845$) and ($t= -.68$; $p= 0.495$).

The integration of virtual programs with in-person instruction in physics significantly enhanced students' attitudes toward the topic compared to traditional face-to-face learning alone. The students in all experimental groups utilized virtual physics programs and achieved considerably higher attitude scores compared to their counterparts in the control groups, who received solely face-to-face instruction. A comparable analysis in the pretest attitude assessment, however, indicated that all groups exhibited statistically identical attitude entrance behaviours. The researcher attributed the difference in posttest attitude to the therapy received by the experimental groups, which involved integrating face-to-face courses with virtual physics applications for instruction.

Results align with those of Yue (2013), who examined Australian university students' perceptions of online learning in a mixed course. The components, including previous attitudes and experiences, were analyzed in relation to the participants' online learning attitudes at the conclusion of the course. The study comprised two phases: Phase One involved a pre-test, post-test, and course participation derived from students' weekly reports and online forum transcripts, while Phase Two consisted of interviews. The students exhibited increased positivity towards online learning by the conclusion of the course. The determinants of their online learning attitudes at the conclusion of the course were their initial online learning attitudes, as indicated by the pretest and posttest data.

The results of the findings are in line with Joolingen et al. (2012) who examined visual and interactive elements of virtual programs have an effect on attitude of students who may struggle with traditional face to face learning. The study was guided by technological pedagogical content knowledge, mixed methodology research design was employed with a sample of 310 students. The study found out improvement in attitude hence content delivery using virtual programs.

The nature of the school positively influenced students' attitudes toward virtual physics programs. Enhanced access to materials, creative pedagogical methods, and robust teacher-student relationships fostered positive attitudes about physics. Computer experience positively influenced students' attitudes towards utilizing virtual physics programs by augmenting their comfort, confidence, and involvement. Gender and age adversely influenced students' attitudes as a result of their learning experiences and motivation levels. Female students and senior students have greater difficulties when utilizing virtual programs.

### 4.6 The effect of virtual Physics programs on students' motivation in physics

The third objective of this study was to determine the effect of the virtual physics program on students' motivation in the subject, a difference in difference model was fitted to estimate the effect on the treatment and control groups before and after the intervention. The fitted difference in difference model controlled for students' gender, age, school type, prior experience in computer training. The results of the analysis are presented in Table 6.

Table 6: Difference in difference regression estimating the effect of virtual physics program on students' motivation in physics

| **Variables** | **Coeff.** | **SE** | **T** | **P** | **95%** | **CL** |
|---|---|---|---|---|---|---|
| | | | | | **LB** | **UB** |
| Intercept | 72.819 | 6.4264 | 11.33 | 0.000 | 60.202 | 85.436 |
| Treatment (intervention) | -.967 | 1.171 | -0.82 | 0.0410 | -3.268 | -1.334 |
| Time After | .608 | 1.159 | 0.52 | 0.600 | -1.667 | 2.883 |
| Treatment#time | 16.963 | 1.641 | 10.34 | 0.000 | 13.741 | 20.186 |
| Treatmentt#After | | | | | | |
| ***Control variables*** | | | | | | |
| Gender | .335 | .977 | 0.34 | 0.732 | -1.584 | 2.254 |
| Age | -.703 | .427 | -1.65 | 0.100 | -1.542 | .136 |
| School type | -.068 | .554 | -0.12 | 0.903 | -1.156 | 1.020 |
| Prior Computer Experience | -.217 | 1.104 | -0.20 | 0.844 | -2.384 | 1.951 |

Note: N =702, Coeff.=Coefficient, SE=Standard Error, t = Statistic; p=significance level; $p < .05$, $p < .01$, $p< .001$; CL = Confidence level; LB = Lower bound; UB = Upper bound.

The results showed that the intervention effect on the treatment group was reducing by .967 point over time. The effect of virtual physics program on students' motivation in Physics in the treatment group was statistically significant when compared to the control group..

The results of the analysis also showed that, students' motivation in physics increased by. 608 points over time, however, the increase was not statistically significant. The interaction term in the model estimates the causal effect of roughly 17-point increase in students' motivation in physics in the intervention group, after receiving the virtual physics program lessons (treatment), controlling for other inferences experienced by other groups. The treatment effect is positive and statistically significant ( ). This indicates that the virtual physics virtual program itself has a positive effect on students' motivation in physics hence rejecting the third null hypothesis test. Of the control variables, students' gender had a positive effect on their motivation in physics, however, the effect was not statistically significant represented as ($t = .34$; $p=0.732$).

The rest of the control variables age, school type and prior experience in computer had negative effect on the student's motivation in physics, which was not statistically significant, presented by ($t = -1.65$; $p = 0.100$), ($t = -.12$; $p = 0.903$), and ($t = -.20$; $p = 0.844$) respectively.

Regarding the third objective, the study's results demonstrated that, when compared to using only face-to-face instruction, secondary schools in the research area that combined traditional classroom instruction with virtual physics programs significantly increased students' interest in the subject. One possible explanation is that the four experimental groups in this study used virtual programs to teach physics, leading to significantly higher attitude scores compared to the four control groups that used only in-person instruction.

Students' motivation was not significantly different across the groups, according to a comparable assessment of pretest scores. Because the experimental groups received a therapy that combined in-person instruction with online physics resources, they were able to achieve higher levels of motivation after the exam compared to the control group.

In a similar vein, Smith (2013) discovered the same thing while comparing online and blended learning in New Zealand secondary schools. Smith (2013) used the same experimental research methodology as this study to look at how blended learning and face-to-face instruction affected students' motivation. The major data in the study, however, was the standard evaluation grades of two classes' worth of students. And to make sure that neither the control nor the experimental courses had a biased teacher, he utilized the same person for both. Because the sampled students' instructors were recruited immediately before the study started, this was not done in the present study. Students' motivation was significantly different in the blended learning group compared to the face-to-face classes, according to Smith (2013).

From the findings of from the third objective, gender had a positive effect on students' motivation on using virtual programs due to confidence in technology experienced by both genders. Lastly school type, prior experience and age had a negative effect on students' motivation using virtual physics programs due difference in technological confidence, experience, cognitive challenges and resistance to change.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Overview

This section provides an overview of the whole study, a summary of the findings and implications, conclusions, the researcher's recommendations and suggestions for further research.

## 5.2 Overview of the study

The study was driven by the critical need to address the current state of physics education, where students have been performing poorly across multiple learning outcomes due to ineffective teaching and learning methodologies. The researchers in this study set out to examine the effect of virtual physics programs on the academic performance of secondary school students in the Kakamega South sub-county. This study set out to accomplish three main goals: (i) to find out how virtual physics programs affected students' performance in the subject at public secondary schools in the Kakamega South sub-county; (ii) to find out how virtual physics programs affected students' perceptions of the subject at public secondary schools in the same sub-county; and (iii) to find out how virtual physics programs affected students' desire to learn the subject at the same public secondary schools in the Sub-county. Statistical significance was assessed at the 0.05 alpha level for the subsequent three null hypotheses:

**:** Virtual physics programs have no statistically significant effect on students' achievement in physics within public secondary schools in Kakamega South sub-county.

**:** Virtual physics programs have no statistically significant effect on students' attitude towards physics within public secondary schools in Kakamega South sub-county.

: Virtual physics programs have no statistically significant effect on students' motivation in physics within public secondary schools in Kakamega South sub-county.

The three null hypotheses were rejected indicating a significant effect of the virtual physics intervention on achievement, attitude and motivation of students.

The study was implemented using quasi-experimental research design. The independent variable was mode of learning while the dependent variables were students' achievement, attitude and motivation in the subject. The target population was all the 4000 form two students in public secondary schools in Kakamega south sub-county, from which a sample of 351 form two students was selected by multistage sampling. Data was analyzed using DiD at 95% confidence level.

## 5.3 Summary of the Findings and implications

The findings of the study indicated that; there was a significant positive difference in achievement between students who were taught physics using virtual physics programs and those taught face to face. Virtual physics programs created enhanced conceptual understanding, mastery-based learning, interactive learning and increased motivation helping learners' better physics achievement. Students benefited through personalized learning and adaptable learning spaces.

There was also a significant positive difference in attitude towards physics between students who were taught using virtual physics programs and those taught face to face in favor of the former. Virtual physics programs improve attitude of students by creating supportive learning environment, engaging and being interactive. A virtual learning environment offers safe space to experiment without fear of failure, which lowers anxiety around the subject.

Moreover, there was a significant positive difference in motivation in physics between students who were taught using virtual physics programs and those taught face to face in. virtual physics programs creates a more supportive learning environment and personalized learning. Virtual learning programs allowed students to control their learning experience, increasing their intrinsic motivation. Also, elements like challenges and rewards in some programs motivate students to engage more actively in the learning process.

These significant findings suggest the need to revamp the use of virtual learning programs in all physics topics in all public schools, so as to improve the learning outcomes that were investigated in this study.

## 5.4 Conclusions

On the basis of empirical evidence arising from data that were collected in this study's quasi experiment and the subsequent testing of the null hypotheses of this study, three major conclusions have been arrived at: From the first objective, the study sought to establish the effect of virtual programs on students' achievement in Physics, it was found out that students who are taught physics by blending face to face lessons with virtual physics programs are more likely to obtain significantly higher achievement scores in the subjects as compared to those who are taught the same subjects by face-to-face mode. This implies that the use of physics virtual programs is superior to the conventional instruction methods and should therefore be emphasized in all public schools to improve student's' achievement in the subject. From the second objective, the study sought to establish the effect of virtual programs on students' attitude towards Physics. It was found out that, students who are taught physics by blending face to face lessons with virtual physics programs are more likely to have a significantly better attitude towards the subject as compared to those who are taught by face-to-face mode only. This implies that the use of physics virtual programs is superior to the conventional instruction methods in terms improving students' attitude towards the subject and should therefore be emphasized in all public schools to improve students' performance in the subject

Lastly, from the third objective, the study sought to establish the effect of virtual programs on students' motivation in Physics. The findings showed that, students who are taught physics by blending face to face lessons with virtual physics programs are more likely to have a significantly higher motivation in the subject as compared to those who are taught by face-to-face mode only. This implies that the use of physics virtual programs is superior to the conventional instruction methods in terms of motivating students to learn the subject and should therefore be emphasized in all public schools to improve students' performance in the subject

### 5.5 Recommendations

The study revealed a considerable disparity in learning results between students instructed in physics through virtual programs and those receiving face-to-face instruction. This indicates that the disparity in efficacy between the two instructional methods is significant. Several recommendations are presented to key stakeholders, including public-private partnerships in the education sector, to inform policy action, as their implications directly relate to the issue that prompted this study. The results of this study bear significance for policymakers. Curriculum planners must cultivate a heightened awareness. The study revealed a considerable disparity in learning results between students instructed in physics via virtual programs and those receiving face-to-face instruction. This indicates that the disparity in efficacy between the two instructional approaches is significant. Several recommendations are presented to key stakeholders, including public-private partnerships in the education sector, to inform policy action, as their ramifications are directly related to the issue that prompted this study.

The results of this study bear significance for policymakers. Curriculum planners must enhance their awareness and comprehension of the diverse factors that substantially influence achievement among high school students, and consequently incorporate them into the CBC curriculum, as demonstrated by students' achievement, attitude, and motivation in the current study. The findings of this study have significant significance for blended learning as an instructional approach. To develop a secondary school curriculum that produces high achievers in physics, integrating in-person instruction with virtual physics programs is essential.

Physics educators should contemplate integrating virtual programs into their everyday instruction to enhance students' learning outcomes. Physics educators must acknowledge the significant impact of virtual teaching tactics, as they can optimize student engagement irrespective of geographical constraints.

Despite its limitations, the findings of this study underscore the significance of learners' achievement, attitude, and motivation in the learning process of the subject. Consistent engagement with physics virtual learning programs on television throughout extended holidays is a crucial strategy for enhancing learning outcomes, as it ensures students maintain continuous access to topic material, regardless of their absence from school. This study exclusively examined virtual physics programs; future research should encompass several subjects to enhance academic achievement in public schools.

## 5.6 Suggestions for further research

The study of all learning outcomes in physics was hindered by various constraints, including time, resources, and the study's scope. Nevertheless, concerning research on the issues presently confronting the teaching and learning of the topic, numerous gaps would persist, even following the implementation of all suggestions from the current study. Consequently, the following recommendations are proposed for further investigation, aiming to address the deficiencies left by this study; firstly, due to technical limitations, this research was conducted in only eight schools within the designated area that utilize virtual physics programs to enhance physics achievement. Extending the conclusions of this study to encompass the entire Kakamega County would consequently be an implausible notion. It is recommended that a comparable study be conducted in other sub-counties of the Republic of Kenya, excluding Kakamega South, to determine the universality of the findings of this study. The study examined virtual programs in physics, focusing solely on accomplishment, attitude, and desire towards the subject; however, numerous other curricular components influence students' outcomes in the discipline. This warrants exploration. The research examined students' motivation about virtual physics curricula. Nonetheless, numerous additional elements of the curriculum influence students' motivation in the subject that warrant research.

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# APPENDICES

**Appendix 1: Physics Achievement Test (PAT)**

**SECTION A: DEMOGRAPHIC DETAILS**

**PSEUDO NAME: ______________________SCHOOL: ______________________**

**FORM: _____________ STREAM: _______________DATE: _________________**

**TREATMENT GROUP (tick one): F2F [ ] KICD/BLENDED [ ]**

**TIME: 1 HOUR**

1 Answer all questions in section B.

2 The paper is worth 40 marks

3 All necessary workings and answers must be written on the question paper in the spaces provided below each question.

**SECTION B: PHYSICS (40 MARKS)**

1. Physics as a science is broken into different branches, state any two branches of physics. (2marks)

2. Define temperature and state its SI unit. (2marks)

3. 2000cm$^3$of fresh water of density 1000kgm$^{-3}$is mixed with 2200cm$^3$ of sea water of density 1025kgm$^{-3}$. Calculate the density of the mixture. (3marks)

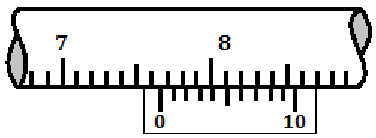
4. The mass of empty density bottle is 15g and 60g when full of oil density, determine the volume of water that would fill the density bottle completely.

(3 marks)

5. (a). Define reflection of light. (1mark)

(b). State the two laws of reflection. (2marks)

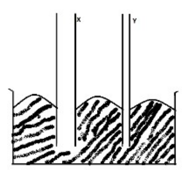
6. The figure 1 below shows a vernier caliper scale. State the correct reading of scale if the instrument has a zero error of -0.02cm. (4 marks)




7. Convection and diffusion both involve motion of fluids. Distinguish between the two. (2marks)

8. A negatively, charged rod is brought close to (but not touching) an uncharged sphere. If the sphere is momentarily earthed and then the rod is removed, briefly explain what happens. (2marks)

9. Indicate on the diagram below, the level of mercury in the tubes X and Y. (2marks)



10. State three properties of a thermometric liquid. (3 marks)

11. In an experiment to estimate the thickness of an oil drop of diameter 0.1cm spread onto a circular patch of diameter 10cm, determine

i. The volume of the oil drop. (3marks)

ii. The area covered by the oil patch (3 marks)

iii. The thickness of the oil molecule (3 marks)

12. (a) Define moment of a force (1mark)

13. (b) A meter rule of negligible weight is balanced by masses of 24N and 16N suspended from its ends. Find the position of the pivot (3 marks)

14. State two factors that affects the turning effect of a force on a body (2 marks)

**The end**

**Appendix 2: The Students' Attitude Questionnaire (SAQ)**

## SECTION A: OVERVIEW

The objective of this questionnaire is to find out your attitude towards Physics. Your cooperation in completing it with sincerity is very important. Findings would be treated very confidentially. Do not write your names on the questionnaire. Instead, use pseudo names provided. Place a tick against your most favorable response to each of the statements.

## SECTION B: STUDENTS' DETAILS

Pseudo Name: ____________

Gender: (*TICK ONE)* Female [ ]   Male [ ]

School Type: (*TICK ONE)* Mixed [ ]   Girls' [ ]   Boys [ ]

Age   [ ]   Prior training in computer [ ]

## SECTION C: PHYSICS ATTITUDE ITEMS

| STATEMENTS | | RESPONSES | | | | |
|---|---|---|---|---|---|---|
| | | SA | A | U | D | SD |
| **1** | Physics is a difficult subject | | | | | |
| **2** | Physics concepts are easy to understand | | | | | |
| **3** | I fear physics examinations | | | | | |
| **4** | Physics lessons are boring | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **5** | I hate Physics experiments | | | | | |
| **6** | I’m impressed by the grades I get in Physics | | | | | |
| **7** | I would drop Physics subjects if made optional | | | | | |
| **8** | Physics lessons are too many and should be reduced | | | | | |
| **9** | I’m not sure of passing Physics in my exams | | | | | |
| **10** | I revise Physics regularly | | | | | |
| **11** | I am confident the method we’ve recently been using to learn Physics is effective | | | | | |
| **12** | The methods used to teach Physics should be improved | | | | | |
| **13** | The methods I use to read Physics on my own are not good enough | | | | | |
| **14** | Most topics in Physics are confusing | | | | | |
| **15** | Physics is one of my favorite subjects | | | | | |
| **16** | I don’t see why we learn Physics topics | | | | | |
| **17** | Physics text books we use are ugly | | | | | |
| **18** | Physics teachers are very knowledgeable | | | | | |

**The end**

**Appendix 3: The students' Motivation Questionnaire (SMQ)**

## SECTION A: OVERVIEW

The objective of this questionnaire is to find out your motivation to learn Physics. Your cooperation in completing it with sincerity is very important. Findings would be treated very confidentially. Do not write your names on the questionnaire. Instead, use pseudo names provided. Place a tick against your most favorable response to each of the statements.

## SECTION B: STUDENTS' DETAILS

Pseudo Name: _____________

Gender: (*TICK ONE)* Female [ ]  Male [ ]

School Type: (*TICK ONE)* Mixed [ ]  Girls' [ ]  Boys [ ]

Age [ ]  Prior training in computer [ ]

## SECTION C: STEM MOTIVATION ITEMS

| | STATEMENTS | SA | A | U | D | SD |
|---|---|---|---|---|---|---|
| **1** | There is something interesting about Physics lessons that catches my attention | | | | | |
| **2** | After any topic in Physics is introduced, I feel confident that I would understand what would be taught | | | | | |
| **3** | Physics topics are so abstract, which makes the subject hard for me to pay close attention | | | | | |
| **4** | The knowledge I get from Physics is relevant to my future interests | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **5** | Physics experiments make me curious | | | | | |
| **6** | After each Physics lesson, I feel confident that I would pass in KCSE examinations | | | | | |
| **7** | The feedback I get from teachers makes me feel rewarded for my efforts in Physics | | | | | |
| **8** | It is clear to me how Physics is related to things I already know in real life | | | | | |
| **9** | Most Physics topics have too much information, which makes it hard to pick out important concepts | | | | | |
| **10** | It feels good to successfully complete a topic in Physics | | | | | |
| **11** | Most topics in Physics are not relevant to my needs because I already know most of them | | | | | |
| **12** | My notes for Physics are too boring, which makes me lose interest in reading them frequently | | | | | |

**THIS IS THE END OF QUESTIONNAIRE**

## Appendix 4: Proposal Approval letter

This appendix contains the official letter of approval of my research proposal. The letter confirms that the research project titled: ‘‘Effect of virtual physics programs on students’ learning outcomes within public secondary schools in Kakamega South Sub-County.’’

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
Fax: 056-30153
E-mail: [illegible]
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P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

3rd July 2023

Aradi Duncan Ambani
EPS/G/003/13,
P.O. Box 190-50100,
KAKAMEGA.

Dear Mr. Ambani,

**RE: APPROVAL OF PROPOSAL**

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your Masters proposal entitled: *"Effect of Virtual Physics Programs on Students' Learning Outcomes within Public Secondary Schools in Kakamega South Sub- County"* and appointed the following as supervisors:

1. Dr. Caroline Wekullo - MMUST
2. Dr. Paul Ogenga - MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Education Graduate Studies Committee and Chairman, Department of Education Planning and Management. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your Master's thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours Sincerely,

Prof. Stephen O. Odebero, PhD, FIEEP
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

**Appendix 5: Research Permit**

The research permit was issued by NACOSTI allowing the researcher to conduct the study.

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: [illegible] Date of Issue: [illegible]/September/[illegible]

## RESEARCH LICENSE

This is to Certify that Mr.. [illegible] of Masinde Muliro University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kakamega on the topic: EFFECT OF VIRTUAL PHYSICS PROGRAMS ON STUDENTS' LEARNING OUTCOMES WITHIN PUBLIC SECONDARY SCHOOLS IN KAKAMEGA SOUTH SUB COUNTY for the period ending : [illegible]/September/[illegible].

License No: NACOSTI/P/[illegible]

[illegible]

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

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