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EFFECTS OF SIMULATION TEACHING TECHNIQUE ON ACHIEVEMENT OF STUDENTS IN PHYSICS CONCEPTS IN BUURI-EAST SUB-COUNTY KENYA.

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ABSTRACT

Introduction: Physics is a science subject that is fundamental for developments in any country. Students' achievement in Physics concepts in the Kenya Certificate of Secondary Education (K.C.S.E) has been below average. Most physics concepts are abstract in nature and the techniques used to teach do not allow learners to conceptualize such concepts. This has led to poor student achievement in physics.

Purpose: The purpose of the study is to investigate effect of simulation teaching technique on secondary school students' physics concepts achievement in Buuri East sub-county, Meru County, Kenya.

Methods: Solomon four non-equivalent control group design was used. Both purposive and stratified sampling techniques were used to select four co-educational schools that were used in the study. The sample of the study consisted of 123 form two students. Physics Achievement Test (PAT) was used to collect data on students' achievement in Physics. The instrument was validated and pilot tested for use in data collection. KR-20 was used to estimate the reliability of PAT, a coefficient of 0.84 was found. Data were analyzed using both descriptive and inferential statistics, which included mean score, t-test, and ANOVA. The hypotheses were tested at 0.05, alpha level of significance.

Findings: The results showed that the difference in physics achievement was statistically significant in favor of experimental group. There was no statistically significant difference in the achievement between male and female students in physics, based on the results.

Recommendations: it was recommended that physics teachers embrace the use of simulation in teaching. The government and education stakeholders should encourage the use of simulation teaching technique in teaching physics in secondary schools.

Keywords: Dual Coding, Gender, Physics, Simulation and Students' Achievement

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PUBLIC INTEREST STATEMENT

Physics concepts remain the most widely used concepts in developments and especially in technology. However, students' achievement in this subject has been below average globally. The poor achievement in this subject has been attributed to various factors. The teaching techniques used have been one of the factors contributing to poor achievement. This study is important especially to the policy makers, teachers, and curriculum developers. The study will further help learners understand the abstract concepts, as the simulation technique presents concepts in both visual and audio form. This makes abstract concepts more concrete.

INTRODUCTION

There is rapid economic and technological development in the world today. Most of these developments demand people to have technological skills and knowledge in physics. Knowledge in Physics is therefore fundamental to the development of a world today. Jayantha (2018) notes that physics is the backbone of technological innovation. He notes that physics has empowered the 21st century students with the relevant skills needed for technological skills. Despite the importance of physics, student achievement in this subject has been below average, as attested by bodies examined. According to Trends in International Mathematics and Science Study (TIMSS 2015) report, students' achievement in Physics concepts was the lowest as compared to other science subjects for the countries that participated in the International Examination. In Kenya, students' achievement in physics concepts is still below average as attested by the reports from Kenya National Examinations Council results (KNEC, 2021).

Table 1: KCSE Physics Results (%) for Year 2014 To 2019

YEAR	2014	2015	2016	2017	2018	2019
PAPER 1	36.03	30.14	36.01	32.49	24.57	25.63
PAPER 2	21.34	27.62	28.92	29.91	26.22	20.43
PAPER 3	22.85	19.68	22.71	17.15	19.33	19.13
OVERALL	40.01	38.84	43.68	39.77	35.05	32.59

Source: Kenya National Examination Council 2018 and 2019 Report

In Buuri East sub-county where this study was carried out, students' achievement in physics concepts is below average and is also below the national achievement in the subject. The sub-county has also registered a declining trend in students' achievement in secondary school physics in the past few years.

Table 2: Physics Results in Buuri Sub-County for Year 2014 To 2019

YEAR	2014	2015	2016	2017	2018	2019
OVERALL SCORE (%)	37.64	34.78	26.44	24.17	29.10	27.42

Recent studies have shown mixed results on students' physics achievement by gender. TIMSS (2015) found that there was no statistically significant difference between boys and girls in science achievement. However, they found out

that girls outperformed boys in most countries. Oluwatelure (2015), in his study on gender differences in science achievement, found a significant difference in the achievement of students in science in favor of girls. Inzahuli, et al. (2012) in their further noted that boys reflected better academic achievement as compared to girls.

Poor achievement in Physics is a major concern to all and especially those in science education. There are a number of reasons that have been attributed to students' poor achievement in Physics concepts. Ibezim and Asogwa (2020) attribute the poor achievement to the teacher-centered teaching techniques used in delivering the subject matter. He argues that these techniques do not give students enough opportunities to think for themselves and actively participate in the learning process. Learners who are actively involved in the learning process have a better understanding and retain the information learnt. Poor academic background of students in basic science taught in lower classes also contributes to poor achievement (Adesoji & Ogini, 2012). López-Pérez et al. (2011) argued that the way the teacher offers instructions affects the student's achievement. Learners come with prior knowledge, which at times entails some misconceptions. If the misconceptions are not corrected in the early stages of their learning, they form some wrong foundations. To erase such foundations, techniques used by teachers should be simple and interesting so as to arise learners curiosity. Poor achievement has also been attributed to gender, according to Agogo and Naakaa (2014), gender is a socially ascribed attribute that differentiates feminine from masculine roles. Girls are made to believe by societal stereotypes that science is a male subject; hence, most girls shy away from learning science subjects' physics being one of them.

Physics is a practical subject that calls for student's engagement during teaching and learning. However, most popular techniques used to teach physics are conventional techniques. The conventional techniques do not allow the learner to actively participate in the learning process. Some of the concepts taught in physics are so abstract and sometimes use of practical work may be too expensive. They may also be hazardous to both students' and teachers' health, or to the environment. Some concepts are also difficult to present in a classroom through demonstration or practical work. Concepts such as radioactivity involve reactions that take long to distingrate, the said reactions also produce radiation that is hazardous to both the environment and the people. Such concepts can be presented by use of simulations without posing any danger. Concepts taught in electricity, such as electric fields, all a teacher can demonstrate is their effects; however, simulation can provide a visual aspect of such concepts without putting the teacher and students in danger. Concepts involving nuclear energy and their application may also the taught using simulation technique due to the nature of the topic being dangerous and also expensive. The simulation teaching technique exposes learners to models that give an opportunity for them to engage with reality. This study focused on the concept of magnetic field on the topic of magnetism. To improve physics achievement, teachers should use a technique that can present the abstract concepts in physics in a simple manner. It should also show no partiality between male and female students.

Simulation is the use of computer to predict the outcome of a real-life situation using a model. Jamil and Isiaq (2019) note that simulation can facilitate active participation of students in the construction and reconstruction of conceptual knowledge in their learning of abstract concepts in the physical world. Chen and Howard (2010) observed that use of simulation teaching technique to teach chemistry gave positive results through improved student performance and increased students' retention. McDonald (2016) says that simulation provides opportunities to visualize dangerous, time consuming or complex events to interact in class or in the laboratory. Ramasundarm et al. (2005) observed that simulation has the potential

to make instruction more interactive and make learning abstract concepts more concrete. Thiongo et al. (2014), agrees with Ramasundarm et al that computer based simulation with animated colour graphics images is capable of presenting the dynamic nature of magnetic fields and electric current that lacks in regular teaching methods. Poripo (2008) experimented on the effect of simulation on male and female students' achievement in Physics. The results obtained indicated that simulation technique increased the achievement for both male and female students. Jayantha (2018) found that student taught using computer simulation in laboratory Physics, had a higher mean in acquisition of practical skills than their counter parts who were taught without computer simulation. This is supported further by Abdullah (2019) findings which indicate that regardless of different types of simulation techniques used in the university settings, teacher practice effectiveness and student learning performance was positively impacted. The results of his study showed that simulation technique increased the achievement for both male and female students. A study by Dennis et al (2020) found out that female and male students performed academically similar in Entrepreneurship Education when taught using simulation technique.

Effects of using simulation teaching technique on students' achievement in physics in Buuri East sub-county are not known. Hence, the purpose of this study was to determine the effects of the simulation teaching technique on the achievement of the students in physics. The study was guided by Dual Coding Theory (DCT) which was proposed by Allan Paivio in 1986. According to this theory, there are two ways a person could expand on learnt materials, through verbal associations and visual imagery. Human mind can code information as visual, verbal, or both. The codes are used to organize incoming information that can be acted upon, stored and retrieved for use. Coding information in two different ways increases the chance of remembering that information compared to coding in just one way. Individuals who dually code information presented are more likely to recall the information when tested at a later date. Simulation teaching technique is a technique that uses both verbal and visual information in teaching. This gives a chance to code the information received as verbal, visual, or both. Some Physics concepts are so abstract and presenting them using visual images supports the verbal presentation, which may make the abstract concepts more concrete.

STATEMENT OF THE PROBLEM

Today people in all societies are completely dependent on machinery, technology and industry, which are all functioning due to application of physics laws. In Kenya, the major pillars of vision 2030 include energy production, infrastructure, and housing, among others. To achieve this vision, people with a wide knowledge of physics will need to be in a good position. However, despite its importance, students' achievement in the subject is still below average. Studies have shown that gender gap in physics achievement has been reducing in some countries over the years. However, this is not the case in Buuri East sub-county co-education secondary schools. The poor achievement in physics has been particularly noticeable amongst the girls. Ineffective teaching techniques have been identified as some of the factors that contribute to students' low achievement in physics. An appropriate technique would be one that enhances achievement in the subject. This study was set up to establish whether the simulation technique has an effect on the concepts of physics achievement of the students. In this study the concept of magnetism was considered, due to its abstract nature. It is also a crucial topic since it forms a foundation for other topics taught in forms three and four physics.

PURPOSE OF THE STUDY

The purpose of this study was to:

1. determine the effects of simulation teaching technique on students' achievement and attitude toward learning Physics.

2. ascertain if simulation teaching technique has any effect on achievement and attitude towards learning Physics by gender.
3. compare students' achievement in physics concepts between students taught through simulation technique and those taught through conventional technique in Buuri East sub-county.
4. investigate if there was gender difference in students' achievement when taught physics concepts through simulation technique.

HYPOTHESES

1. There is no statistically significant mean difference in pretest student achievement physics concepts between taught through simulation technique and those taught through conventional techniques in Buuri East sub-county.
2. There is no statistically significant mean difference in posttest students' achievement in Physics concepts scores between students taught through simulation technique and those taught through conventional techniques in Buuri East sub-county.
3. There is no statistically significant mean difference in pretest student achievement physics concepts scores between boys and girls.
4. There is no statistically significant mean difference in post-test students' achievement in physics concepts when taught through simulation technique.
5. There is no statistically significant mean difference in post hoc students' achievement in physics concepts scores between students taught through Simulation and those taught through conventional techniques in Buuri sub- county

METHODOLOGY

Design

The study employed a quasi-experiment, specifically, Solomon four non-equivalent control group research design. This is because secondary school classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and reconstituted for research purposes (Gall & Borg, 2007; Fraenkel & Wallen, 2001). This design makes it possible to evaluate the main effects of testing, history, and maturation.

Population and Sample

The target population of the study was 1119 form two students from all secondary schools in Buuri East sub-county. The accessible population was 542 participants which comprise of form two students in Buuri East sub-county in 16 co-education secondary schools. The sample was drawn from the accessible population. Four schools were purposefully sampled from the 16 co-educational public secondary schools in Buuri Sub-County of Meru County, Kenya. Stratified sampling was used to group the qualifying schools into four strata, this controlled the diffusion effect. One school was selected randomly from each strata giving a total of four schools. Simple random sampling was used to allocate the four schools into either experimental or control groups. Two of the schools were randomly assigned to experimental groups, while the other two were assigned to control groups. A total of 123 students from the schools sampled participated in the study. Each school provided a form two class to participate in the study, in case where a school had more than one stream, simple random sampling was used to select the one stream for the purpose of data analysis.

Instruments of Data Collection

Data for this study were collected using the Physics Achievement Test (PAT). A Physics Achievement Test (PAT) was developed, validated by secondary school physics teachers, and moderated by experts in the Department of Curriculum Instruction and Education Management (CIEM). PAT was pilot-tested in two co-educational secondary schools in Buuri-East sub-county; the schools were not part of the sample schools. The reliability coefficient of PAT was estimated to be 0.84. A training

manual on the simulation teaching technique was developed to prepare teachers for the implementation of the simulation teaching technique.

Procedure for Data collection

The teachers in the experimental schools were trained by the researcher for a period of one week on how to use Simulation teaching technique. A pretest was administered to students in one control and one experimental school. The simulation teaching technique was then applied to the experimental groups as a treatment for three weeks. The control groups were taught using the conventional method. A posttest Physics Achievement Test (PAT) was administered to students in all the four groups after three weeks. The PAT results were then scored and analyzed using ANOVA and the t-test at 0.05 α level of significance of 0.05. The Solomon Four-Equivalent Control group design consisted of four groups two experimental E1 & E2 and two control groups that are C1 and C2. A post-test was administered to one control group C1 and one experimental group E2. The treatment was administered to experimental groups only while the post test was administered to all groups.

Methods of Data Analysis

Analysis was done with the aid of the Statistical Package for Social Sciences (SPSS) version 22. Both descriptive and inferential statistics was used to analyze the data. Descriptive statistics such as means and standard deviations were used. Further analysis was obtained using, inferential statistics to analyze the data and test the research hypotheses. ANOVA was used to analyze differences in the four means of post-test scores. A t-test was used to test if gender difference in achievement and attitude towards learning physics is significant or not. Hypotheses was tested at $\propto$=0.05 level of significance.

RESULTS

Hypothesis 1: There is no significant mean difference in pretest student achievement physics concepts scores between those taught through simulation technique and those taught through conventional techniques in Buuri East sub-county.

Table 3: Comparison of the Students' Pre-test Mean Scores in Physics Achievement between E1 and C1 using a t-test

Variable	Group	Mean	SD	t-value	p-value
PAT	C 1	8.1761	1.974		
				0.046	0.964
	E 1	8.1056	1.833		

The results of Table 3 show that the mean score of the PAT pre-test was not statistically significant since p=0.964, was greater than .05. This means that the groups used in the study were comparable. They had a similar entry behaviour before treatment administration, as indicated by the mean scores of the physics achievement pre-test. Due to this similarity in characteristics between the two groups E1 and C1 in the Physics achievement, the four groups were considered suitable for the study since they were drawn from same population and sampled randomly.

Hypothesis 2: There is no statistically significant mean difference in posttest students' achievement in Physics concepts scores between students taught through simulation technique and those taught through conventional techniques in Buuri East sub-county

Table 4: Mean Scores for the Physics Achievement Test (PAT) of Students

Group	Mean score	N	SD
C 1	9.3125	32	2.78750
C 2	9.0323	31	2.25808
E 1	12.8750	32	2.67304
E 2	13.6071	28	2.55806
TOTAL	**11.1463**	**123**	**3.26854**

The results in Table 4 show that the posttest mean scores for the control group were lower than those of the experimental groups.

Hypothesis 3: There is no significant mean difference in pre-test student achievement physics concepts scores between boys and girls.

Table 5: Independent Sample t-test Pretest Scores on Physics Achievement Test Based on Students Gender

Scale	Group	N	Mean	SD	t-value	Df	p-value
PAT	Boys	28	12.84	4.55			
					0.541	58	0.59
	Girls	32	11.89	2.33			

The results in the Table 5 indicate that the male students had higher mean score than that of the female students in the PAT scores. However the p> 0.05 indicating that the scores are not statistically significant different by gender. Only one control group and one experimental group were subjected to the pretest. This helped the researcher to establish similarities of the groups before introducing the intervention and generalize the findings to the groups which were not given the pre-test.

Hypothesis 4: There is no significant mean difference in the achievement scores of students after the test in physics concepts when taught by simulation technique.

Table 6: PAT Posttest Scores for Male and Female Exposed to Simulation Teaching Technique

Gender	N	Mean	SD	t-value	Df	p-value
Boys	28	13.03	2.75			
				-0.496	58	0.401
Girls	32	13.06	1.83			

Table 6 shows the results of post-test PAT mean score for boys and girls as 13.03 and 13.06 respectively. From the results the girls performed slightly higher than the boys. The results of the independent sample T test show that the p-value was 0.401 implying that the difference between the mean score of girls and boys was not significant at α=0.05. The results obtained implies that the null hypothesis was accepted. This means that the simulation teaching technique showed no partiality between boys and girls

Hypothesis 5: There is no significant mean difference in students' achievement in physics concepts scores between students taught through simulation and those taught through conventional techniques in Buuri sub- county.

Table 7: ANOVA Results for Post-test PAT

Sources of Variation	Sum of Squares (SS)	D.f	Mean Squares	F-ratio	p-value
Between groups	511.345	3	170.448	25.610	.000
Within groups	792.021	119	6.656		
Total	**1303.366**	**122**			

The results of Table 7 show that the p-value is less than 0.05. This indicates that there is a statistically significant difference among the four groups. Therefore the hypothesis that stated 'there is no statistically significant difference in students' achievement in physics concepts between students taught through Simulation and those taught through conventional techniques in Buuri sub- county' is rejected in favor of the alternative. However, these results don't show which group or groups are significantly different. A Bonferroni post hoc test was conducted to reveal which group or groups were different since it reduces type I error Richard (2014). Table 8 shows results obtained from the post hoc analysis.

Hypothesis 6: There is no statistically significant mean difference in post-hoc students' achievement in physics concepts scores between students taught through Simulation and those taught through conventional techniques in Buuri sub-county.

Table 8: Post-Hoc Results for Post-test Scores

(I)Group	(J)Groups	Mean Differences(I-J)	p-value
C 1	C 2	.28024	1.000
	E 1	-3.562508*	.000
	E 2	-4.29462*	.000
C 2	C 1	.28024	1.000
	E 1	-3.84274*	.000
	E 2	-4.57488*	.000
E 1	C 1	3.56250*	.000
	C 2	3.84274*	.000
	E 2	-.73214	1.000
E 2	C 1	4.29464*	.000
	C 2	4.57488*	.000
	E 1	.73214	1.000

The mean difference* is significant at p<0.05

The results of Table 8 indicate that C 1 has a statistically different difference with E1 and E2, and the results also indicate that C2 has a statistically significant difference with E1 & E2. This indicates that there is a statistical difference between the control groups and the experimental groups. This implies that the null hypothesis which stated that there is no statistically significant difference in students' achievement between those taught through simulation technique and those taught using conventional techniques is rejected.

DISCUSSIONS

The study sought to find out whether there was statistically significant difference in physics concepts achievement between students taught through Simulation teaching technique

and those taught through Conventional teaching technique .The study established that students who were taught through simulation teaching technique achieved significantly higher scores in the PAT than those who were taught through the conventional teaching technique. The results of ANOVA, analysis showed a significant difference in PAT means scores between the experimental groups and control groups, in favor of the experimental groups. This indicates that the simulation teaching technique was more effective in improving the students' Physics achievement compared to the conventional teaching technique. It improved the achievement in physics concepts when compared to the conventional techniques that are mostly used by teachers. The findings of this study agree with other studies that the use of simulation in learning enhances the achievement of students. Thiongo et al. (2014) in their study found that computer simulation was a more effective teaching technique to improve students' achievement than the regular teaching techniques. Mwei, et al. (2011) in their study indicated a higher achievement with Computer Assisted Integration (CAI) treatment groups. Ouhai et al. 2021 revealed that there is a significant different in achievement for those exposed to the treatment. Simulation teaching technique has shown remarkable positive results not only in physics but also in other subject. Simulation teaching technique presents abstract concepts in a simpler manner making them concrete. It also makes it possible to learn concepts that are expensive to present in real life, time-consuming, dangerous, and complicated to do in real environments. Such experiments can be performed safely and repeated as many times as desire until the learner understands. Simulation Technique provides two way of coding information learnt that is by visual and audio this increases chances for learners to retain and understand physics concepts. In return, this leads to improved achievement by the learners.

The analysis of the experimental schools by-gender was conducted to find out if there is a difference in achievement for boys and girls. Table 8 shows the independent sample test of the PAT scores for male and female exposed to simulation teaching technique. The analysis of the PAT scores also indicated that girls performed slightly better than boys in the PAT further analysis showed that the difference between the mean score of girls and boys was not statistically significant. This indicates that simulation teaching technique had statistically significant no effect on students achievement by gender since the boys and the girls had no statistical significant different in their achievement. Ouhai et al. 2021 in their study on the effect of using computer simulation on students' performance in teaching and learning Physics revealed that a significant different in achievement for those exposed to the treatment. Those exposed to simulation had higher scores; however, they also noted that the difference had no statistically significant difference in achievement between boys and girls. Computer simulations bridge the gap in achievement of male and female students, respectively, this is according to Akhgibe (2019) in his work that gender difference in achievement did not yield any significant results. This finding supports the view of Asogwa et al. (2016) who posited that gender does not influence the achievement of students in genetics when exposed to computer simulation instructional strategy. There has been an existing gap between boys and girls achievement and especially in science subjects. The gap has been attributed to many factors such as, society orientation, resources, prior knowledge before coming to school, teaching technique etc. This study has revealed that simulation teaching technique is a technique that does not discriminate any gender when it comes to achievement. Therefore, teachers, curriculum developers and other education stakeholder should champion for this method to be used more frequent in our schools since it's an inclusive technique of teaching. The government should also facilitate with both human resources and other resources that may be needed to ensure that the implementation is

inclusive, especially to the needed community.

CONCLUSION

From the findings of this study, it is clear that the simulation teaching technique improves the achievements of learners in physics concepts. Simulation is therefore a good technique that brings the outside world or the real world into a classroom setup. It provides active participation by learners and also gives room for manipulation especially for experiments that would take long duration to occur. This comes along with implication to education stake holder, especially for curriculum developer to develop, teaching aids that support this technique and for the government to facilitate to ensure that all learners benefit from the developed materials.

RECOMMENDATIONS

Based on the finding from the study, the following recommendations have been made.

1. Physics teachers should be encouraged to use Simulation teaching technique in teaching physics.
2. The curriculum developer should, develop materials that would assist, teachers to incorporate Simulation teaching technique in their teaching.
3. The government should provide necessary resources to enable teachers to incorporate this method in their teaching with ease.
4. The teacher employer should team with the government to organize workshops to train teachers on how to use this method, to ensure all teachers are well equipped with the correct skills.
5. Finally, teacher training institution should offer the skills of Simulation teaching technique to the teacher trainees.

Conflict of Interest: The authors declare no conflicts of interest.

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Disclaimer Statement

The opinions expressed in the study are those of the author and are not a representation of the official position of the Department of Curriculum &Instructions and Education Management, Egerton University. The journal has been generated from objective one of the authors thesis which is currently under examination.

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Authorship and Level of Contributions
Agata. W. Ndegwa developed the manuscript, developed tools for data collection, established reliability of the tools, collected data, analyzed and interpreted the data.
Joel K. Ngeno validated the tools for data collections, proof read the manuscript, assisted in data analysis and discussion of results.
Grace C. W. Ndeke validated the tools, improved some items after piloting, proofread the manuscript, assisted in the interpretation and discussion of results.

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