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Effect of Collaborative Teaching Strategy on Students' Academic Achievement, In Physics in Public Secondary Schools in Nyeri County, Kenya.

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Abstract
Science education is a key driver for development because technological and scientific revolutions underpin economic advances, improvements in health systems and infrastructure. The study of Physics, as a science subject has seen technological advancement and improved speed of communication. It has resulted to quality security systems and use of high precision equipment in hospitals and industries. However, secondary school students' achievement in Physics has been declining. Different factors including the different strategies used in teaching Physics have been reported to affect students' achievement in Physics. Based in Nyeri County the study assessed the effect of collaborative teaching strategy on secondary school students' achievement in Physics. The Solomon Four group quasi experimental design was used. A sample of 173 form four students in four mixed day secondary schools in Nyeri County participated in the study. The sample was obtained through purposive sampling to obtain a list of mixed day secondary schools that offer the Physics subject at form four. Through random sampling a list of four schools that participated in the study was obtained. The schools were randomly assigned to experimental and control groups. The research instruments consisted of Physics Pre-test (PPT) and Physics Achievement Test (PAT). The Kuder Richardson test was used to determine the reliability of the PPT and PAT. A reliability coefficient of 0.7 and 0.8 was obtained for the PPT and PAT respectively. Descriptive statistics (mean, standard deviation) and inferential statistics (t-test and ANOVA) were used in data analysis. The Statistical Package for Social Sciences (SPSS) version 22.0 was used for statistical analysis. Hypotheses was tested at α=0.05 level of significance. The study established that Collaborative Teaching Strategy enhanced students' achievement in Physics. The study recommended that teachers should expose students to Collaborative Strategy more frequently and teacher training programmes to equip teachers with skills for collaboration. The findings of the current study are helpful to the curriculum developers in revising curriculum towards learner centeredness by in cooperating collaborative activities. The Kenya Institute of Curriculum Development may find the information useful during in servicing of teachers towards making the curriculum more learner centered. The Instructional material developers may find the information useful while developing materials that enhance learner activity. The findings of the study may be useful in implementing the competence based curriculum at secondary school level through incorporation of collaborative tasks since collaboration is one of the core competencies to be achieved through the curriculum.

Key Terms: *Achievement, Collaborative teaching strategy, Conventional teaching strategy*

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I. Introduction

Science education forms an important cog in the education and training of a critical mass of a country's population. According to Roy, Michael and Preston (2012), science driven improvements in sectors such as health services have improved the lives of people through access to timely and quality medical services. Science and technology jointly are perceived to be enablers of life outcomes such as employment, income or wealth generation, safety, security and social status in the society (Lilia, Halim, Mohd & Erfy, 2019, Kola, 2013) and Telima, Alamina and Temitope (2013). According to Interanational Union of Pure and Applied Physics (2020), the study of Physics as a science extends and enhances our understanding of other science disciplines such as the earth, agricultural, chemical, biological and environmental sciences plus astronomy and cosmology which are subjects of substantial importance to all peoples of the world. According to Modin (2020) the many technologies that are continually transforming the world we live in can be directly traced back to important Physics research such as the Physics of semiconductors which is the key component in all electronic systems that run the world.

In many countries therefore, education curriculum especially in science education at the secondary school level emphasizes the study of Physics along with other science subjects such as Biology and Chemistry. Amongst these subjects, Physics is perceived to greatly contribute in the development of scientific knowledge, skills and attitude required by the learners transiting the secondary school level to fit into the highly competitive society (Minish, Muni, Mutai, Mwangasha, Omolo & Munyeke, 2004). It has also been illustrated that the study of Physics helps to develop certain abilities and skills in the learners which include communication, Mathematics, aesthetic, safety, laboratory, manipulative and process skills. These skills are useful in other areas of life including business, medicine, engineering, politics, law, archeology and industry (Twoli, 2006). There are desirable attitudes that develop in learners when they study Physics. At secondary school level Physics students develop attitudes such as critical mindedness, intellectual honesty, objectivity, open-mindedness, questioning, curiosity, humility, risk taking, inventiveness, responsibility, suspended judgement and respect for evidence (Minish *et al.*, 2004). These attitudes are important for national unity and harmonious coexistence as documented in the objectives of educational (MOEST, 2015). Therefore the ultimate goal of teaching and learning Physics should be the understanding of its scientific processes and applications in everyday activities.

Despite its importance, evidence indicate that a majority of students continue to register low achievement in the subject in many countries, both developed and developing which is a matter of concern to education stakeholders (Centre for Mathematics, Science and Technology Education in Africa, 2012, West Africa Examination council and KNEC 2017). Lawrenz, Wood, Kirchoff, Kim and Einsenkraft (2009) attributed the declining performance to the inadequate mathematical skills possessed by the students recommending the enhancement of mathematical skills and use of student centered approaches to improve students' achievement in physics. A study in the Phillipines by Antriman (2007) exposed the worrying trends in secondary school students achievement in Physics and further exposed the factors contributing to the trend among which were :teacher qualification, availability of resources, Physics class size and learning environment. Studies done in Kenya have raised concern over the dismal performance by form four students in Physics in secondary schools in Kenya (Muriithi, 2018: Nderitu, 2007: Muchai, 2014: Kuria, 2014). This studies attributed the low achievement of students in Physics to negative students' attitudes towards Physics, inadequate teaching resources and poor choice of teaching strategies. In Nyeri County, Kenya, a similar trend is being witnessed with existing data showing a worrying declining trend of learners achievement in the subject as shown on Table 1.

Table 1: Summary of Data of Candidates' Mean Scores in Physics in the Six Counties of Central Region between 2014 and 2019

	Mean score in Physics					
Year	Kirinyaga	Kiambu	Laikipia	Muranga	Nyeri	Nyandarua
2014	3.99	4.34	4.11	4.213	4.179	4.28
2015	4.22	4.26	4.14	4.15	4.014	4.14
2016	4.20	4.21	4.23	4.201	4.192	3.92
2017	4.15	4.30	4.19	4.14	4.124	4.13
2018	3.98	4.26	4.09	4.00	4.061	4..12
2019	4.00	4.16	4.11	4.05	3.892	4.04

Source: Nyeri County Education Office, 2020

Analysis of the vertical trends for each County reveals drops in mean scores in all the counties. The drops are more significant in Nyeri County which recorded the lowest mean score of 3.892 in 2019. Previous studies have indicated that achievement in Physics is determined by the teaching strategy. Teacher qualification and experience play a key role in learner achievement in Physics. Different strategies have been used in Physics instruction which include traditional and creative strategies. According to Giridhan and Raju (2016), Abdulkadir (2016) and Adeyemi and Awolere (2016), innovative strategies prove to be more effective towards academic achievement in Chemistry than traditional strategies concurring with Taylor and Francis (2011) who urgue that during a lecture students remain passive and contribute very little to real learning. Emmanuel and Ebere (2016) argue that problem solving, concept mapping, game/simulations, group discussions and peer teaching/tutoring yield higher achievements among secondary school Chemistry students than expository/ traditional strategies (lecture and demonstration methods) agreeing with Robluer (2006) in Virginia state and Sajjad (2011) in Pakistan who associated poor achievement in Mathematics with the intensive use of the lecture method. The finding also agrees with Bwari, Gisore and Ntabo (2019) in the case of learner's achievement in Kiswahili in secondary schools in Kenya. On the contrary, Namasaka, Mondon and Wasike (2017) found lectures and demonstrations to be effective in enhancing learners' achievement in Biology. The teacher/students interactive strategies (hybrid) were found to be more effective than the student /centred and teacher/centred strategies in the teaching of Economics and business studies (Munyardzi, 2013) while Muema, Mulwa and Mailu (2018) study in Mathematics in Garrissa County of Kenya found teaching through ICT to be strongly correlated to learners'

achievement than traditional strategies of teaching in Mathematics. The findings in Robluer (2006), Sajjad (2011), Emmanuel and Ebere (2016), Munyardzi, (2013) and Muema, Mulwa and Mailu (2018) point at teaching strategy as a determinant of students' achievement in the different subject areas.

There is a shift from competitive strategies towards cooperative and collaborative strategies in science teaching for improved interaction. Several studies have been carried out to investigate the effects of collaborative teaching on achievement in science globally. For instance, Olivia and Gordon (2013) in the United States of America and Fui and Hong (2007) in China Eyayu and Meseret (2018) in Ethopia and Keraro & Wachanga (2015) found that collaborative strategy enhanced students' science achievement and reduced achievement disparities between low and high ability learners. The study purposed to expand on the existing knowledge on collaborative strategy by determining the effectiveness of collaborative strategy on secondary school students' achievement in Physics in Nyeri County Kenya. Information on figure 1 demonstrates the relationship between the involved variables.

II. Statement of the Problem

Physics plays a fundamental role in acquisition of knowledge, skills and attitudes required by individuals to contribute in enabling the country attain its developmental targets. Individuals trained in the subject have been shown to contribute in the science and technology related fields thus in the process enabling the country to become industrialized. However, and despite its significance, data obtained show that a majority of learners continue to perform poorly in the subject thus stifling their ability to contribute in self and national development especially in the science and technology related fields. The low achievement by a majority of learners nationally in Kenya and Nyeri in particular continue despite interventions already implemented. Previous studies attribute the poor achievement of learners in Physics to a number of factors including access to instructional materials, learning environment, learner related factors including learner ability and attitude towards Physics as well as teacher related factors such as choice of teaching strategies. Relative to choice of teaching strategies, studies have documented the contributions of inquiry, discovery, peer teaching, think /pair-share, problem solving and experiment/ hands on activities. However, despite their implementation, achievement in the subject is still wanting calling for the need for further studies especially with regard to other strategies whose adoption could help improve achievement in the subject. Some researchers have illustrated that collaborative teaching strategy immensely contribute in improving learners' achievement in science subjects such as Biology and Chemistry. Studies addressing the contribution of the strategy towards learner achievement in Physics are minimal in Kenya. The limited information on contributions of collaborative strategy on students' achievement in Physics leaves a gap in research for studies specifically addressing the contributions of the strategy towards learner achievement in Physics especially within the Kenyan context. To fill this gap the current study investigates the effects of collaborative teaching strategy on learner achievement in Physics with a specific focus on form four Physics students in Nyeri County, Kenya.

III. Hypothesis

The hypothesis for the study was:

$H_{01.}$ There is no statistically significant difference in learner achievement between learners exposed to Collaborative Teaching Strategy and those who are exposed to Conventional Teaching Strategy in Physics in Nyeri County.

IV. Methodology

The study adopted a Solomon four group quasi experimental design. The target population was the entire form four Physics students in Nyeri County studying in Public secondary schools. The sample was obtained through purposive sampling of mixed day secondary schools then random sampling to obtain four schools. The classes in the four randomly sampled schools were then randomly assigned to the experimental and control groups. The four schools that participated in the study contained 173 students out which 153 students completed the study (C1=36, E1=39, C2=33, E2=45) where C1 and C2 were control groups and E1 and E 2 were experimental groups. Based on Kathuri and Pals (1993) and Mugenda and Mugenda (1999) at least 30 cases are required for experimental research hence a sample size of 153 students was considered fit for the study. Physics Pre-Test (PPT) and Physics Achievement Test (PAT) were used to collect data.

The PPT consisted of 4 structured test items on the topic of work energy, power and machines. These items tested the entry level of students. The PPT was marked out of a total score of 40 marks while the Physics Achievement Test PAT consisted of four structured test items on the different subtopics of the topic on cathode rays and was marked out of 40 marks. The reliability of the instruments was determined using the internal consistency techniques. Since the items were not of the same levels of difficulty the reliability was estimated using the Kuder-Richardson formular. Based on this formular, the reliability of pretest and posttest PAT determined from the data obtained during piloting were 0.7 and 0.8 respectively. Therefore the pretest PAT and

the Post-test PAT were accepted in accordance with Kothari (2004) whereby Kuder Richardson coefficient of between 0.7 and 1.0 is acceptable. The instruments were considered reliable for the study. A pretest (PPT) was administered to E1 and C1 before intervention and the results obtained used to establish any initial differences among the groups by carrying out an independent t-test. E1 and E2 were taught using the Collaborative Strategy while C1 and C2 were taught using the conventional strategies. The PAT was administered to all the groups after intervention. The data obtained was cleaned, coded and subjected to analysis through both descriptive and inferential statistics. The descriptive statistics included means and standard deviations while the inferential statistics included t-test, Analysis of Variance (ANOVA) and Post Hoc (Tukey HSD). The Statistical Package for Social Sciences (SPSS) computer package version 22.0 was used for analyzing the data. All the tests were performed at significance level of alpha (α) equals to 0.05.

V. Results and Discussions

Collaborative Teaching Strategy and Achievement in Physics

The study aimed at determining the difference in achievement in Physics between students taught using collaborative teaching strategy and those taught using conventional teaching strategies. Students in two groups, C1 and E1(control and experiment) were pre-tested and then post tested. Findings are presented beginning with descriptive findings, hypothesis testing and qualitative as well as overall discussions.

Descriptive Findings on Effects of Collaborative Teaching Strategy on Achievement

The results obtained in the pre-test examination to the two groups C1 and E1 were as shown on Table 1

Table 1: Students' Achievement in Physics Pre-test (E1 and C1)

% score	Group				Total	
	C1		E1			
	F	% of total	F	% of total	f	% of total
Below 20	6	8.00	12	16.00	18	24.00
20-40	28	37.30	22	29.30	50	66.70
Above 40	2	2.70	5	6.70	7	9.30
Total	36	48.00	39	52.00	75	100.00
Mean	28.53		26.51			
SD	9.85		11.07			
Combined mean			27.48			
Combined SD			10.48			

Pre-test results showed that the mean achievement for students in the control group C1 (M=28.53; SD=9.85) was higher than for the students in the experimental group E1 (M= 26.51; SD=11.07). The combined mean for E1 and C1 was 27.48 with a standard deviation of 10.478. More than 90% of the students scored below 40% (45.3 % in both E1 and C1). Those who scored above 40% were 9.3% represented by 6.7% from E1 and 2.7% from C1. Thus E1 had more higher performers than C1. However E1 also had more lower performers (18%) than C1 which had 8.0% of learners who scored below 20. An independent sample t-test performed on the pre-test to assess the existence of any differences (homogeneity) in composition of the test groups based on students' ability yielded the results on Table 2

Table 2: Independent Samples Test on pretest results for E1 and C1

	Test group	N	Mean	Df	t-value	p-value	F	Std errors
Achievement	C1	36	28.53	73	.830	.447	.584	1.641
	E1	39	26.51					1.772

Levene's test for equality of variance F(1,73)=0.584,P=0.447) showed insignificant differences between variances of experimental and control groups. This implied that experimental and control groups were homogenous. The mean for experimental (26.51) and control (28.53) were not significantly different as indicated by t (73)=0.830, p=0.447 thus these groups had comparable means indicating that the learners in the groups were suitable for the study. An assessment of the effect of collaborative teaching strategy and conventional strategies was done after teaching was done for two weeks. Table 3 displays the findings on experimental and control groups.

Table 3: Post –Test Results for all groups

	Group								Total	
	C1		E1		C2		E2			
Category	F	%	f	%	F	%	f	%	f	%
Below 30	14	9.20	10	6.50	20	13.10	25	16.3	69	45.1
30-50	22	14.40	21	13.70	13	8.50	10	6.50	66	43.1

Above 50	0	0.00	8	5.20	0	0.00	10	6.50	18	11.8
Total	36	23.50	39	25.50	33	21.60	45	29.4	153	100
Mean	28.36		39.28		24.82		36.14		32.67	
SD	10.42		13.67		11.18		15.89		14.27	

Although the results indicate that the general performance in the post test was low, the students in the experimental group performed better than those in the control group (E1 mean=39.29, C1mean=28.36). Specifically all students who scored above 50% were from E1 and E2 (5.2% and 6.5% respectively). More students from C1 (9.2%) scored below 30% compared to those from E1(6.5%). This observation is consistent with that made in E2 and C2 whereby all the students who scored above 50% (6.5%) were from E2 and also the mean score for E2 (36.13) was higher than that of C2 (24.82) confirming that the students in the experimental group performed better than those in the control group.

Hypothesis Testing for Effects of Collaborative Teaching Strategy on Students' Achievement in Physics

The first null hypothesis sought to establish whether there is a statistically significant difference between achievement of students exposed to collaborative teaching strategy and those exposed to conventional teaching strategies in Physics. The means for the four groups were compared and results displayed on Table 4.

Table 4: Post- Test Means for all groups.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
C1	36	28.36	10.415	1.736	24.84	31.88	9	41
E1	39	39.28	13.669	2.189	34.85	43.71	15	70
C2	33	24.82	11.179	1.946	20.85	28.78	8	40
E2	45	36.13	15.885	2.368	31.36	40.91	13	71
Total	153	32.67	14.269	1.154	30.39	34.95	8	71

Results in Table 4 show that students from experimental groups E1 registered the highest mean achievement (M= 39.28) followed by E2 (M= 36.13). However learners in C1 registered relatively low mean achievement (M=28.36) followed by C2 (M=24.82). A one way analysis of variance (ANOVA) was performed on post-test results of students in all the four test groups. The results were summarized as displayed in Tables 5.

Table 5: ANOVA on Relationship between Achievement and Strategy

Post test

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4947.688	3	1649.229	9.452	.000
Within Groups	25998.312	149	174.485		
Total	30946.000	152			

ANOVA result showed that the observed mean difference was significant as shown by F (3,149) =9.452, P< .001. A Post Hoc test (Tukey HSD) was carried out to reveal further details about the differences. The results of the post Hoc (Tukey HSD) test were as presented on Table 6

Table 6: Post Hoc Test (Tukey HSD) results

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	E1	-10.921*	3.053	.003	-18.85	-2.99
C1	C2	3.543	3.183	.682	-4.73	11.81
	E2	-7.772*	2.954	.046	-15.45	-.10
	C1	10.921*	3.053	.003	2.99	18.85
E1	C2	14.464*	3.124	.000	6.35	22.58
	E2	3.149	2.890	.696	-4.36	10.66
	C1	-3.543	3.183	.682	-11.81	4.73
C2	E1	-14.464*	3.124	.000	-22.58	-6.35
	E2	-11.315*	3.027	.001	-19.18	-3.45
	C1	7.772*	2.954	.046	.10	15.45
E2	E1	-3.149	2.890	.696	-10.66	4.36
	C2	11.315*	3.027	.001	3.45	19.18

Based on observed means.

*. The mean difference is significant at the .05 level.

The post HOC Tukey's (HSD) test showed that the post-test results for E1 (M =39.28) were significantly different from C1 (M=28.36) and C2 (M=24.82) with mean achievement of students in the experimental groups being significantly higher than those in the control groups at 0.05 level of significance. The post HOC Tukey's (HSD) test also showed that the mean of E2 (M=36.13) was significantly different from the

mean of C1 (M=28.36) and that of C2 (M=24.82) revealing that the students in the experimental groups that were exposed to collaborative teaching strategy performed significantly better than those in the control groups. The findings therefore led to the rejection of the null hypothesis H_{01} which stated that there is no statistically significant difference in achievement in Physics between students taught through collaborative teaching strategy and those taught through conventional methods. The students exposed to collaborative teaching strategy performed better than those taught using conventional methods. Therefore the collaborative strategy is a more effective strategy than the conventional strategies in teaching Physics.

An assessment for probable effect of pre-test sensitization on the outcome of the the process was made based on an independent sample t-test for the post test results of the two groups that were not exposed to pre-test (C2 and E2). The results for the independent sample t-test for C2 and E2 are presented on Table 7.

Table 7: Independent Samples t- Test on Post-Test Results for C2 and E2

	Group	N	Mean	Df	t-value	P value	F value
Post test	C2	33	24.82	76	-3.502	004	8.633
	E2	45	36.13				

Levene's test for the equality of variance F (1,73) =8.633, P=0.04 and t (76)=-3.502, p=0.004 showed significant differences between variances in the achievement levels of students in the experimental and control groups E2 and C2. Thus the data obtained in the post tests fits the assumptions of homogeneity of variance for the combination of experimental and control groups.

Descriptive results showed that generally the achievement of students in Physics in both pretest and posttest were low. Pretest mean for C1 and E1 were 28.53 and 26.51 respectively while posttest mean for C1 and E1 were 28.36 and 39.28 respectively. This observation is in line with existing data on students' achievement in Physics (KNEC, 2019, KNEC, 2017, KNEC, 2015, Muindi, 2006 & CEMASTEA, 2012) that show low achievements in Physics in Kenya and Africa.

Descriptive analysis of the post test results showed that the mean achievement of students from experimental groups was higher than that of students from control groups. In pretest the control group C1 had a higher mean (28.53) compared to that of the experimental group E1 (26.51). In the post test the experimental group E1 achieved a higher mean (39.28) compared to that of the control group C1 (28.36). Also 8 % of students in experimental group scored above 50% while no student from control group scored above 50 % implying that the intervention (Collaborative Teaching Strategy) enhanced learning of Physics concepts on cathode rays. The finding in the current study agreed with Kerero and Wachanga (2015), Fui and Hong (2007) and Muchai (2014) who discussed that Collaborative Teaching Strategy enhances learners' thinking capabilities and development of science process skills which result into high achievement. However the findings disagreed with Barchok (2011) that did not find a significant difference in achievement between students exposed to collaborative teaching strategy and those exposed to conventional teaching strategy in Chemistry and Nilgin and Yaratan (2016) who reported a drop in achievement grades when students learnt collaboratively through discovery. The drop in achievement was attributed to the unfamiliarity of students with discovery skills since the strategy is not commonly used.

ANOVA analysis indicated significant effect of Collaborative Teaching strategy on achievement of students in Physics on the topic of cathode rays. The achievement of learners in the experimental groups was significantly higher than that of the learners in the control groups. This finding was in agreement with Elavan, Ezig, Aka and Mustafa (2010) who assessed the effect of collaborative problem solving on students' achievement and found achievement of experimental groups to be significantly higher than that of the control groups but contradicted findings in Barchok (2011) that indicated no significant difference between students taught using collaborative concept mapping and those taught using conventional methods in Chemistry.

VI. Conclusions and Recommendations

The results obtained indicated significant differences in students' achievement in Physics between students exposed to collaborative strategy and those exposed to conventional teaching strategies since the mean achievement of students in the experimental groups was significantly higher than that of those in the control groups after intervention. The study recommended that since the collaborative teaching strategy showed beneficial effects on students Physics achievement, the use of collaborative teaching strategy should be given attention by teachers in order to address the persistent problem of underachievement in Physics teacher training programmes should equip teachers with skills of collaboration so that they can implement the collaborative teaching strategy appropriately and effectively.

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