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Collaborative Teaching Strategy and Learner Ability Interaction on Students' Academic Achievement, in Physics in Nyeri County, Kenya

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Abstract:

The study of the Physics subject continues to play a vital role in industrial development and economic revitalization. For instance, the Physics of the electronic chip has seen tremendous improvements in communication, entertainment, medicine and industry. However, secondary school students continue to achieve dismally. Different factors including the different strategies used in teaching Physics and learner factors have been reported to affect students' achievement in Physics. Based in Nyeri County the study investigated the interactivity between strategies, learner abilities and academic achievement secondary school students 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. The hypothesis was tested at $\alpha=0.05$ level of significance. The study established that Collaborative Teaching Strategy enhanced achievement of students of all abilities in Physics. The study recommended that teachers should expose students to Collaborative Strategy more frequently and teacher training programs 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. 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 to teachers while implementing the competence-based curriculum at secondary school level during and after transition stage.

Keywords: Achievement, collaborative teaching strategy, learner ability

1 Introduction

The Physics subject is recognized as an important science that is required in industrialization and economic revitalization (Roy, Michael and Preston, 2012 and Lilia, Halim, Mohd and Erfy, 2019). However, poor students' achievement in Physics is a common challenge in Africa where most individuals are unable to access scientific and creative programmes at the university level that require good scores in Physics as essential entry requirements. For instance, in Kenya, according to the Daily Nation 8 May 2019, at the University 187-degree programmes require at least a C+ in Physics. However, during placement of students in Universities in 2019-2020 academic year, 107 programmes failed to attract students. Most of these courses are Physics related. The university managers warn that in the near future, important courses that are core to the country's development may be scrapped for lack of learners.

Studies identify learner characteristics such as learners' gender, personal study, class attendance, learner's entry level and learner ability as determinants of learner achievement. For instance, Peter, Nephath and Obara (2014) found a positive correlation between gender, ability, attendance and personal study and learner's achievement among form four agriculture students. According to Nakayama, Yamamoto and Santiago (2007), the ability of the learner to use e-learning promoted learners' achievement in hybrid courses among Japanese students at the 19 May University in Turkey. Ang, Abdul and Zubair (2013) in Malaysia, Rajshri (2013) in India and Buckley, Gopalakrishnan, Kramer and Whisman (2017)

in Turkey were in agreement that learning styles (Visual, Auditory and Kinesthetic) had varied effects on learners' achievement in Mathematics. Highest positive correlation existed between the kinesthetic learning style and academic achievement implying that different learning styles can be implemented in the classroom to address disparities in learner achievement resulting from their varied abilities.

The study by Bello (2011) established that the collaborative strategy was more effective on the below average than on the above average students agreeing with Keramati (2010) implying that the strategy may be used to bridge the gap between strong and weak students. Zachariah, Chin and Daudi (2010) in Malaysia found that learning Mathematics collaboratively enabled high knowledge retention among secondary school students while Shimazoe and Aldrich (2010) in Malaysia and Keramati (2010) in Iran after similar studies in Physics found that collaborative teaching group instructional strategy promoted deep learning of concepts and helped students to achieve better grades. However, the high ability learners did not show improvement in achievement which contradicts findings by Gupta and Pasrija (2012) in India that the group instructional strategy improved academic achievement across all levels of students. After investigating the effects of group practical on students' academic achievement in Kenya, Muchai (2014) found out that performing Physics practical in groups enhanced development of psychomotor skills such as classifying and interpreting irrespective of learner abilities.

Learner ability refers to the degree of ease or difficult with which a learner comprehends, understands and profits from experience. According to Bloom, Engelhart, Furst, Hill, and Krathwohi (1956) learners have various cognitive abilities that relate to their level of cognition. There are six levels of cognition as expressed by Bloom *et al.* (1956). Knowledge level involves the recall of specifics and universals, the recall of strategies and processes or the recall of pattern structure or setting. Comprehension refers to a type of understanding such that the individual knows what is communicated and can make use of the material or idea. Application refers to the use of abstractions in particular and concrete situations. Analysis represents the breakdown of communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and the relations between ideas is expressed. Synthesis involves the putting together of elements and parts so as to form a whole. Evaluation considers judgments about the value of material and strategies for giving purposes. The secondary Physics curriculum aims at equipping learners with cognitive abilities within knowledge, comprehension, application and synthesis.

There are different abilities developed by students as a result of learning Physics. For instance Etkina, Alan, Suzanne, David, Michael, Sahana, David and Aaron (2006) identified seven scientific abilities that include: ability to represent information in multiple ways, the ability to use scientific equipment to conduct experimental investigations and to gather information to solve problems, the ability to collect and represent data in order to find patterns, ability to devise multiple explanations for the patterns, ability to evaluate the design and the results of an experiment and the ability to communicate. The abilities identified are hierarchical just like in blooms *et al* (1956) where the lowest ability is in knowledge and highest is in evaluation. In the case of Etkina *et al* (2006) the lowest psychomotor skill is ability to represent information in multiple ways and the highest is the ability to communicate findings concurring with Johnson, Johnson and Smith (2015) argument that the highest level of thinking is reflected in the ability to communicate effectively through use of proper scientific language.

Students in a classroom have different abilities of learning new content. Meenu (2016) carried out descriptive research adopting an ex-post facto method on the factors affecting academic achievement. On a sample of 110 students (55 boys and 55 girls) the study purposed to analyse the relationship of general mental ability, interest and home environment with academic achievement on 13-14-year-old students. The study established that mental ability and achievement are highly positively correlated. Thus, IQ and achievement increases or decreases proportionally supporting Tyagi (2001). The measure of ability is given by students' scores in a test on content that has been taught. In this study learner ability is a form of grouping in which students were categorized as high and low ability learners based on criteria that stemmed from students' achievement in prescribed test items (Pretest Physics Achievement). Generally mental ability and academic achievement are positively correlated (Tharyani, 1986 and Tyagi, 2001). This justifies why learners will realize different levels of academic achievement when essential factors such as teaching strategies, environment and resources are held constant. According to Salami (2010) and Aluko (2010), students are not the same especially when considering the rate at which facts and principles in science (Physics) are being assimilated, thus there is disparity in students' abilities to perform specific tasks. For this reason, the study considered the influence of learner ability on students' achievement in Physics with a view to establishing how well the gaps between the learners depending on abilities could be bridged.

In addressing the gaps in achievement due to learner ability in science, studies have been done concerning teaching strategies that could reduce disparities in learner achievement. For instance, Chieng, Guan, Kuang, Hao, Yu-min and Ting (2017) in China carried out a quasi-experimental study with an aim of investigating the effect of Collaborative Computer Based Concept Mapping Strategy (CCBCM) on students' achievement in Geographic Science and reported that the CCBCM strategy enhanced students' memorization, understanding and application of concepts and their high order cognitive ability. The findings of the study revealed that the CCBCM outperformed the other strategies on enabling learners among all ability groups to gain high order cognitive abilities.

The finding in Chieng *et al.* (2017) was complemented by Omeodu and Utuh (2018) study in Nigeria that reported deep understanding of the concept of radioactivity by secondary school students exposed to the CCBCM strategy. In addition, the CCBCM reduced the gap in achievement between low ability and high ability learners for both boys and girls. However, the results in Chieng *et al.* (2017) and Omeodu and Utuh (2018) differed with Retnowati and Ayres (2017) study in Indonesia that sought to determine whether collaborative learning can improve the effectiveness of worked examples in learning of Mathematics among form three students. The study established that individual learning through worked

examples was superior to collaborative learning when worked examples were used. However, for items that involved application of knowledge, collaborative teaching strategy was more effective than conventional teaching strategies agreeing with Telima *et al.* (2013) study in Nigeria that reported improved problem-solving abilities in Physics among form three students who were exposed to collaborative learning. The improvement was noted among learners of all abilities. However, Collaboration through reciprocal peer tutoring helped in improving secondary school students' achievement in Physics in favor of low achieving students in Ethiopia (Alemu, 2020).

Group learning strategy is gaining popularity in the teaching and learning of science in the 21st century as revealed in Melnie, Charles, Nammouz, Case and Stevens (2008), Adolphus, Alamina, and Aderonmu (2013) and Bika and Sule (2019). According to Melnie *et al.* (2008) experimental study in Nigeria on 167 secondary school students, the group strategy enhanced organic Chemistry content retention. Further the strategy improved abilities for both low and high ability learners. However, Adolphus *et al.* (2013) study negated the findings by reporting that the strategy did not improve memory retention but improved problem-solving abilities. The observation by Adolphus *et al.* (2013) adds more value to group learning strategy since problem solving which is a reflection of ability to transfer knowledge and skills is a higher measure of cognitive ability than memory retention. Although Bika and Sule (2019) found the group instruction strategy to increase memory retention, the retention abilities were stronger in high ability than low ability students which differs with Melnie *et al.* (2008). According to Melnie *et al.* (2008), collaborative inquiry led to greater confidence and reasoning gains for both low ability and high ability students where by the low reasoning students made significantly greater reasoning gains within inquiry instruction when grouped with other low reasoning than when grouped with either medium or high reasoning students while Kimbrough (2017) observed improved learning among the low ability subjects in Physics when instructed through peer to peer teaching. The discussions in these studies point towards the use of collaborative strategy as away of increasing learner abilities in Physics.

2. Statement of the Problem

The study of the Physics subject continues to play a vital role in industrial development and economic revitalization. However, high school students' achievement in Physics has been declining. Various factors including instructional strategies, school factors home factors and learner characteristics have been found to influence learner achievement in Physics. Studies have shown that collaborative strategies enhance students' achievement in Science. Different strategies influence the academic achievement of various categories of learners differently. There are limited studies on the interaction between collaborative strategies, learner characteristics and learner achievement in Physics. The study sought to investigate the interaction between learner achievement in Physics, collaborative strategy and learner ability in Nyeri County, Kenya.

3. Hypothesis

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

4. Methodology

The study adopted the quasi-experimental design using the Solomon four group design as shown on Figure 1.

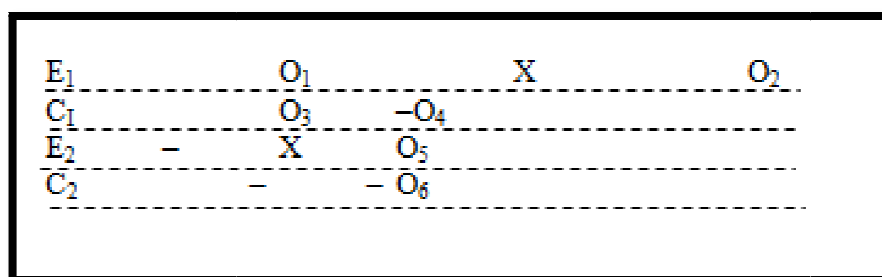


Figure 1: The Solomon's Four Group Design

Key

E_1 Was experimental Group 1

E_2 Was experimental Group 2

C_1 Was control Group 1

C_2 Was control Group 2

O_1 and O_3 Were Pre-tests

O_2 , O_4 , O_5 , and O_6 Were post tests

X Was the treatment where students were taught through collaborative strategy.

The Solomon four group design was appropriate for the study since the groups were intact and identical. It also enabled comparison of groups before and after treatment to establish whether academic achievement in Physics was as a result of treatment only (Vanderstoep & Johnson, 2009). Two research instruments were used in the study namely; Physics Pre-Test (PPT) and Physics Achievement Test (PAT). There were two experimental groups and two control groups. The experimental groups were exposed to the treatment which was the Collaborative Teaching Strategy while the

control groups were taught using the Conventional Teaching Strategy. To avoid the effects of contamination, the treatment and control groups were from different schools which were far apart (schools were drawn from the different sub counties of Nyeri County). The pre-test provided knowledge on the entry level of the students before the start of the intervention so that the effects on students may be attributed to the intervention only.

Before commencing with the experiment, the experimental group E1 and control group C1 were exposed to pretesting (PPT) to determine their entry abilities. The content on cathode rays was divided into logical portions and taught during the time tabled period of three weeks. Collaborative activities such as, discussions, peer teaching and think pairs were incorporated into the teaching of the lesson content for the experimental groups. Post-test was administered to all groups. Groups E1 and C1 was exposed to pre-tests and post -tests while groups E2 and C2 was exposed to post-tests only.

5. Results and Discussions

5.1. Collaborative Teaching Strategy and Learner Achievement Based on Learner Ability in Physics

The study intended to examine the effect of Collaborative Teaching Strategy on achievement of students in Physics based on their abilities. The students were categorized as Low Ability (LA) and High Ability (HA) based on the distribution of the scores within the range of scores. The difference between the highest score (71) and lowest score (8) is the range which is equal to 63 ($71-8=63$). Low achievers (LA) were the students who scored between the lowest score (8) and the sum of the lowest score and half the range ($8+63/2=39.5$). The high achievers (HA) consisted of those with scores 39.5 and ($39.5+63/2=71$) (Deary, Strand, Smith and Fernandes, 2006). The distribution of students in the groups according to levels of performance based on learner abilities were as shown on Table 1.

			Ability		Total
			LA	HA	
Group	C1	F	14	22	36
		%	18.7	29.3	48.0
	E1	F	18	21	39
		%	24.0	28.0	52.0
Total			32	43	75
		% of Total	42.7	57.3	100.0

Table 1: Distribution of Post-Test Scores Based On Students' Abilities

Data obtained shows that out of 42.7 % representing low ability students, 18.7% were from control group C1 while 24% were from experimental group E1. Of the 57.3% representing HA students, 29.3% were from C1 while 28.0% were from experimental group. Therefore, there were slightly more high ability students in C1 than in E1. An independent sample t-test was performed to assess homogeneity in composition of the groups. The findings are expressed in Table 2

	Group	N	Mean	Df	t-value	sig	F	Std error mean
Ability	C1	36	1.6111	73	.629	.250	1.345	.08240
	E1	39	1.5385					.08087

Table 2: Independent Sample t-test Results on Post Test Based on Abilities

The Levene's test carried out on the data indicated significant differences between variances in achievement levels of students categorized as LA and HA $F(1,73) = 1.345, P=0.250$. Thus, data obtained points at heterogeneity of variance for the combination of groups relative to ability of students in experimental and control groups. However, an analysis of test results for equal variance assumed showed no significant mean difference of the mean for experimental ($M=1.5385$) and Control ($M=1.611$) groups at $t(73) = 0.629, p=0.250$.

5.2. Hypothesis Testing for Effects of Collaborative Teaching Strategy on LA and HA Students

The hypothesis, of the study sought to establish whether there exists a statistically significant difference between achievement of LA students and HA students exposed to Collaborative teaching strategy. The analysis of the effect of Collaborative Teaching Strategy on students' abilities was undertaken based on the post test results using two-way ANOVA. The results are as shown on Table 3

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	η^2
Corrected Model	4932.993 ^a	3	1644.331	14.245	.000	.376
Intercept	79194.807	1	79194.807	686.055	.000	.906
Group	2401.201	1	2401.201	20.801	.000	.227
Ability	2568.624	1	2568.624	22.252	.000	.239
Group * Ability	68.827	1	68.827	.596	.443	.008
Error	8195.887	71	115.435			
Total	100033.000	75				
Corrected Total	13128.880	74				

a. R Squared = .376 (Adjusted R Squared = .349)

Table 3: Two Way ANOVA between Strategies and Achievement Based on Students' Abilities

Results obtained showed that 37.6% of the total variance in students' achievement was accounted for by the teaching method which reflected moderate effect (Cohen, 1992) Teaching method explained more than one third of the total variance in achievement of students in the test groups. As a model, ability and groups were significant implying main effect of Collaborative Teaching Strategy and conventional methods at (1, 71)=22.252, $P<0.01$, $\eta^2 = .227$ indicating significant differences between the experimental and control groups on students' ability (HA or LA). Significant differences were observed for achievement levels of HA and LA students $F(1,71)=20.801$, $P<0.01$, $\eta^2 = .239$. However, there was no significant interaction effect between students' ability and group $F(1,71) = .596$, $P=0.443$, $\eta^2 = 0.08$ when means of HA and LA students were compared at 0.05 level of significance. The result of this test was suggestive of rejection of the null hypothesis H_{02} that there was no significant difference in students' achievement in Physics between students exposed to collaborative teaching strategy and those exposed to conventional teaching strategies based on learner ability. Table 16 shows the means of (LA and HA) students in (E1 and C1).

Ability	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
LA	27.060	1.914	23.242	30.877
HA	38.947	1.639	35.679	42.215

Table 4: Means for Low Ability and High Ability Students in Post Test

It was observed that achievement of HA students ($M=38.947$) was significantly different from that of LA students (27.060). Pair wise comparison was done at 0.05 level of significance and yielded the result shown on Table 5

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
C1	27.256	1.837	23.594	30.919
E1	38.750	1.726	35.309	42.191

Table 5: Pair Wise Comparison of Post Test

The mean for experimental group ($M=38.750$) was higher than that of the control group ($M=27.256$) implying that the collaborative strategy was more effective than the conventional strategies in teaching Physics. A univariate test was carried out to determine the comparisons among the estimated marginal means. The test yielded the results shown on Table 6

	Sum of Squares	Df	Mean Square	F	Sig.	η^2
Contrast	2401.201	1	2401.201	20.801	.000	.227
Error	8195.887	71	115.435			

Table 6: Univariate Tests Results for C1 and E1

The univariate test revealed significant differences in the means $F(1,73) = 20.81$, $P<0.001$, $\eta^2 = .227$. This result confirmed rejection of the null hypothesis H_{02} that there is no significant difference in achievement in Physics between students exposed to collaborative teaching strategy and those exposed to conventional strategies based on learner ability. A pairwise comparison between the marginal means of experimental and control groups was performed at 0.05 level of significance. Table 7 shows the comparisons.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
C1	E1	-11.494*	2.520	.000	-16.518	-6.469
E1	C1	11.494*	2.520	.000	6.469	16.518

Table 7: Pairwise Comparisons between Marginal Means for C1 and E1

The results indicate a difference in the means of experimental and control groups at 0.05 level of significance as shown by the asteriks. Table 8 shows the pairwise comparisons within ability groups.

(I) Ability	(J) Ability	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
LA	HA	-11.887*	2.520	.000	-16.912	-6.863
HA	LA	11.887*	2.520	.000	6.863	16.912

Table 8: Pairwise Comparisons within Ability Groups

The findings indicated significant mean difference among HA students and LA students at .05 level of significance for both groups. A comparison of posttest means for the LA and HA in experimental and control groups was performed at 0.05 level of significance and yielded the results shown in Table 9

Group	Ability	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
C1	LA	22.286	2.871	16.560	28.011
	HA	32.227	2.291	27.660	36.795
E1	LA	31.833	2.532	26.784	36.883
	HA	45.667	2.345	40.992	50.342

Table 9: Post Test Means for the Low Ability and High Ability

The HA students in control group registered a lower mean ($M=32.227$) compared to that of the HA students in experimental group ($M=45.667$). Similarly the LA students in control group registered a mean of 22.86 as compared to the LA students in experimental group who scored a mean of 31.833. This finding indicated that the means were significantly different at 0.05 level of significance supporting the rejection of the null hypothesis H_{02} which stated that there is no significant difference in achievement in Physics between students exposed to collaborative teaching strategy and those exposed to conventional strategies based on learner ability. Therefore, there is statistically significance difference between achievement of students exposed to collaborative strategy and those exposed to conventional strategy in Physics based on learner ability in which high ability learners in experimental group benefited more.

Descriptive data showed that there were more LA students in experimental group (24%) than in the control group (18%). Also, there were more HA students in control group (29.3%) than in experimental group (28.0%). A t- test carried out on pre-test results showed no significant mean differences between experimental and control groups therefore qualifying the subjects in the groups for comparison. The two-way ANOVA test carried out revealed significant differences between the experimental groups and control groups based on students' abilities (HA or LA) implying the main effect. The findings also revealed that 22.7% of students' achievement in Physics was attributed to by learner ability agreeing with Meenu (2016), Deary, Strand, Smith and Fernandes (2006) who found a large contribution of general mental ability to educational achievement and Cano (2007) who discussed that leaner abilities and approaches to learning are significant in predicting students' academic achievement.

The finding of the study agrees with Chieng *et al.* (2017) and Omedu and Utuh (2017) in which learners exposed to collaborative strategy in Physics gained high order cognitive abilities and Melnier *et al.* (2008) who found the use of collaborative strategy through inquiry to lead to greater confidence and reasoning gains. The current study is in line with the findings in Pinar and Filiz (2010) study in which collaborative activities were found to impact positively on students conceptual understanding and scientific process skills and Swing and Peterson (1982) study in which task-oriented interaction in collaborative groups enhanced the achievement and retention of high and low ability students. However, the findings in the current study partly agree with Kimbrough (2017) in which there was general improvement in students' achievement but students in the low ability category registered higher improvement compared to the students in middle and high ability categories. Also, the findings in the current study are partly in line with Bika and Sule (2019) study in which improvement in memory retention was registered among all learners but highest improvement was observed among high ability students. In Telman, *et al* (2013) both LA and HA students made significantly greater reasoning gains but low reasoning students made greater gains than high reasoning students in problem solving abilities.

The two-way ANOVA test result revealed no significant interaction effect between students' ability and group, meaning that the collaborative strategy was beneficial to both LA students and HA students. The findings in the current study contradict Retnowati and Ayres (2017) study in which individualized learning was more effective than collaborative teaching strategy among all ability groups. In Melnier.*et al* (2008) low ability students benefited more from collaborative

strategy than high ability student agreeing with Kimbrough (2017) who found collaborative teaching to improve achievement of low ability students although the low ability students suffered if high ability students were not present to teach them but agreed with Bika and Sule (2019). This observation implied that collaborative groups are most effective if the groups formed are heterogenous (mixed ability groups). In general, the achievement levels of students from experimental groups were significantly higher compared to those from control groups with varied magnitudes among ability groups which confirms the effectiveness of collaborative teaching strategy on achievement levels of both HA and LA students.

6. Conclusions and Recommendations

The study aimed at establishing whether the effect of Collaborative Teaching Strategy on students' achievement in Physics is based on learner ability. The results from the study revealed significant differences in achievement levels between high ability students and low ability students in experimental groups implying that learner achievement was based on learner ability when the collaborative strategy was used in instruction. The study recommends the use of collaborative strategy for enhancement of academic achievement in Physics among all ability groups.

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