Physics Practical Work and Its Influence on Students' Academic Achievement

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Abstract
In Kenyan secondary schools, form two is an important class for all students. The students choose relevant subjects to study in form three and four. Physics is compulsory at form one and two but optional thereafter. Performance in the subject at the end of the secondary school is usually dismal. Majority of students lack motivation for most activities related to the subject. Few boys and even fewer girls opt to study this subject. The teacher centered mode of study has often been reported as the culprit leading to this problem. This study investigated whether structured practical work can aid the process of learning the subject. Specifically, the study sought to find out the difference in academic achievement in physics between students taught using intensive practical activities and those taught using conventional teaching methods, mostly theoretically. The findings were analyzed ovarally and gender wise. The study involved two groups from sampled average performing secondary schools in Kakamega South Sub-County-Kenya. The quasi-experimental pre-test, post test non-equivalent group research design was adopted. The study period covered term two and three. The end of form two term one physics examination scores formed the pretest. The cumulated result on the chosen topics at the end of form two formed the post test for both groups. Two instruments were used to collect data. These are End of Term One Form Two Examination (EOTOFTE) and the Performance Test on the Chosen Topics (PTCT). Validity of the instrument was ascertained with the aid of experienced secondary school physics teachers and science education instrument construction experts. Reliability of the Performance Test on the Chosen Topics determined using Kuder Richardson KR-20 was found to be 0.95. The performance on the pre-test result was comparable for both experimental and control groups. The results of the post-test were analyzed using the t-test, Analysis of Variance and Chi-Square. Experimental group recorded better performance than the control group. The study helped in determining the value of experimentation in physics instruction. It is hoped to help shape policy on the nature and quality of practical work to be encouraged in secondary school physics instruction. The study was aimed at contributing towards realization of needs to resolve problems w 3q2 1`inherent in physics reflected in the poor performance in the subject. The findings are formed on the basis of dynamic and creative instructional strategies since good learner's intelligence and skills can be expressed if better instructional methods are in place.
Keywords: Science Concept, Science instruction, Science Process skills, Practical Work, Average Performing Schools.

The Background

Science is an integral part of everyone's life. Scientific knowledge and skills provide practical assistance in helping people make informed decisions and choices concerning life that best suit them (Hirschfeld, 2012). Physics generates fundamental knowledge needed for future technological advances that will continue to drive the economic engines of the world (Amunga, et al. 2011, Nashon, 1989). It contributes to the technological infrastructure and provides trained personnel needed to take advantage of scientific advances and discoveries (Kuhn et. al, 2012; Freeman, 2012). All school systems have provision for studying physics.

The usual physics teaching method in Kenyan schools is the lecture. This technique has not been found to be effective for science instruction since performance in the subject has continued to be low (Toplis et. al, 2012). The traditional lecture method produces little or no change in most students' understanding of how the physical world works (Capanis, et al. 2010, Garwin et al, 2003). This method has been reported to work for about ten percent of the students (Gekelman et al, 2011). These are mostly self motivated students who would essentially have learnt the subject on their own. Listening to lectures is not efficient way to learn any subject. Learners should be active in creating and widening their knowledge since.

Thomton (1990) and Tamir (1991) have shown that even teachers who are good at lecturing still have only limited success in helping students make sense of physics using this technique. Even in the traditional class with a large number of students, Thomton and Tamir have recommended that students should be more engaged than is possible during the lecture. Asking theoretical questions, asking them to think about something the teacher has said; telling them to make predictions, having them work out something in their notebooks or even doing lots of demonstrations, does not seem to have much effect. Something more structured as hands – on, minds – on seems to be required. This would involve the students to give explained responses that are collected and paid attention to (Sadiq, 2003; Salim, 2011). Science should be seen as a subject that stimulates student's curiosity, inquiring minds and that requires students to solve problems. The practical nature of the subject leads to teamwork and acquisition of manipulative skills of the subject. It also promotes observational, deductive and evaluative skills (Rawer, 1993).

The fact that science is about learning about the real world, knowledge of how things work suggests that students' knowledge should be applied to real life situations (Sadiq, 2003, Lunetta, et al. 2007) . Hence it is not surprising that policy makers put much of the blame on science teachers for the lack of creativity and practical applications by the students. Practical work involves learning through selected contexts that promote students' motivation and engagement as a result of relevant learning episodes drawn from everyday experiences and phenomena (TIMSS, 1995; Stanley, 2000). Practical work provides students with opportunities for understanding and manipulating the complex and abstract nature of science in inducing effective conceptual change (Daramola, 1987). Practical work helps diagnose and remediate students' misconceptions. It motivates and interests students in science (Nashon, 1989). As a result practical work endears the learners to confirming and gathering new insight into scientific knowledge. They take charge of their own ability to investigate and question nature (Hirschfeld, 2012). This study investigated how practical work can help in learning physics and getting more students to get interested in the subject at secondary school.

Statement of the Problem

The performance of the physics for girls is below that of the boys. This is compounded by issues of low interest and poor motivation to study the subject. The rising problem of students' poor performance in secondary school physics in the sub-county needs to be addressed urgently for more students to play an important role in achieving goals of Kenya's Vision 2030. These require concerted effort from all gender in order to improve the country's technological standing in the creation of social, technological and industrial transformation. For the students to attain their full potential and to contribute meaningfully in the country's technological and scientific development, studies that can foster students' interest in physics using appropriate instructional technologies are desirable. This study investigated practical work in physics as a central instructional technique that can influence the students' performance in physics. It contrasted the effect of practical based instruction and theoretical treatment on achievement.

Objectives of the Study

(i) To find out if there is an overall difference in academic achievement by students taught using intensive practical activities compared to those taught using conventional teaching methods.
(ii) To find out if there is a gender difference in academic achievement by students taught using intensive practical activities compared to those taught using conventional teaching methods.

Research Design

The study was conducted through quasi-experimental design having pre-test, post-test non equivalent group. After the pre-test, the experimental group was taught physics by intensive practical activities while the control group was taught by conventional teaching methods. This design was chosen because the mode of assigning participants involved non equivalent whole class groups. The class sizes were not equivalent.

Sample Size

Out of nineteen average performing mixed secondary schools with form two student population of 1,098 in the divisions that form the Sub-County, ten schools were selected and used in the study. Each school had one group, either experimental or control group. This made a total of 450 students as shown in the table 1 below.

Table 1: Sample Size.

Division	School in the Division	Number of Schools Selected	Number of Students Per Group		Total
			Experimental	Control	
U	4	2	52	39	91
W	5	3	49	68	117
X	2	1	25	17	42
Y	4	2	53	41	94
Z	4	2	56	50	106
Total	19	10	235	215	450

Out of the 450 respondents, 235 formed the experimental group and 215 formed the control group.

Methodology

End of Term One Form Two Examination (EOTOFTE) formed the pre-test that was taken by both experimental and control groups. This was a standard examination which was administered to all the subjects at the end term one of form two. This pre-test helped in determining the entry performance for both the groups. The pre-test covered the whole of form one and form two term one physics syllabus. The topics involved include introduction to physics, measurement I, force, pressure, particulate nature of matter and thermal expansion. It also contained heat transfer, rectilinear propagation of light, electrostatics, cells and simple circuits, magnetism and measurement II. The concepts in these topics are best learnt through practical work.

The experimental group was then taught by intensive practical activities. After every practical there was a class interaction and discussion led by the teacher. Data collection, data manipulation and data analysis as experimental procedure were applied before writing a an experimental report by the respondents. The control group was taught by conventional teaching methods. This majorly included theoretical lecture without much of practical activities. Demonstrations by the teachers were mostly used to show the aspects of the practical in the control group.

Performance Test on the Chosen Topics (PTCT) was then administered at the end of the study. The total score was evaluated from cummulation of specific tests generated from selected three topics. These topics include Turning Effect of a Force, Reflection at Curved Surfaces and Magnetic Effect of an Electric Current. The tests were administered at the end of every selected topic. The same tests were given to all students in the selected study schools.

Results and Discussion

Analysis of the pre-test results showed that the difference in mean scores between experimental and control groups was dismal (0.3). The mean score of the experimental group was slightly above that of control group. The post test results show that experimental group performed better than their counterpart control group by having a higher mean gain of 26.0 compared to 2.8 respectively. Table 2 below indicates the results of experimental and control groups on the pre-test and post tests.

Table 2: Overal Results for Experimental and Control Groups on Pre-test and Post-test.

Group	Pre-test Mean	Post test Mean	Mean Gain
Experimental	27.0	53.0	26.0
Control	26.7	29.5	2.8

Global Comparison of Post test Results

The post test results for both experimental and control groups were compiled and expressed in terms of mean scores and standard deviation. The t-test was used to determine significance of difference of the means from the groups. Table 3 shows the post test results in terms of means, standard deviations and t-test.

Table 3: Global Comparative Post test Results for Experimental group and Control Group.

Group	Mean Score	Standard Deviation	t-test
Experimental	53.0	7.9	
Control	29.5	9.5	3.14

$$\alpha = 0.05; \ |t| > 1.93$$

From table 3 the mean score for experimental group was 53.0. The mean score for control group was 29.5. The t-test value was 3.14; this was greater than the tabulated t-value (1.93). This indicates that the control group and experimental group performance were significantly different from each other. The standard deviation for experimental group was 7.9 and that of control group was 9.5. This indicates that the experimental group had converged more in their understanding of the topics compared to the control group who still had a large spread in their understanding.

Gender Consideration for Post test Performance

Both mean scores and standard deviations were used to compare experimental group and control group in terms of gender. This was represented in table 4 below.

Table 4: Gender Comparison for Post test Performance Results

Group	Boys		Girls	
	Mean Score	Standard Deviation	Mean Score	Standard Deviation
Experimental	55.9	9.4	48.8	9.0
Control	28.6	10.7	29.5	9.7

The leading group was experimental with higher mean score of 55.9 and 48.8 for boys and girls respectively. The control group had lower mean scores of 28.6 and 29.5 for boys and girls respectively. The standard deviations for boys were 9.4 and 10.7 in experimental group and control group respectively. The standard deviations for girls were 9.0 and 9.7 in experimental group and control group respectively. The spread shows that the two groups were statistically different. The mean score in experimental groups was larger than that of control groups showing that the instructional method used in teaching experimental group was more effective than that used in the control group. In both groups the mean scores for boys were higher than that of the girls. This shows that boys grasp physics concepts better than their counterpart girls.

To provide a clear picture about effectiveness of intensive practical activities in teaching and learning physics over conventional methods a one way ANOVA was performed on the post test results. Application of the ANOVA test provided the results in table 5 below.

Table 5: Analysis of Variance of the Post test Scores on Performance

	Sum of Square	Df	Mean Square	F	Sig.
Between Groups	4672.38	43.00	108.66	4.21	0.016
Within Groups	4754.75	175	27.17		
Total	9427.13	218			

Significant at $P<0.05$; Critical Value = 2.65

The results in table 5 indicates that the F-Value of 4.21 exceeds the critical value of 2.65 at $\alpha = 0.05$. This shows that both experimental group and control group were statistically different at post test. The p-value(0.016) was also less than α -value (0.05).

Discussion of findings

The results from the current research concur with KNEC (2013) which determined that in the national examinations, those students who performed well in practical work also performed well in the final physics examination. Uwaifo (2012) found a statistically significant relationship between theory and practical scores on all science subjects. A similar correlation was also found between understanding science subjects and practical work which lead to improvement in achievement tests (Wasanga, 2009). Practical work makes the students take science learning seriously as demonstrated by Amunga, et al (2011). The determination to meet physics objectives requirements of practical task leads the student to take charge of the learning situation and develop an insight in the requirements of the task involved. Lunetta et al (2007) suggested that engaging in science practical work provides simulation experiences which situate students' learning in states of inquiry which needs high mental and physical engagement.

Gender-wise practical activities have been found to benefit girls tremendously (Amadalo et al, 2012). The performance in physics achievement tests for the girls improved when practical work was incorporated in the teaching retinue of the girls. Benson and Nkiruka (2013), Nduru (2014) and Abungu et al (2014) have also found similar results when working with girls in Nigerian and Kenyan girls secondary schools respectively.

Conclusions

1. From the study first it was found out those intensive practical activities have a positive influence on student's achievements in physics. It improves physics academic performance of the learner. This can be achieved if the learners are fully involved in the practical learning process. This was confirmed from post-test results in both experimental and control group. At the beginning of the study respondents from both groups scored low grades. By the end of the study experimental group improved by more than half while the control group improved by less than a tenth. Boys performed better than girls both in the two tests.
2. There was a bigger improvement within experiment group for boys than for the girls. Therefore there was magnified difference in achievement by students taught using intensive practical activities.

Suggestion for further research

1. The study to be repeated based on expanded sample of schools in the county, regional and national

categories in secondary schools.

2. With technological advancement similar research to be carried out by involving learners in physics learning practical through electronic work bench.
3. A similar study should be done in other classes in secondary school physics.
4. A similar study should be carried out in other science subjects in the secondary school.

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