

EFFECT OF PRACTICAL WORK IN PHYSICS ON THE STUDENTS' PERFORMANCE IN PHYSICS

Augustine N. Muchai
Murang'a University College
ngetheaugustine@yahoo.com

Nicholas W. Twoli
Kenyatta University
nicholastwoli@yahoo.com

Science knowledge and skills are being regarded as very important in national development. Physics as one of the science subjects is useful in developing the upcoming engineers and medical doctors for any nation. An important component of the knowledge in these professions are skills which are acquired mainly through practical situations. This study explored the effect of practical work in physics among secondary school students in central part of Kenya. A quasi-experimental design was applied in the study. The experimental group was taught using a practical approach for one term while the control group followed the conventional or traditional approach. A pre-test was given to both groups at the start to determine their equivalence in ability. After the 12 weeks, a post – test, which was a physics achievements test, was administered to both groups. The results revealed that there was a significant difference in performance between the control and the experimental group, with the experimental group performing a lot better ($\bar{x} = 30.70$) than the control group ($\bar{x} = 27.25$). The results were significant at ($\bar{x} = 0.05$) level. This outcome showed that practical approach does reinforce the understanding of concepts in physics and thus boosts achievement.

Keywords: Practical, Physics, Performance, Student

Introduction

Physics is a core subject in science and technology since it enlightens the essence of natural phenomena and helps people to understand the rapidly technological changing society (Zhaoyao, 2002; Juceviciene & Karenauskaita, 2004). Despite the importance of physics in the scientific and technological development, it appears physics education has been facing various challenges. First, the enrolment in Physics courses at all levels is low in many African countries (Amunga et al., 2011a). Many reasons are advanced for this discrepancy which include inadequate lower level preparations, weak mathematics background, limited resources lack of job opportunities outside the teaching profession, inadequate teacher qualification as well as possession of below standard pedagogical content knowledge (Semela, 2010).

Boyo (2010) viewed Physics as a course of study that is perceived to be experimental and that almost all aspect of life science, both living and non-living has something to do with Physics, ranging from Engineering to Mathematics, Biology and Chemistry. The understanding of practical Physics may help students to accommodate Physics concepts. According to Pohl, a German Physicist, Physics is a science based on experiences and whose facts are found (Michael & Klaus-Peter, 2012). Practical work may be considered as engaging the learner in observing or manipulating real or virtual objects and materials (Millar, 2004). Practical knowledge, according to James (2000), refers to that knowledge that is connected with reality rather than ideas and theories. It is the knowledge acquired through the practical approaches that assist one to carrying out scientific investigation and teaching. Appropriate practical work enhances learners' experience, understanding, skills and enjoyment of science. Practical work enables the students to think and act in a scientific manner. Practical work of a more open-ended, investigative kind can develop students' tacit knowledge of scientific enquiry (Millar, (2004). The scientific method is thus of great importance in acquiring knowledge. Laboratory investigation holds significant promise for being able to support conceptual and epistemological learning when favorable conditions are put in place for students (Bell, 2005). Thus, the laboratory has been given a central and distinctive role in

science education, and this explains why science educators have suggested that rich benefits in learning accrue from using Laboratory activities (Hofstein & Lunetta, 2004). Laboratory experiences have been purported to promote central science education goals including the enhancement of students' understanding of concepts in science and its applications; scientific practical skills and problem solving abilities; scientific 'habits of mind'; understanding of how science and scientists work; interest and motivation (Hofstein & Mamlok-Naaman, 2007).

This then means that learning Physics is incomplete without the acquisition of practical skills in Physics. Physics, according to Ndupu & Okeke (2007), is a practical subject and every scientific discovery has been made as a result of experimental investigation. If students are to understand the theoretical aspect of Physics taught in the classroom to help to translate to real life situations, they must master the techniques of practical Physics. Research has shown that the effect of demonstration makes a significant contribution to general and conceptual understanding of the concepts of Physics in cases when students make hypotheses and discuss them, when they create experiments, verify their hypothesis and make conclusions (Svedružić, 2008). The importance of Physics was made the ministry of education to make it a compulsory subject for all students at Form One and Form Two in Kenyan Secondary schools. At the end of Form Two, they have to make a choice; to continue with the subject or drop out. The enrolment at after a compulsory state is low and one reason for this is that physics performance is poor. Several studies have been done to address the problem. Several interventions have been put in place to address the identified challenges. They include in servicing of Physics teachers through SMASSE, provision of teaching resources through KESSEP, campaigns on the importance of Physics (Nderitu, 2009), which have not been satisfactory. This explains the importance to come up with this study.

Methodology

The study adapted a quasi-experimental pre-test post-test design. It involved four schools in two categories: A and B. there were two schools from category one and two in category B. Each category had one experimental and one control group. The experimental groups were taught using the practical approach, while the control groups were taught using the conventional method of teaching. This was done for one full term of three months. Then the post-test questionnaires were administered and the results analyzed. The rubrics for the design are presented in Table 2.1.

Table 2.1 Designs for the Study

Experimental group	R	O₁	X	O₃
Control group	R	O ₂	⊙	O ₄

Where X = Treatment and ⊙ = No treatment

- O₁ pre-test result for the experimental group
- O₂ pre-test result for the control group
- Q₃ post-test result for the experimental group
- O₄ post-test for the control group

The study was located in secondary schools of Murang'a East Sub-County. The district has 28 secondary schools. The district was chosen due to the low enrolments in Physics and also the low students' achievement in the subject in KCSE. The target population was the

secondary school students in Murang'a East Sub-County. The unit of analysis was the Form Two students in secondary schools. A list obtained from the County Education Office indicate that the district has 28 secondary schools which are categorized as follows: (a) Two private schools, (b) one national school, (c) one County school, (d) one extra county school, and (d) twenty three day schools.

Sample and Sampling Procedures

Purposive sampling was used to select the study sample. This was to ensure that the prerequisite skills and the knowledge level of the students in Physics is almost the same. Also one of the key resource that was required for practical work as a method of instruction is availability of a relatively functional laboratory with basic laboratory fittings. The sample was drawn from the District schools' category. This was because of low enrolments and achievement in Physics. Stratified sampling technique was used to select the sample. The District schools were classified into two; those with a mean score of between 4-5 and those with a MSS of below 4 in the 2012 KCSE results. From each stratum, two schools were purposively chosen totaling to a sample size of four schools. Sampled schools were far from each other to minimize interaction. In addition, they had the same MSS score per the KCSE results of 2012. They also had the same characteristics in terms of entry behavior and infrastructure. This ensured homogeneity of the sampled schools. They were also mixed secondary schools (boys & girls) so as to capture the gender component. One school from each category formed the experimental group while the other the control group.

Research Instruments

There were two instruments used in this study, the pre-test and the post-test. Pre-test was used to measure the performance of the learners in Physics of both the experimental and the control group before the treatment was administered. This aimed at ensuring that, both groups were of relative same ability in performance in Physics. The achievement was composed of 10 open-ended questions, which took 40 minutes.

Post-test used Students Achievement Test (SAT) that was administered to both control and experimental students in a staggered manner throughout the term. Specific tests evaluating the work done in each topic was given at the end of the topic. These was graded and eventually compiled at the end of the term.

A pilot study was undertaken for purposes of validation and testing the reliability of the research instruments that were used. Two district schools in the neighboring Kirinyaga County were purposively chosen for piloting so as to capture the key characteristics of the study. The pilot study helped to identify and rectify the mistakes in set questions. It also helped to determine the suitability and the appropriateness of the language used in both pre-test and post-test. It also helped in making any adjustment to the practical set up and write-ups. The test items were constructed using the Form Two syllabuses were adopted from KNEC past papers. The reliability of the assessment tests was determined using the split-half method. Correlation between the two halves was determined, using Specimen – brown prophecy formula to estimate the reliability of the whole test. The Specimen–brown prophecy formula adopted from Elsinga et al (2012) was used.

$$PXX^{11} = \frac{2p_{xx}^1}{1 + p_{xx}^1}$$

Where PXX^{11} is the reliability co-efficient for the whole test and PXX^1 is the split half correlation. A value of 0.7 and above was considered reliable. A reliability coefficient of 0.83 and 0.87 were obtained for the Pre-test and posttest tests respectively.

Data Collection Methods and Procedures

At the beginning of the term school the four groups were given a standard achievement test that served as a pre-test. This pre-test was based on Form One Physics syllabus. The results from this test were analyzed to ascertain the relative performance levels of both the

experimental and the control groups. At the beginning of the study, the teachers who were involved with experimental group in the study underwent training exercise to familiarize themselves with the practical approach to be used. The students were taught using the practical approach for the experimental group and the conventional method for the control group for a period of one term. The topics were selected from the syllabuses as stipulated by Kenya Institute of Curriculum Development.

During the term the teachers were oriented on how to use the practical approach in their teaching method. The experimental group instructional technique emphasized practical work when teaching the topics. During the practical activity the students were actively involved in setting the equipment and apparatus used in the laboratory. After each experiment, there was an intensive class interaction. Experimental procedure, data collection, manipulation and analysis procedures were reviewed in the class before the students were required to complete writing the laboratory report. The students’ achievement tests (SAT) were administered to the respondents in a staggered manner throughout the term. Specific tests evaluating the work done in each topic was given out at the end of each topic. This formed the post-test scores.

The data obtained from both pre and posttests were analyzed using descriptive and inferential statistics. This involved the use central tendency (mean, variance and standard deviation). To determine whether there were significant differences between the control and experimental groups, in terms of performance in the pre-test and posttests and between groups, a t-test was computed. The results were tested at a significance level $\alpha = .05$.

Results and Discussion

Demographic Characteristics

The study ensured the gender distribution of the students (Table 1). For the purpose of this study the schools were categorized into two groups A and B. Groups A were those schools with a MSS of between 4-5 and group B schools with a MSS of below 4 in the 2012 KCSE results. From each stratum two schools were purposively sampled totaling to four schools.

Table 1: Gender Distribution of the Respondents

School		Female	Male	Total
Experimental A	N	24	21	45
	%	12.8	11.2	23.9
Control A	N	29	19	48
	%	15.4	10.1	25.5
Experimental B	N	26	20	46
	%	13.8	10.6	24.5
Control B	N	26	23	49
	%	13.8	12.2	26.1
Total	N	105	83	188
	%	55.9	44.1	100

The majority 105 (55.9%) of the respondents were females while 83 (44.1%) were males. This shows some gender disparity. Majority of the mixed day and boarding schools from which the sample was drawn have more girls than boys (Murang’a County Education Office, 2014). This ratio seems to favor the lower classes but is a different matter at higher levels.

Effects of Practical Work in Physics on Student’s Performance in Physics

In order to establish the effects of practical work in Physics on student’s performance in Physics, the respondents group was first subjected to a pre-test Physics achievement test followed by treatment for the experimental groups and the post-test was administered. This section presents the student’s performance of each of these tests. The results of the students’ performance in the pre-test are presented in table 2.

Table 2: Mean Scores of the Pre-Test per Group

Group (School)	N	Mean (\bar{x})	Std Deviation (SD)
Experimental A	45	27.73	7.817
Control A	48	27.17	5.513
Experimental B	46	25.24	8.239
Control B	49	25.31	7.177
Total	188	26.35	7.266

Table 2 shows that the experimental school A, (mean = 27.73) SD = 7.817) performed better than control school A (mean = 27.17 SD = 5.513) while control school B (mean = 25.31, SD =7.177) performed better than the experimental school B. In additional school set A performed better than school set B because set A had a higher entry behavior than set B. An independent t-test was then computed to determine if there were any significant differences in each set. The results are presented in table 3.

Table 3: Comparison of Mean Scores of Control and Experimental School

School	t-test				Sig (2-tailed)
	N	(\bar{x})	t	df	
Experimental A	45	27.73	4.06	91	.686
Control A	48	27.17			

Table 3 shows an independent t-test consulted $t(91) = 4.06, \rho = .686, \alpha = .05$ revealed that there is no significant mean difference between experimental and control schools in set A in the performance of the pre-test. An independent t-test was also conducted for the schools set B. The results are presented in table 4.

Table 4: Comparison of Mean Scores of Control and Experimental School

School	t-test for Equality of Mean				
	N	(\bar{x})	t	df	Sig (2-tailed)
Experimental B	46	25.24	.042	93	.966
Control B	49	25.31			

The results show an independent t-test conducted, $t(93) = .042, \rho = .966, \alpha = .05$ and revealed that there is no significant mean difference between the experimental and control schools in set B in the performance of pre-test. This means that the study started off with equivalent groups that are an important requirement for the study.

The experimental group was then exposed to practical approach method of teaching for 12 weeks while the control groups were taught using the conventional or traditional methods. After exposure the post-test was administered. The results are presented in table 5

Table 5: Students Performance in the Post-Test

School	N	(\bar{x})	(SD)
Experimental A	45	34.60	9.521
Control A	48	27.25	5.526
Experimental B	46	30.70	7.586
Control B	49	27.04	6.377
Total	188	29.08	7.918

The results show that the experimental group performed better than the control group in the post – test. The table shows that the experimental school A (\bar{x} = 34.60 SD = 9.521) performed better than the control school A (\bar{x} = 27.25 SD = 5.526). In addition, experimental school B (\bar{x} = 30.70 SD = 7.586) performed better than the control school B (\bar{x} = 27.04 SD = 6.377). An independent t-test was then computed to determine if there was any mean significant difference between the control and experimental groups from each set of school.

The study concluded that the students' exposed to practical work in Physics performed better than those taught through conventional method. These results are supported by a number of researchers. Wasanga (2009) also found a similar correlation between practical work and understanding of science subjects which leads to improved performance in achievement tests. Amunga et al (2011a) have demonstrated that practical work makes the students take learning science better. The determination to unravel the requirements of the objectives of the practical task leads the learners to take charge of the learning situation and to develop an insight in the challenges of the tasks involved in the practical work.

Lunetta et al (2007) have suggested that engaging in scientific practical work provides simulation experiences which situate students learning in states of inquiry that require heightened mental and physical engagement. This engagement leads to better understanding and improved performance. However, Hodson (1991) casts cautionary aspersions on the relationship between practical work and performance in secondary schools.

The current study also agrees with Freeman (2007) who found out that girls who had taken part in laboratory work intervention improved their Science achievement compared with the girls who had received traditional teaching with no or little laboratory component. The study reports that laboratory work demanded active participation by all students, and it was this participation that was responsible for the girls' higher achievements scores. These results concur with the findings of Wachanga, (2002b) in his study on effects of cooperative class experiment teaching method that boys and girls performed equally well when exposed to this instructional strategy. According to Millican, Richards and Mann (2005) physics is an experimental subject. General principles and concepts are more easily understood if they are demonstrated in the laboratory. Laws and relationships are more fully appreciated if the student investigates and verifies them at the laboratory bench.

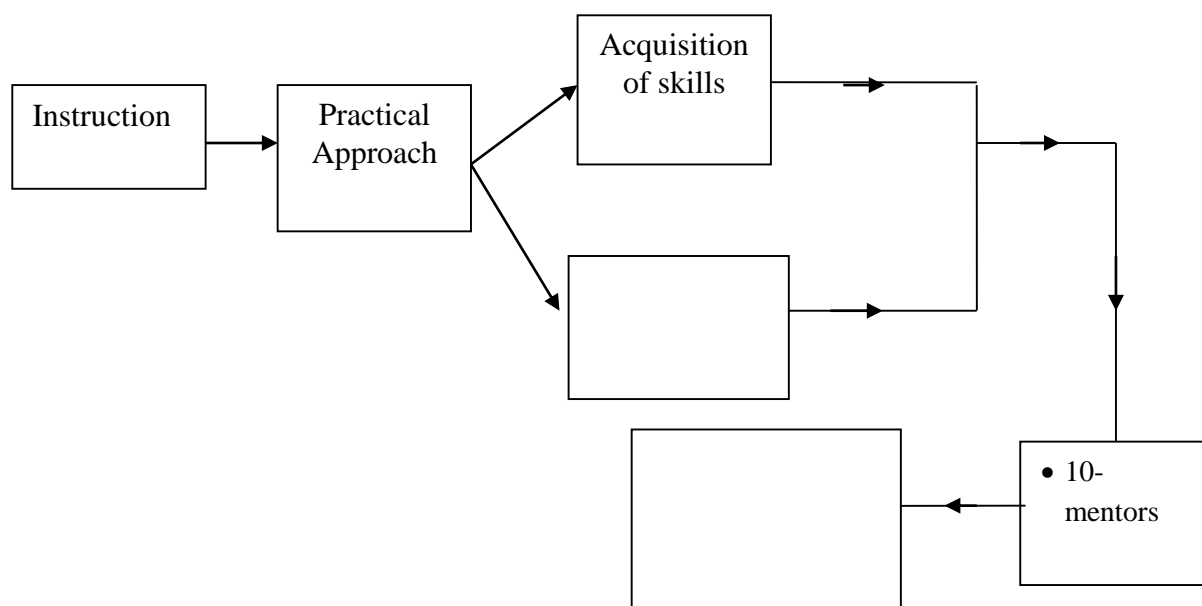
Table 6: Independent t-Test for the Post-Tests

Set	School	n	T-Test For Equality of Mean			Sig (2-tailed)
			(\bar{x})	t	df	
A	Experimental A	45	34.60	4.588	91	.000
	Control A	48	27.25			
B	Experimental B	46	30.70	2.548	93	.012
	Control B	49	27.04			

The post-test was subjected to t-test for further analysis. Table 6 shows that there was a significant mean difference between experimental school A (\bar{x} =34.60) and control school A (\bar{x} =27.25), $t(91) = 4.588$, $p = .0001$, $\alpha = .05$. In addition there was a significant mean difference between the experimental school B (\bar{x} =30.70) and Control B (\bar{x} =27.04), $t(93) = 2.548$, $p = .012$, $\alpha = .05$.

Conclusion

The study concluded that the students’ exposed to practical work in Physics performed better than those taught through conventional method. This can be explained using the following model.



The study shows that practical approach in teaching physics brings a lot of benefits to learners. First it gives opportunity to learners to acquire scientific skills that can include a range of process skills. It has been noted that such skills support learning in science. The other benefit is that practical approach reinforces or clarifies a number of concepts in physics. The resultant of these contributions is improved performance in the subject and a good performance is likely to lead to a higher enrolment of students. This is a picture that many science education stakeholders would welcome.

The study ends with a general recommendation that teachers of physics and science in general should be encouraged by their schools and ministry to emphasize practical approach in their instruction. This is only possible if teachers are facilitated in terms of resources and running in-service courses.

References

- Amunga, J. K., Musasia, M. A., & Musera, G. (2011). Disparities in the Physics Achievement and Enrolment in Secondary Schools in Western Province: Implications for Strategy and Renewal, *Problems of Education in the 21st Century*, 31(31), 18-32, ISSN: 1822- 7864.
- Australia: ASEE/AaeE.
- Bell, P. (2005). *The school science laboratory: Considerations of learning, technology, and scientific practice*. Paper prepared for the National Academies Board on Science Education, High School Labs Study Committee. Available:http://www.nationalacademies.org/bose/High_School_Labs_Presentation_P_Bell.html.
- Boyo, A. (2010). *Identifying Problems Associated with Studying of Physics in Lagos State, Nigeria*. Retrieved on 2nd September, from http://www.wcpsd.org/posters/education/Boyo_Adenike_1.pdf
- Freeman, M. P. (2007). The Influence of Laboratory Instruction of Science Achievement and Attitude towards Science across Gender Difference. *Journal of Women and Minorities in Science and Engineering*, 8, 191-200.
- Hodson, D. (1991). Practical work in science: time for a reappraisal, *Studies in Science Education*, 19, 175—184.
- Hofstein, A. & Lunetta, V. (2004). *The laboratory in science education: Foundations for the Twenty-First century*. Science Education, 88, 28–54.
- Hofstein, A., & Mamlok-Naaman, R. (2007).The laboratory in science education: The state of the art. *Chemistry Education Research and Practice*, 8: 105–107.
- Juceviciene, P., & Karenauskaite, V. (2004). *Learning environment in Physics: the context of double paradigm shift*, Paper presented at the European Conference on Educational Research, University of Crete, 22-25 September.
- Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). *Learning and Teaching in the School Science Laboratory: An Analysis of Research, Theory, and Practice*. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 393–441). New York & London: Routledge.
- Michael, V., & Möllmann, K. (2012). Low cost hands-on experiments for Physics teaching. *Latin-American Journal of Physics Education*, Vol. 6(1):3-9.
- Millar, R. (2004, June 3). The role of practical work in the teaching and learning of science. Paper presented at the “*High School Science Laboratories: Role and Vision*” Meeting, Board on Science Education, National Academy of Sciences. Washington DC.
- Millican, G., Richards, P., & Mann, L. (2005). *The engineering link project: Learning about engineering by becoming an engineer*. In Radcliffe, D. and Humpries, J. (Eds.), *Proceedings of the 2005 ASEE/AaeE 4th Global colloquim*. Sydney,
- Nderitu, M. K. (2009). *Determinants of Enrolment and Performance in Physics in Selected Secondary Schools in Murang’a District Kenya*. Unpublished Master of Education Kenyatta University .Nairobi.
- Semela, T. (2010). Who is joining Physics and why? Factors influencing the choice of Physics among Ethiopian university Students, *International Journal of Environmental & Science Education*, 5(3), 319-340.
- Svedružić, A. (2008). *Demonstration in teaching Physics*. *Metodika*, 17(2): 442-450.