Effect of Practical Work in Physics on Girls' Performance, Attitude change and Skills acquisition in the form two-form three Secondary Schools' transition in Kenya

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Abstract

The form two-form three transition period is important for Kenyan secondary school students who wish to pursue Physics at senior secondary school. The subject enables the students to participate in technology related studies in tertiary institutions. Many students opt out of physics at the end form two. The national enrollment at form three show that Physics is least studied science subject at this level. The number of girls pursuing the subject is even smaller. It has continued to dwindle with time compared to their male counterparts. Additionally, the performance in the subject at the end of secondary school is dismal. Most students lack motivation for engaging in activities related to physics. Few if any useful science process skills are effectively learnt. This study identified practical work as an influencing agent in the process of learning physics. By enabling the girls to carry out practical investigations, theoretical implications are clarified. The study involved two groups of girls from three sampled medium performing schools in Western Kenya. The experimental group was exposed to intensive practical work. The control group was conventionally taught the same content. A performance test of reliability index, $r_{xy} = 0.879$ *was administered to both groups at the end of form two. Comparison in terms of achievement on the test, attitude developed towards physics, science process skills learnt, and relative choice to pursue the subject in form three for the two groups was made. The experimental group outperformed the control group on all the research objectives.*

Key Terms: Practical work, performance in physics, attitude change, science process skills acquisition, form two-form three transition.

Introduction

Science has been viewed as an instrument that can aid development in many countries. It plays important and dominant roles in spearheading technological advancement, promoting national wealth, improving health, and accelerating industrialization (Validya, 2003). During the twentieth century, science through agricultural research ensured food security through the green, white and yellow revolutions.

Aided by genetic engineering, use of artificial fertilizers, and carefully executed irrigation systems, many developing countries benefitted (Holt-Giménez, 2008). Sufficiency was ensured in cereals, wheat, leguminous plant seed, milk and dairy products outputs (Sreedharan, 2011). This ability to feed mankind happened despite acquired longevity due to breakthroughs in medical care. This food security has not been enjoyed by many sub-Saharan African countries (Borlaug, 2000). Among the sciences, physics is considered a fundamental subject (Wenham et al, 1984). It imbues learners with systematic thinking and supplies the theories necessary for understanding the mechanics of how the things mankind relies on work. It provides students with analytical, problem solving and quantitative skills which are important for many sciences. Physics prepares students to synthesize and analyze data and to present their findings in understandable formats. Systematization of the scientific problem solving technique is employed. The link between physics and other sciences is profound. It continues to expand tremendously in the contemporary world.

All technology is beholden to physics due to its emphasis on addressing phenomena involving the interaction of matter and energy. This interaction is necessary for the technological needs of the changing society (Juceviciene and Karenauskaite, 2004; Zhaoyao, 2002). Physics continues to influence applications in medicine. Medical methods including imaging techniques (X-rays, CT-scanning, ultra-sound echo techniques, MRI techniques) and diagnostic patient screening techniques (Freeman, 2012) are based on physics principles. Currently, a wide variety of treatment techniques made possible by the discovery of radioactivity and other high frequency radiations exist. The unraveling of the DNA structure and the subsequent genome project required a significant input from physics techniques (Stanley, 2000). Continuing research into challenges posed by diseases such as cancer, Ebola, and HIV/AIDS, will require the development of high precision equipment employing physics principles. The current fixation with information communication technologies (ICTs) could not have occurred without the primal physics discovery of the transistor. Computers, mobile phones and their attendant spin-off technologies show the indispensability of physics. Photonics and other quantum nanostructures show promise in terms of optical fiber based communication systems (Sharma et al, 2010). Laser applications are used in commerce and industry. Electromagnetism is vital in the generation of electricity, mobile phone communication, optical and satellite communication, portable electronics, radio and radar perception, and X-ray crystallography (Campbell, 2006).

However, physics education has been undergoing a crisis. Enrolment in physics courses at all levels is low in many African countries. Reasons for this range from: inadequate lower level preparation, weak mathematics background, lack of job opportunity outside the teaching profession, inadequate teacher qualification as well as possession of below standard pedagogical content knowledge (Semela, 2010). Many students consider physics as difficult, abstract and theoretical (House of Lords, 2006). The subject is considered devoid of applications in the day to day life. Many students find the subject boring, unenjoyable (Hirschfeld, 2012). Interest in high school physics is decreasing, learning motivation is declining, and the examination results are getting worse (Garwin & Ramsier, 2003; Manogue & Krane, 2003). In many school settings, little time is allotted for the discipline compared to language and mathematics, the other important subjects (Tesfaye & White, 2012; UNESCO, 2010).

In Kenya, few students choose to pursue the subject during the last two years of secondary school (Oriahi et al, 2010; Wambugu & Changeiywo, 2008). Teaching is geared around memorization of basic concepts and their reproduction in the examinations (Sadiq, 2003). The students who enroll for the subject resort to cramming definitions and formulae. Consequently it is difficult for even the high achievers to apply what they have learnt in novel situations. Usually the performance in physics is among the worst among all the subjects at the school leaving level (KNEC, 2003, 2006). The problem of low enrollment and poor performance is particularly noticeable amongst the girls in Kenyan secondary schools (Amunga et al, 2011a; Wasanga, 2009). It locks the girls out from participating in careers that are physics based. The girls form a significant composition of all secondary school going students. This trend of opting out of physics influenced technology is worrying given Kenya's emphasis on the achievement of Vision 2030 (Amunga et al, 2011b). Strategically, the demand for physics should be growing due to its strong influence on technology programs at university and other tertiary institutions of learning.

The low enrollment in upper secondary school physics has been linked to a shortage of inspirational and well trained physics teachers, inadequate laboratory facilities and the accompanying limited exposure to practical instruction at junior secondary school level (Daramola, 1987). The science teachers are mainly trained in theoretical content aspects.

Training in handling physics practical lessons has been ineffective in many developing countries including Kenya. Training in conducting school type science experiments is completely ignored in many university teacher training curricula. Many, if not all the Kenyan university trained Bachelor of Education (Science) graduates lack the skills of handling high school type practical work. There are no school-type laboratories set aside for this exercise in the various Kenyan universities that train teachers (Masingila & Gathumbi, 2012). Being a science subject, effectiveness of teaching physics should be judged by the kind of practical activities that teachers and students engage in (Oyoo, 2004). The consequence is that the physics teachers lack the skills for effectively guiding learners in conducting laboratory work. The attendant advantages of performing practical work are lost on the learners.

Practical work may be considered as engaging the learner in observing or manipulating real or virtual objects and materials (Millar, 2004). Appropriate practical work enhances pupils' experience, understanding, skills and enjoyment of science. Practical work enables the students to think and act in a scientific manner. The scientific method is thus emphasized. Practical work induces scientific attitudes, develops problem solving skills and improves conceptual understanding (Tamir, 1991). Practical work in physics helps develop familiarity with apparatus, instruments and equipment. Manipulative skills are acquired by the learners. Expertise is developed for reading all manner of scales. The observations made and results obtained are used to gain understanding of physics concepts. Science process skills, necessary for the world of work are systematically developed (Manjit et al, 2003). Firsthand knowledge is generated. Abstract ideas can be concretized. Naïve, neonate and scientifically primitive ideas can be challenged (Osborne, 2002). Tacit knowledge of scientific phenomena can be gained (Collins, 2001). Practical work creates motivation and interest for learning physics. Students tend to learn better in activity based courses where they can manipulate equipment and apparatus to gain insight in the content. Millar (1998) has suggested that practical work should be viewed as the mechanism by which materials and equipment are carefully and critically brought together to persuade the physics learner about the veracity and validity of the scientific world view.

If practiced in the right manner from the early secondary school period, critical thinking skills can be attained from practical work in physics. Practical work puts the students at the center of learning where they can participate in, rather be told about physics. In this way the desire and eagerness to know more about what the subject can offer is developed.

However, the reality on the ground is that most experiments are sterile, un-illuminating exercises whose purpose is often lost on the learners. In many countries practical work is ill conceived, confused and unproductive (Hodson, 1991). Whatever goes on in the laboratory has little to do with actual students' learning science. Demonstrations are usually done by the teachers who also often miss the point of the demonstration. Small group work is done, but the follow up discussions on the purpose of the exercise are usually counterproductive. There is usually limited planning and formulation of hypotheses, mostly done by the teachers. In many cases the experiments are derived from mostly irrelevant cultural settings with the attendant equipment disasters. The students follow a fixed program of experimental manipulations and observations set by the teacher, cookbook style. This research acknowledges the great role that well planned and delivered practical work in physics can play in influencing students learning physics in the Kenyan secondary school. For this to happen, practical work has to form a central part of classroom learning of physics. Deliberate effort have to be made to attract and retain the students into the physics class by appealing to the curiosity raising element and discovery component of practical work in the subject.

Meaningful practical work is always embedded in a discussion of ideas that makes it necessary to check observations and findings against experience and theory. Teachers hold the key to this interchange of ideas. Studies show that secondary school science teachers' education correlates positively with their learners' achievement in matriculation examinations. The theoretical content and pedagogical content knowledge of the teacher, the ways in which the teacher delivers instruction, and the teacher's attitudes toward science have been shown to have an impact on student learning and achievement (Ware, 1992). This is especially so in the laboratory where the essence of the practical instruction is not immediately abundantly clear to the learners. Drawing meaning out of practical and experimental work requires guided higher level abstraction. Learners can benefit from an inspirational and knowledgeable teacher. All of these factors are related to the teacher's own education, both as a teacher and as a former school pupil.

Practical work in secondary school physics takes the form of laboratory experiments, demonstrations, fieldwork and excursions. Teacher innovativeness and creativity could also introduce novel modes of practical investigations. In Kenya these innovations include: physics micro-kits, specifically prepared Science Equipment Production Unit (SEPU) kits, as well as crude improvisations (Ndirangu et al, 2003). Of late, efforts are being made to utilize virtual laboratory that rely on the interplay of the computer and the internet (Scheckler, 2003). Clearly, every effort should be made to create interest in the students to study physics. Whereas the above efforts can be lauded, this study concentrated on exploring the role traditional laboratory experiments could play in developing interest in learning physics amongst form two girls. This research investigated how such an interest may be ignited in average performing secondary schools in the Western part of Kenya.

The problem

The total number of girls in Kenyan secondary schools matches that of the boys. On admission to form one, physics is a compulsory subject in most schools. Students (boys and girls) study physics in form one and two. The students usually choose the science subjects they will study in upper secondary school at the end of form two. Far fewer girls opt to study physics in form three and form four compared to the boys. In addition to low enrollment, the average performance of the 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 girls' low enrollment and poor performance in secondary school physics needs to be addressed urgently for the girls to play an important role in Kenya's march towards Vision 2030. This Vision requires input from all sectors in order to enhance the country's technological standing in the run-up to social and industrial transformation. For the girls 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 should be carried out. This study investigated practical work in physics as a central instructional technique that can influence the girls to develop interest in physics.

Objectives of the Study

The objectives that guided this study are:

(i) To investigate the effect of practical work on girls performance in physics
(ii) To determine whether there is an attitude change towards physics for girls as a result of participating in practical work
(iii) To investigate whether practical work enables the girls to acquire science process and practical skills
(iv) To determine the effect of practical work on girls enrollment in the physics class in form three.

Research Design

The study utilized the two group pre-test, post-test quasi-experimental design. Three secondary schools, each producing two complete form two classes were investigated in the year 2011. One of the classes from each school formed the experimental group. The other class constituted of the control group. The results of both the experimental and control groups were analyzed in their respective categories.

The Sample

Table 1 below shows the sample size of the respondents from each of the three schools.

Table 1: Respondents from each of the schools

	Respondents from			**Total**
Group	**School A**	**School B**	**School C**	
Experimental	45	48	45	138
Control	41	45	47	133
Total	**86**	**93**	**92**	**271**

All the 271 respondents were drawn from medium performing girls' schools. The schools' mean performances on the 2010 Kenya Certificate of Secondary Education (KCSE) national examinations ranking scale shows that their performance ranged between 4.400 - 6.200 out of a possible maximum of 12.000 score.

Methodology

The end of form one term three physics examinations formed the pre-test for the respondents. Then the respondents were taught using two instructional techniques over a period of one academic year in 2011. Two topics from each of the three terms were selected for this study. The experimental group instructional technique emphasized practical work when teaching the topics. During the practical activities, the respondents were actively involved in setting up the equipment and apparatus used in the laboratory. After each experiment, there was intensive class interaction and discussion led by the class teacher. Experimental procedure, data collection, manipulation and analysis procedure were always reviewed in the class before the respondents were required to complete writing the laboratory reports. The instruction in the control group did not emphasize practical work. Most content in this group was theoretically covered. Teacher demonstrations were the standard way of showing the learners the practical aspects of the topics. There were few respondent performed experiments in the control group.

The Students' Achievement Test, SAT, was administered to the respondents in a staggered manner throughout the year. Specific tests evaluating the work done in each topic was given at the end of each term. These were graded and eventually compiled at the end of the form two. They formed the post-test scores. In addition, all the students were given a Form Two Students Attitude Questionnaire, FTSAQ. The questionnaire was based on a five point Likert type attitude scale. It was made up of five positively and five negatively stated attributes. It measured the students' attitude towards physics learnt up to the form two. The respondents' proficiency in practical skills garnered from each of the topics learnt in class was determined using the Observation Checklist For Skills Acquired (OCFSA) administered to each study group. The OCFSA determined proficiency in aspects of science process skills and experimental performance aptitude. Finally, during term one of form three, the same respondents were tracked to find out how many of them had chosen to study physics.

Results and Discussion

Effect of Practical work on Girls' Performance in Form Two

The Pre-Test scores for the respondents were obtained from the end of form one examinations. The experimental and the control groups had mean performances of 46.35 and 47.21 respectively on the Pre-Test. These results showed that the two groups were of comparable ability. These results indicate that medium performance in these selected schools is already entrenched by the end of form one of secondary school education.

The total scores on the SAT were compiled and expressed as a percentage, for every respondent in each of the experimental and control groups. The SAT performances were the Post-Test scores. The mean performance and the standard deviations for each group were determined. The results are indicated in Table 2 below.

Table 2: Group Performances on the SAT

Group	Number of Respondents, N	Mean Performance, (%)	Standard Deviation, Σ	*z* – test
Experimental	138	58.09	5.78	9.76
Control	133	40.92	16.32	

$\alpha = 0.05$; R: $|z| > 1.96$

The performance of the experimental group was higher than that of the control group. The experimental group had a smaller standard deviation compared to that of the control group. This indicates that the experimental instructional technique was having a positive influence on the respondents' direct understanding on the items in the SAT. The respondents were developing a focused view-point about the task requirements after instruction. The large value of standard deviation observed in the control group indicated persistence of variegated thinking despite the teacher centered instruction. Since the experimental and control groups were large, the *z*-test was used to determine significance of difference of the means from the SAT. At a confidence level of 5% ($\alpha = 0.05$), the observed *z* - value lay beyond the tabulated rejection value, R: $|Z| > 1.96$. Thus the performance of the experimental group was statistically different from that of the control group.

The results from the current research resonates well with KNEC (2006) 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. 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 seriously. 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 requirements of the tasks involved in the practical work.

They found this to be particularly true when the practical work was enjoyable and meaningful to the students. 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 thrust of his argument is that experimental attempts in the average high schools are sterile and un-illuminating. That many times practical work is ill conceived, confused and unproductive. It does not translate into tangible performance bonuses for the learners. Also, Hofstein (1982) points out that too much emphasis on laboratory activity leads to a narrow conception of the content. Rediscovery of the basic tenets that constitute the concepts of science is seen as time intensive and not worth the effort. If too much time is spent on experimentation at this level there tends to be a significant reduction in overall content coverage. The lack of overall conceptualization of the topics leads to limited understanding and poor performance on a comprehensive assessment of the subject matter.

Attitude towards physics as a result of Participation in Practical Work

The Form Two Students Attitude Questionnaire (FTSAQ) was used to investigate the development of the girls attitudes towards identified features concerned with learning physics. The five attitudinal concerns that were investigated were:

A: Ability to understand the topics taught
B: Applicability of the topics learnt in everyday life
C: Development of interest in physics after the course
D: The role of the teacher in assisting learning of the topics
E: Overall student interaction when learning in class

Likert-type attitude scale scores were worked out for each of the categories of respondents. The percentages of respondents scoring high, average and low attitudes were determined. These findings are shown in table 3 below.

Table 3: Respondents Group Attitudes on several concerns

Attitude concern	Experimental group Attitude score (N=138)			Control group Attitude score (N=133)		
	High (N, %)	Undecided (N, %)	Low (N, %)	High (N, %)	Undecided (N, %)	Low (N, %)
A	88 (63.8)	30 (21.7)	20 (14.5)	41 (30.8)	65 (48.9)	27 (20.3)
B	74 (53.6)	33 (23.9)	31 (22.5)	36 (27.1)	75 (56.4)	22 (16.5)
C	89 (64.5)	27 (19.6)	22 (15.9)	25 (18.8)	45 (33.8)	63 (47.4)
D	98 (71.0)	15 (10.9)	25 (18.1)	30 (22.5)	36 (27.1)	67 (50.4)
E	100 (72.5)	20 (14.5)	18 (13.0)	20 (15.0)	40 (30.1)	73 (54.9)

(Calculated χ^2 value =138.47, tabulated χ^2 value = 31.41)

On the Likert scale, scores of 4 and 5 were considered High scores whereas scores of 1 and 2 were designated Low scores. A score of 3 indicated an average score, interpreted as being unsure or undecided about the concerned attitudinal attribute. Table 3 above shows the frequency (and percentages) of respondents from each of the experimental and the control groups on each attitudinal concern. For every concern, the experimental group had more respondents scoring 'High' compared to the control group. This implies that the experimental group had a more positive view concerning the concerned attitude.

The table indicates that the experimental group had more respondents (63.8%) who understood the topics after instruction compared to the control group (30.8%). There were fewer respondents in the experimental group (21.7%) who were undecided about whether they understood the topics compared to the control group (48.9%). Application of the topics outside the classroom and into everyday life activities (concern B) indicated that 53.6% of the experimental group felt that they were able to do this satisfactorily compared to only 27.1% of those in the control group. After going through the course, 64.5 % of the experimental group respondents reported having developed a better interest in physics compared to only 18.8% of the control group respondents.

Attitude towards the role played by the physics teacher in assisting the respondents to understand the topics had 71.0% of the experimental group respondents indicating that the teachers played a central and significant role. Most of the control group respondents (50.4%) felt that the teachers did not offer enough help. The issue of student interaction during instruction also favored the experimental group. The experimental group had 72.5% of the respondents indicating that there was plenty of student-student interaction compared to only 15.0% of the control group who felt there was adequate interaction amongst the respondents. This interaction included discussions on the best ways of effecting equipment and apparatus connections, joint working out of solutions to problems provided at the end of the practical task, and determination of applications of theory work outside the classroom. The control group had a higher proportion (85.0%) who felt that the interaction between the respondents was of no benefit in fostering learning.

Chi-square (χ^2) for the distribution of attitudes towards the concerns by both experimental and control groups was performed to determine its' significance. The calculated χ^2 value (138.47) is greater than the tabulated χ^2 value (31.41) at 5 percent level of significance ($\alpha = 0.05$) and 20 degree of freedom (dF = 20). This lends credence to the observation that the experimental group had developed better attitudes as a result of practical based instruction in physics. The findings of this study concerning respondent formed attitudes concur with the observations of Talisayon (2006) who found out that learners developed improved attitudes towards science as a result of practical courses. Kim & Chin (2011) have reported that practical work was a significant tool for developing students' scientific knowledge and habits of mind which concurs with the finding that practical work contributed to increased ability to understand the content in this study. Toplis & Allen (2012) suggest that practical work has been used as an integral effort of ensuring that learners develop an in-depth understanding of content during the formative years of secondary school science learning. This understanding leads to a 'feel good' attitudinal disposition to the subject under study.

Acquisition of Science Process Skills and general Practical Skills as a result of practical work in Physics

During term one the respondents learnt Magnetism and light refraction at a non-curved inter-face as part of this study. The experiments that could have been used in accompaniment of the theory are indicated in table 3 below. Each experiment is described and the practical details involved are provided.

Table 3: Available Experiments for Term One

	Expt no	Description	Practical Details
Magnetism	1	Suspending magnets	• Detection of magnetic poles • Attraction and repulsion of magnets
	2	Magnetic material	• Ferromagnetic material • Non-magnetic material
	3	Shapes and sizes of magnets	• Rectangular, Circular, Horseshoe of all sizes • Electromagnets
	4	Detecting and mapping magnetic fields	• Using Iron fillings and paper, magnetic needle determination • Fields around single and two magnets in close proximity
Refraction of light at non-curved inter-faces	1	Bending or broken Pencil	• Change of direction of light due to different speeds in two media
	2	How Prisms work	• Splitting up of white light to form a rainbow
	3	Refractive Index of water	• Finding apparent and real depth • Direction of light in media
	4	Refractive Index of glass	• Determining angles of incidence and refraction relative to a normal • Using Snell's law to calculate Refractive Index of glass

The Experimental group did all the 8 experiments during term one. The Control group carried out only three experiments. For magnetism, the control group was able to perform the magnets suspension (Experiment 1) as well as testing for materials magnetic properties (Experiment 2). In addition, this group was able to perform the Refractive Index of water light experiment (Experiment 3). Simple experiments, like the broken pencil experiment and the prism experiment were not undertaken. The experiment about the detection of the magnetic field involves readily available material but was omitted.

Table 4: Acquisition of Basic Science Process Skills during Term one.

Group	Science Process skill							
	Observing		Measuring		Classifying		Recording	
	No	%	No	%	No	%	No	%
Experimental (N=138)	97	70.29	86	62.32	89	64.49	88	63.77
Control (N=133)	23	17.29	25	18.80	17	12.78	24	24.05

Table 4 shows acquisition of four basic science process skills as a result of performing magnetism and refraction of light experiments. The Experimental group reported having gained more experience in all the indicated process skills compared to the control group. Observing the direction in which the poles pointed when the freely suspended bar magnets came to rest, painting various poles of the magnets, repulsion of like poles as well as attraction of opposite poles of various magnets were actively investigated by the experimental group. Detection of magnetic material and the subsequent identification that these materials were mainly iron based were activities which were enjoyed by this group. Investigation and classification of the various shapes of magnets and identification of common appliances that use these shapes of magnets was also undertaken by this group. This group particularly enjoyed detecting magnetic fields using iron filings and the magnetic needle. The patterns were drawn and compared for various pole combinations of magnets approaching each other.

Experiments with the refraction at the flat surface interface involved a series of observations that were appreciated by the respondents. Concepts of real depth and apparent depth were differentiated. Observing the pencil placed in the water-filled beaker from the sides showed that the pencil was broken. If observed from the top of the beaker the pencil appeared bent. Though tricky, the experimental group was able to see that a ray of light was spread into a myriad of rainbow colors by a triangular prism. Several measurements of incident and refracted angles were made and recorded. The experimental group was able to measure the real and apparent depth of the water in a beaker in order to find the refractive index by the no-parallax pin method.

The control group showed enthusiasm with the experiments 1 and 2, though they wished that they would have done more experiments in magnetism. The group also actively participated in Experiment 3 on refraction of light at flat interfaces. Inal (2003) found that the basic science process skills were picked and consolidated by secondary school practical work. He adds that the learners picked up information and skills more quickly when they actually did the experiment compared to when they were simply lectured in class. The learners reported valuing the role of all the senses in learning and the fact that they came to their own conclusions. Looking at and touching the apparatus and equipment made the conclusions of the experiments believable. Gekelman et al (2011) have suggested that even for detection of complex media plasma substance based refractive indices basic science process skills are best developed through practical experimental set-ups. Tifi et al (2006) suggest that investigations allow learners to reach their own conclusions. When done in groups the gained process skills allow development of social skills of collaboration, sharing, debating and extending ideas in the group. Miles (2010) has found out that science process skills were associated with content familiarity, interest and display of conceptual knowledge. These findings generally agree with those of this study which put the control group at a disadvantage in the acquisition of the basic science process skills.

Table 5: Demonstration of Practical Experimental Performance Skills in Term One

Group	Experimental performance skills							
	Setting up Equipment		Reading scales on equipment		Manipulation of Experimental Data		Writing up Laboratory reports	
	No	%	No	%	No	%	No	%
Experimental (N=138)	111	80.43	98	71.01	109	79.00	113	81.88
Control (N=133)	26	19.55	29	21.80	20	15.04	22	16.54

Table 5 illustrates four key practical skills that the respondents undertook as they worked through the magnetism and flat inter-face refraction experiments. The results indicate that the Experimental group demonstrated superior practical performance skills compared to the Control group. This is attributed to the fact that the Experimental group did more of the equipment setting up by virtue of having done more experiments than their control group counterparts. They also read scales on the spring balances showing force required to attract or repel a magnet. More data manipulation was followed by required writing of laboratory reports. The laboratory reports were more than those turned in by the control group.

These findings are in agreement with those of Kandjeo-Marenga (2011) who found out that teacher demonstrations led to little learner acquisition of pertinent science practical skills. Salim et al (2011) have reported that important practical skills are gained when students directly engage in laboratory experimental work. Such skills include circuit connection, assembling instruments, reading instrument scales, recording the obtained readings, and interpreting the findings. Ssempala (2005) echoes these findings when he reports that practical work bequeathes on the learners the ability to manipulate equipment, make clear and detailed observations, report and record results accurately as well as compute and analyze results appropriately. The findings of the present study are in tandem with these literature findings.

During Term two the respondents laboratory experience was from two experiments: Hooks law and sound. The individual experiments that the respondents could have engaged in are indicated in table 6 below.

Table 6: Available experiments for Term two

	Experiment no	Description	Practical Details
Hook's Law	1	Force constant	Finding stretch of spring for several masses added
	2	Making own spring	Winding a wire around a test tube and calibrating the finished spring product.
	3	Springs and masses	Oscillating several masses from springs and finding time for a complete oscillation
Sound	1	Sources of sound	Causing objects to make sound
	2	Sound in the three forms of matter	Testing whether sound can travel through air, solids and liquids
	3	Changing sound wave frequency	Group work with strings, air columns and water in tall jars

The experimental group participated in all the experiments. The control group managed to do two experiments in total namely, Experiment 1 on Hook's law and experiment 1 on Sound. With a little improvisation the rest of the experiments could have been performed by the control group.

Table 7: Acquisition of Basic Science Process Skills during term 2.

Group	Science Process skill							
	Observing		Measuring		Classifying		Recording	
	No	%	No	%	No	%	No	%
Experimental (N=138)	118	85.51	100	72.46	86	62.32	120	89.96
Control (N=133)	26	19.55	23	17.29	18	13.53	27	20.30

Table 7 indicates the percentage of the respondents who were confident that they had acquired the requisite science process skills as a result of undertaking practical work during term two. The experimental group led the control group in all the skills indicated. Both the experimental and control groups reported that they enjoyed making the springs and calibrating them on their own. However, determining extensions due to repeated addition of weights and vibrating springs was done only by the experimental group. The group reported these additional experiments were of great fun and educational value. Several respondents worked on different types of wires to construct springs of different strengths. The subsequent calculation of spring constants and the period of each spring's oscillation was a challenge that was embraced by the experimental group to the detriment of the control group. Both the experimental and control groups had an exciting time with causing various objects to make sound. Classification of the quality of the sound created was performed satisfactorily. However only the experimental group was able to do the experiments involving conduction of sound in the three states of matter, and deliberately changing the loudness and quality of sound produced using tension of strings and variation of air columns.

Shi et al (2011) have demonstrated that the basic science process skills are gained more readily when practical work involving springs are performed by the learners accompanied by detailed discussions about the nature and purpose of the experiments. Coil et al (2010) in their study involving university and high school faculty have stressed the importance of science process skills as the foundation of the scientific enterprise for learners. They indicated that these skills were gained principally through experimentation and practical work. They asserted that science process skills enhanced current and future science content. Chabalengula et al (2012) have demonstrated the usefulness of mastery of science process skills among elementary school science teachers. The performance of the elementary teachers was certified to have become more meaningful for those who had practically gained them. Yandila & Komane (2004) have investigated the central role active pursuance of science process skills in the laboratory and class experiments can have on meaningful learning and understanding of secondary school science in Botswana. Acquisition of these skills hones the learners emerging ability to interrogate the events in the scientific environments. These findings are in line with the current study which has determined that variety and consistency in practical investigations should be accorded to the young learners to gain the science process skills.

Table 8: Demonstration of Practical Experimental Performance Skills in Term Two

	Experimental performance skills							
Group	Setting up Equipment		Reading scales on equipment		Manipulation of Experimental Data		Writing up Laboratory reports	
	No	%	No	%	No	%	No	%
Experimental (N=138)	110	79.71	103	74.64	106	76.81	115	83.33
Control (N=133)	20	15.04	23	17.29	18	13.53	21	15.79

More respondents from the experimental group reported they had gained experimental performance skills compared to the control group respondents. They reported having grown in confidence in setting up the equipment. They singled out the force constant determination experiment in which they set up the spring on a retort stand, attached a load pan and added different masses as the string extended. The oscillating loaded spring experiment received rave responses concerning its assemblage, data generation and manipulation leading to the determination of the period of oscillation. Similar responses were obtained concerning creation of sound from many vibrating material, testing for the conduction of sound in the states of matter and alteration of the quality of sound by alteration of the various vibrating parameters (i.e tension in a string, length of the air column). Reading of scale was relatively straight forward. Known masses were placed on the pan which then caused the spring to extend. Initial and final pointer readings were determined from which the spring extension was worked out. Distance in meters and times in seconds were used to find out the speed of sound in the various media. Group and class discussions came in handy in performing the various manipulations that led to the determination of the resultant constants (speed of sound in air, period for oscillation of the loaded springs, the individual spring constants of the various springs). All groups of respondents reported learning successfully how to write acceptable laboratory reports. The control group was disadvantaged because they did not benefit from as much exposure as had the experimental group.

Holland (1999) has recognized that improvisation and simplicity are crucial to performing many high school type experiments. He traces such simple improvised apparatus in history. Pantano & Talas (2010) have also traced how such equipment can be used in school settings in Italy. Many of the sound and hook's law equipment did not require sophisticated and expensive equipment. Many stop gap measures can be practiced in teaching topics involving Hook's law and sound which were the focus for the current study. Erickson & Cooley (2007) have indicated that in order to make meaningful headway with concepts derived from spring extensions, careful collection, recording of the observed data and professional manipulation of the data are necessary conditions. Forinash & Wisman (2002) make similar suggestions concerning data collection for sound experiments. The findings from literature indicate that the more experiments are done by the learners, the more the practical experimentation skills are gained. The control group was not given enough practice and hence lacked this important ingredient in the process of learning physics during the form two formative stage.

In term three, the experiments were derived from the topics of refraction of light through thin convex lenses and simple direct current electricity. There were seven experiments available: three from refraction the thin lenses and four from direct current electricity. The experimental group did all the seven experiments on offer. The control group did only two experiments ie experiments 2 from both topics. The control group could easily have performed all the experiments since they did not require expensive apparatus. The details of the experiments are shown in table 9.

Table 9: Available Experiments for Term Three

	Experiment no	Description	Practical Details
Refraction of light in thin lenses	1	Categorization of thin lenses	Naming of various types of thin lenses
	2	Finding focus for convex lenses	Practical finding of principal foci for convex lenses;
	3	Images from convex lenses	Location of image position for various object positions for the convex lenses
Current electricity	1	Circuit components	Identifying circuit elements, connecting the elements to form an electric circuit
	2	Connecting cells	Cells in series, in opposition, in parallel
	3	Resistors in a circuit	Resistors in series and parallel
	4	Ohm's law	Measuring current and voltage for passive material

When they were able to participate in the experiments both groups were delighted to have hands-on practical work in addition to the theory.

Table 10: Acquisition of Basic Science Process Skills during Term Three

	Science Process skill							
Group	Observing		Measuring		Classifying		Recording	
	No	%	No	%	No	%	No	%
Experimental (N=138)	89	64.49	79	57.25	82	59.42	78	56.52
Control (N=133)	30	22.56	25	18.80	29	21.80	22	16.54

Table 10 indicates the number of respondents who were confident to have acquired the indicated science process skills. The experimental group, by virtue of having participated in all the available experiments, had a higher proportion of respondents reporting confidence in the skills. For both groups, observation followed by classification, were the most mastered process skills. Also, both groups had most difficulty in mastering the science process skill of recording. The findings of the current study are in agreement with several existing findings on acquisition of science process skills as a result of performing practical work experiments. Feyzioglu (2009) has reported a positively significant and linear relationship between science process skills taught to students in laboratory applications and their achievement in a current electricity course.

Baser & Durmus (2010) have shown that there is no difference in science process skills attained through actual laboratory activities or through the virtual learning environment in direct current electricity amongst pre-service elementary teachers. Karamustafaoglu (2011) found out that science process skills involving direct current electricity could be highly enhanced if the learners actively engaged in laboratory type practical work. Mohan (2007) shows the importance of laboratory experiments involving thin lenses in developing important scientific processes. These include intellectual processes and skills like observing, inferring reading scales and making accurate recordings. Hudson (2010) has expounded on the role of the teacher in arranging environments for maximum learner benefits in important areas. The areas include explication of theoretical underpinnings, teaching approaches, resources (equipment and technology) application, and locating the activities in the classroom, school grounds, or in excursions centers. The current study found that teaching approaches that carefully led to discovery and acquisition of science process skills were of most benefit to the respondents.

Table 11: Demonstration of Practical Experimental Performance Skills in Term 3

	Experimental performance skills							
Group	Setting up Equipment		Reading scales on equipment		Manipulation of Experimental Data		Writing up Laboratory reports	
	No	%	No	%	No	%	No	%
Experimental (N=138)	97	70.29	87	60.04	75	54.35	99	71.74
Control (N=133)	32	20.06	27	20.30	21	15.79	24	18.05

The respondents' expertise in experimental performance is shown in table 11. Overall the experimental group reported to have gained more expertise at performing these experiments compared to the control group. This could have been due to the greater exposure the experimental group had to practical work relative to the control group. The practical skills least mastered by the experimental group were report writing followed by setting up the equipment. The two leading practical skills for the control group were setting up the equipment and laboratory report writing. For both groups, data manipulation was the least mastered practical skill.

The findings from the current research are in tandem with several research findings on the acquisition of practical experimental skills. Frost (2010) suggests that most illustrative practical work requires that teachers transfer the task of setting up practical activities to the learners so that they can gain in proficiency and expertise. The core intention is to collect, record and manipulate the data be it digital or analog in order to obtain patterns that explain the data in investigations concerning various topics. They aver that more exposure to the practical situation the more the practical skills are mastered. Working on Hooke's law, Dudley-Evans (1986) cites this experiment with ability to equip the learners with apparatus handling skills, subsequent ability and expertise in scale reading, collection and manipulation of experimental data, and the subsequent laboratory writing skills. The current research found out that these skills were gained more by the experimental group than the control.

Girls Enrollment for Physics during Form Three

The current research sought to find out the effect of practical work in form two on the subsequent enrollment into the physics class in later academic years. The form two physics respondents who were involved in the year-long investigation were tracked to find out whether they had opted to study physics at higher secondary school. When the respondents opt for a subject in form three, they are obliged to study it up to form where they will be examined in that subject for the final national secondary school leaving examination, KCSE. The findings of this follow-up investigation are indicated in Table 12 below.

Table 12: Respondents enrollment for Physics during Form Three

Group	**School A**		**School B**		**School C**	
	Form 2	**Form 3**	**Form 2**	**Form 3**	**Form 2**	**Form 3**
Experimental (N=138)	45	25	48	27	45	29
Control (N=133)	41	9	45	13	47	15
Total	**86**	**34**	**93**	**40**	**92**	**44**

The table 12 above indicates that 81(58.70%) of the respondents in the experimental group enrolled to study physics in form three. Only 37(27.82%) of the respondents in the control group opted to study physics in form three. The ratio of the respondents from the experimental group to that in the control group who enrolled for physics in form three was determined to be 2.2. This indicates that overall for every control group student enrolling there were more than two enrollments from the control group. The enrollments from the control group continued the usual pattern observed from these schools before the study. The total enrollments into form three physics in the last two years before the study were 36 and 39 girls respectively. For the experimental group the order of enrollments were school C (29), school B (27) and School C (25). The total experimental group enrollment was 82 girls. This was more than twice the normal average of enrollment. The same order was observed for the control group with the individual enrollments being 15, 13 and 9 respectively. This gave a total enrollment of 37 girls. Since the findings compare enrollments in the same schools it is clear that practical work has affected the motivation to study physics in form three.

Williams et al (2003) investigated the issue of why students are not interested in studying physics in higher secondary school classes. They found out that interest in and actual participation in practical experimental work during foundational secondary school education was a strong factor in deciding to pursuance of the subject in later secondary school. Assefa et al (2008) have determined that amongst other intervention remedies for boosting enrollment in advanced physics courses, ensuring participation in practical work was rated highly. It made students most ardent about the subject. Owoeye & Yara (2011) determined that the rural-urban high school differential performance in Agricultural sciences hinged on availability of laboratory facilities and the quality of practical work done therein. That performance was a significant factor in enrollment in higher courses and careers. The literature cited is in agreement with the findings of the current research. Both emphasize the link between stressing practical work to students in their formative years of scientific study and future enrollments in those science subjects. The current study found a similar link for secondary school physics.

Conclusions

The study investigated the role that practical physics played in creating interest in secondary school physics. The specific conclusions from the objectives findings are:

1. Involvement in meaningful practical work contributes to improved performance in the topics from which the practical was derived. Practical work made the students keener on the content. The subsequent discussions allowed the students to hone their analytical skills concerning manipulation of data. The theories developed were founded on a personal experience rather than on a theoretical imposition.
2. A significant change occurred in the attitude towards physics in the experimental group compared to the control group. This group was able to determine for themselves the touted experiences. They were able to control the pace at which the practical progressed. They found out that they could negotiate meanings and all of a sudden the subject was comprehensible. This experience was repeated many times in the various experiments they went through. Lack of continued exposure to these experiments by the control group left them still wondering what the subject was all about.
3. The girls were able to acquire many relevant practical skills. The science process skills of observing, measuring recording and classifying were developed by the experimental group. Similarly all the respondents reported enjoyment in actual setting up of the equipment and apparatus, reading of the various measurement scales, and writing laboratory reports. Manipulation of the data proved to be a bit more intimidating for both groups. However overall the experimental group benefitted more than the control group in the acquisition of the science process skills and the actual practical performance skills.
4. Practical work in physics disposed the respondents favorably to the subject. The experimental group to control group enrollment ratio was 2.2:1. Clearly the waning interest in physics at secondary school level can be checked and even reversed if the students are exposed to meaningful practical in the earlier secondary classes.

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