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The Effect of Intergrating Micro Science Kits VIS-À-VIS Conventional Apparatus in The Teaching and Learning of Physics Practical Work in Kenya

[I]Amadalo Maurice Musasia, [II]Wesonga Mukhuyu Murundi Fanuel
[I]Masinde Muliro University of Science and Technology, Kaimosi University College, Kaimosi, Kenya
[II]St. Mary Goretti Shikoti Girls High School, Kakamega, Kenya

Abstract

This study investigated the effect of integrated micro science kits on student's achievement in physics practical work among form two students in Kakamega Central sub-county. Micro science approach is a new and highly innovative practical science concept that uses very small scale or micro scale apparatus and chemicals. It has several of advantages over the tradition approach. It is cheap, easy to store, and easy to clean, as well as saves on hazardous waste disposal. Two groups of the form two physics students from 16 secondary schools were designated as experimental and control groups who participated in the study. The experimental group consisted of 319 students from 8 schools. They carried out experiments using micro science kits. The control group consisted of 321 students from the other 8 schools. The control group performed experiments using conventional apparatus. The pre-test post-test equivalent group research design was used. Physics practical achievement tests PPAT1 and PPAT2 were used to gather data for the study. The data was analyzed using SPSS version 16. Findings indicated that the micro science kit performed practicals generally enhanced the understanding of physics concepts in comparison with the conventional apparatus. The unique integration of practical work with the theory is deemed to have contributed to the positive response of conceptual understanding detected.

Keywords

Micro kit integration, conventional physics apparatus, Achievement in physics practicals

I. Introduction

The aim of Science Education in Kenya is to produce Kenyans who will have the capacity to be innovative, curious and are able to solve problems scientifically for the benefit of the society. In Kenya, science is on an evolutionary path. Education commissions and other education reviews have consistently recommended measures to improve teaching of science in the country since independence (Eshiwani, 1993). Science is learnt under the following subjects: Biology, Physics, Chemistry and Agriculture in Kenya. However Physics is considered paramount for the country's industrialization and technological development (UNESCO, 2001).

Physics knowledge has made tremendous impact in nearly all aspects of human life. The subject has important applications in research, information communication technology, industrial and agricultural development. It integrates knowledge learnt in other subjects such as Mathematics, Biology and Chemistry. In Kenya, Physics is optional in the upper secondary school curriculum. Even then, the results have continued to show low performance at Kenya Certificate of Secondary Education (KCSE) examinations even for those students who opt to take it. After performance critical survey by the Kenya National Examination Council (KNEC) was carried out over the period 2009-2012. The reports show that academic performance in secondary schools physics is generally poor. The subject is tested in three examination papers i.e. KCSE 232/1, 232/2 and 232/3. Practical work is tested in the Kenya Certificate of Secondary Examinations (KCSE) in paper three (232/3). The Physics practical paper carries a lot of weight on the performance of students in physics examinations since it accounts for 40% of the overall examination grade. Poor performance in the practical paper means on the overall, lack of a Physics quality grade.

Physics practicals are important since the experience helps learners acquire a variety of science skills. Practicals enable the application of scientific knowledge and methods in solving problems in everyday life (Hazel, 1994). In the school setting, practicals test and verify laws, ideas, principles and hypotheses. In this way the learning process makes the concepts vivid, concrete and understandable. Practical work in Physics is an essential component of teaching. Important reasons for practical work include students performing activities in order to: discover something yet unknown, test a hypothesis, confirm already known facts, or personalize the experience through self directed investigation (Hudson, 1990; Changeiywo, 2000). In order to perform these activities, the student has to learn the skills required for practical work which include: preparing for, performing the experiment, and processing the results thereby obtained. According to KNEC (2006) practical examinations usually involve performance of various activities. These include following instructions in order to arrange the experiment, making observations and recording them clearly, legibly and logically, constructing tables and diagrams, drawing graphs and interpreting them.

Poor performance in Physics raises concern if Kenya as a country has to achieve the vision 2030. This vision relies strongly on technical subjects. According to the First Medium Term Vision 2030 plan, the foundations for National transformation are: infrastructure, information and communication technology (ICT), Science, technology, innovation and human resource development. All these cannot be realized when the Physics input is low. Low performance in practical physics will lead to low overall performance in physics. Various initiatives have been put in place concerning the teaching, learning and performance of sciences in general and physics in particular. The Ministry of Education has initiated the Strengthening of Mathematics and Sciences in Secondary Education (SMASSE) project to address this (SMASSE baseline report, 1998). For over ten years, the programme has been involved in in-service capacity building of mathematics and science teachers. The thrust of SMASSE has been to improve on methodological intervention to make content delivery more meaningful for the learner.

However, the Physics results show that the performance has not improved as expected. The KNEC (2007) report has highlighted some of the causes of poor performance in the practical paper. These include lack of understanding of procedures, incorrect reading of scales (e.g for voltmeter and ammeter) and inability to follow instructions especially in practical examinations. The poor performance is generally attributed to the teaching method in vogue. The KNEC reports point out that practical work in Kenya is mainly taught through teacher controlled demonstration method. These class demonstration method does not provide the students withrequisite hands-on experience (Hazel, 1994).

Student controlled class experiments exposes learners to hands-on experiments and interactive environment. The collection of activities involved help learners to answer questions, prove or disapprove ideas, collect and analyze the data from the experimental results (Toplis et al 2012).There are however many challenges associated with the class experiment method of teaching in African countries. There is concern over issues such as waste disposal from laboratories, shortage of laboratory space in schools, shortage of apparatus and equipment, large class size and shortage of physics teachers, environmental pollution of chemicals and gases from laboratories (World Bank, 2004).As a result of these challenges, it has been observed that the teaching of physics is mostly done theoretically in most schools in Kenya.

All over the world currently, there are debates over the effect of green life generally. This particularly so in the developed world. It is evident that green science is unavoidable in the teaching of science subjects. The increased presence of green science movement has spilt over into the teaching of physics. Green science is the application of eco-friendly scientific manipulations to scientific disciplines such as chemistry, physics, biology, astronomy and others. It involves learning about global warming, pollution and other impacts on nature and the planet. It also includes learning what can be done to combat these effects. In the physics class green science kits are modern apparatus for teaching physics practical work. They involve miniaturization of laboratories to small portable equipment packages for teaching (Bradley, 1999). Apparatus, equipment and materials that do not pollute the environment are used. The kits are small and convenient to use even in the normal classroom (Vermaak, 1997; Kolobe, 1998). They are virtually unbreakable and inexpensive, and have been designed to enhance the quality, relevance and accessibility of science and technology education. The current study investigated the use of these micro-science kits in physics teaching.

II. The Problem

Student performance in physics has continued to challenge concerned stakeholders in Kenya for a long time now. The results in both end of year and end of school examinations are far from exemplary. Though there is a slight gender differential in favour of boys, this is not very wide. The mode of conducting practical work has been identified as a major roadblock to improved performance in physics. This study considered the effect of utilizing physics micro-kits in performing selected form two experiments. This was compared to the achievement when normal large scale practical equipment was utilized. In addition, the level of three science process skills thereby developed was assessed.

III. Objectives and Hypotheses of the Study

The study was guided by three objectives. These are:

A. To compare the overall achievement of students taught practical work using micro-kits with those taught using conventional class experiment apparatus
B. To determine whether there is a difference in the achievement in terms of school types by students taught practical work using micro-kits with those taught using conventional class experiment apparatus.
C. To find out if there is a difference in the achievement in terms of gender by students taught practical work using micro-kits with those taught using conventional class experiment apparatus.

The objectives translated into the following three hypotheses

H01: There is no significant difference in the overall achievement of students taught practical work using micro-kits with those taught using conventional class experiment apparatus.

H02.: There is no significant difference in the achievement in terms of school types by students taught practical work using micro-kits with those taught using conventional class experiment apparatus.

H03: There is no significant difference in the achievement in terms of gender by students taught practical work using micro-kits with those taught using conventional class experiment apparatus.

IV. Research Design

The study utilized the two group pre-test, post-test quasi-experimental design. The subjects were selected by streams at form two in each chosen secondary school. Schools were picked using random sampling. Each school produced one stream. Eight school formed experimental group. This group received the treatment i.e. use of micro science kits. The other eight schools were the control group which used conventional apparatus.

A. The Sample

The sample for the study from the 16 schools is shown in table 1 below.

Table 1: The overall sample for the study

Groups	Participants from County schools	Participants from District schools	Total
Experimental	80	239	319
Control	81	240	321
Total	161	479	640

There were 161 respondents from County schools. Of these, 80 formed the experimental group and 81 formed the control group. There were 479 respondents from Sub-County schools (also designated as District schools). Of these, 239 and 240 respondents formed the experimental and control groups respectively. In total the experimental group had 319 respondents while the control group had 321 respondent. The total respondents who took part in the study were 640

The sample, re-designated in gender terms is illustrated in table 2 below.

Table 2: Gender wise distribution of the sample

Groups	Girls	Boys	Total
Experimental	157	162	319
Control	149	172	321
Total	306	334	640

There were 306 girls that took part in the study. Of these 157 and 149 respondents formed the experimental and control groups respectively. The boy respondents were 334. Of these, 162 and 172 formed the experimental and control groups respectively.

B. Research Instruments

A Physics Practical Achievement Test (PPAT1) was designed. This was used as a pre-test. It was administered before the study to both experimental and the control groups. The content of the test was derived from approved 8-4-4 Physics syllabus, teachers guide and students text books. The test consisted of experiments on Cells and Circuit connections involving bulbs. It had ten items which were closed ended. The purpose of the (PPAT1) was to establish the level of achievement in practical work of the respondents before further instruction. A post-test (PPAT2) was administered at the end of the study. The results were used to check the impact of the treatment on the student's achievement in practical work. The test covered the process of electrolysis using electrolytic cells. The test consisted of four closed ended items and three open ended items.

C. Data Collection

Data collection was done in term one. The duration between the pre-test (PPAT1) and a post-test (PPAT2) was four weeks, after continuous instruction of both experimental and control groups. Each week comprised of four forty minute sessions. The PPAT 1 was administered in all schools within a period of two days before the intervening instruction of the experimental and control groups. The post-test (PPAT 2) was also administered within two days period at the end of the study. Class teachers of physics in respective schools were deployed as research assistants

D. Results and Analysis

An independent t-test for difference in physics practical achievement between groups at $\alpha=0.05$ was considered significant. In addition the one-way Anova was used to test for significance of difference in PPAT2. Further the chi-square was used as a test of goodness of fit for the science process skills acquired.

V. The findings of the study

This is provided under findings concerning overall, school type and gender achievement on the practical physics test.

1. Overall Practical test Achievement after Instruction

In objective one, the study determined overall practical test achievement after instruction. The results are in table 3 below. The table shows the overall pre-test and post-test results for the study in terms of experimental and control groups. Standard deviations for both groups are also provided.

Table 3: Comparison of the pre-test scores for experimental and control group

Group	N	Pre-test Mean	Pre-test Standard Deviation	Post-test Mean	Post-test standard deviation	Gain
Experi-mental	319	49.9	11.97	70.6	13.97	20.7
Control	321	51.2	12.11	62.5	15.34	11.3

Applying the independent samples t-test to the pre-test results yielded a value of 1.35. This is less than the critical tables value of 1.93 at $\alpha = 0.05$. This indicates that the experimental and the control groups are not statistically different from each other. The standard deviations of the scores also indicate that the individual response scores spread is in the same range for both the control and the experimental groups.

The mean post-test scores from PPAT2 indicates that there is a difference in performance between the two groups (70.6 for the experimental group and 62.5 for the control group). The mean score of the experimental group was higher than that of the control group. The standard deviation of the experimental group was lower than that of the control group. The independent samples t-test results yielded a value of 4.80 which was higher than the table's critical value of 1.93. The null hypothesis HO1 which stated that there is no significant difference in the overall achievement of students taught practical work using micro-kits with those taught using conventional class experiment apparatus was rejected. This indicates that the post-test results were significantly different, attributable to the micro-kit intervention.

2. Practical test Achievement after Instruction based on school type

In objective two, the study determined achievement on the practical test achievement after instruction based on school type. Comparison of post-test scores for the schools categories was done. The categories were County and Sub-County (district) schools. There were 480 respondents from the Sub-County schools and 160 respondents from the county schools. This distribution was due to establishment of many sub-county schools in the Sub-County compared to the county schools. The achievement results were as shown in table 4.

Table 4: Comparison of County and Sub-County Schools Students' scores on PPAT2

Group	County mean, N=160	Sub-County mean, N=480
Experimental	74.0	69.6
Control	55.8	58.6

The overall mean post-test scores indicate that there was a difference between groups (74.0 and 69.6 for experimental group comparing county and sub-county schools, and 55.8 and 58.6 for control group when comparing county and sub county schools categories). The mean scores of the experimental group were higher than those of control group in both county and sub-county schools. A one-way Anova was conducted on these results to test for significance. The results of the Anova are indicated in table 5 below

Table 5: One-way Anova results on the type of schools achievement scores

Differences	Sum of Squares	dF	Mean Score	F-Ratio	p
Between Groups	33.0625	1	33.0625	64.5122	0.01515
Within Groups	1.025	2	0.5125		
Total	34.0875	3			

The results of the one-way Anova indicate that there was a

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significant difference in practical performance between county and sub-county schools using the two practical techniques in electrolysis (F(1,2) = 64.51, p =.015 at α=.05). The null hypothesis HO2 which stated that there is no significant difference in the achievement in terms of school types by students taught practical work using micro-kits with those taught using conventional class experiment apparatus was rejected. Taken together with results in table 4 the findings show better results were obtained using micro-kits compared to using conventional apparatus during the teaching and learning of the physics practical work.

3. Achievement on the Practical test Achievement after Instruction based on gender

In objective three, the study determined achievement on the practical test achievement after instruction based on gender. The gender based achievement results are provided in table 6.

Table 6 : Post-test gender-wise

Group	Percentage Scores	
	Girls	**Boys**
Experimental	73.4	68.6
Control	59.9	57.2

Table 6 shows the post-test results according to gender. All the experimental results are higher than the control results. Among the experimental and control results, the girls posted higher performance than the boys. A one-way Anova was done to determine the significance of these findings. This is depicted in table 7.

Table 7. One-way Anova results on the post-test gender-wise scores

Difference	Sum of Squares	df	Mean Score	F-Ratio	P- value
Between Groups	14.0625	1	14.0625	18.51282	0.180167
Within Groups	156.105	2	78.0525		
Total	170.1675	3			

The one-way Anova indicates that there was no significant difference in practical performance based on gender, F(1,2) = 18.51, p =.180 at α=.05. The null hypothesis HO3 which stated that there is no significant difference in the achievement in terms of gender by students taught practical work using micro-kits with those taught using conventional class experiment apparatus was accepted. This implies that the effect on performance in practicals for both experimental and control groups was not based on gender. Gender did not have significant influence on practical performance.

4. Discussion of the findings

The findings of this study are consistent with those of Bradley (2000) who found out that the use of micro science apparatus by pre-service teachers had improved their conceptual understanding and pedagogical content knowledge in Chemistry. The study was done in topics such as titration and qualitative analysis of ions in South Africa as compared to the use of traditional equipment. Vermaak (1997) and Kolobe (1998) reported that there were satisfactory knowledge gains accompanying practical work that was carried out in their study using micro science kits as an alternative approach in science practical work in South Africa. This study findings are also consisted with those of Mafumiko (2008) who reported that the use of micro scale experiments in chemistry teaching have the potential to promote an active classroom learning environment through small group activities in Tanzanian secondary schools as compared to the use of traditional apparatus. Active learning eventually led to deeper intellectual insights and developments eventually leading to better achievement scores.

These findings are also similar to those found by Abdullah et al (2005). They reported that using micro chemistry experimentation improved students' scores when studying the topic of qualitative analysis of ions in Malaysia. Veemak et al (2003) found that pupils in South Africa significantly improved on their understanding of Stoichiometric concepts when taught using micro chemistry kits on experimentation practical work compared to the use of conventional apparatus.

Michieka et al (2013) reported that students achieved a better understanding of targeted volumetric analysis concepts during integrated representation of micro scale kits ICT integration and virtual laboratory in Kenyan secondary schools. These had more significant effect on the student's performance in practical work compared to the use of conventional apparatus. Hanson et al (2014) reported that the use of micro chemistry equipment enhanced understanding of chemistry concepts such as acid and base reactions in Ghanaian senior high school students compared to the use of traditional apparatus.

VI. Conclusion

The use of micro science kits appears to improve the student's achievement scores in secondary school Physics practical work. This suggests that teachers of Physics should recognize their potential of instruction in influencing student's achievement in practical work and general performance improvement in the subject. This study shows that poor performance in examinations can be mitigated by careful selection of instructional intervention styles and materials.

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