Towards an Enhanced Performance in Physics Practicals: The Microscience Kits Experience.

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Abstract

This study investigated students' performance in physics practicals through the usage of Microscience Kits (MSK) and Conventional Laboratory Apparatus (CLA) in Rivers State, Nigeria. The research design adopted for the study was a quasi-experimental, randomized pretest – posttest experimental design. Forty (40) Senior Secondary class 1 (SS1) physics students were selected by stratified random sampling technique for the study. Two research questions were answered and two null hypotheses were posited and tested at 0.05 level of confidence. The research instruments used for the study were "Reporting Physics Practical Package" (RPPP) and "Test on Verification of Ohm's Law" (TOVOL). Using a test-retest method and statistical formula of Pearson Product Moment Correlation, reliability coefficient of 0.81 was obtained for TOVOL. The obtained data were analyzed according to research questions and research hypotheses using the mean, percentage, standard deviation and Analysis of Covariance (ANCOVA).The findings of the study indicated that students that used the Microscience Kits (MSK) performed better than those that used the Conventional Laboratory Apparatus (CLA) in physics practicals. Male students that used the MSK performed better than their female counterpart, while for the usage of CLA, male students also performed better than female student. Based on the above findings, the following recommendations were posited: There is need for physics students to use microscience kits so as to provide practical experience and conceptual understanding of physics concepts. Physics teachers should also give attention and encourage female physics students during practical sessions such that both male and female students can perform better in the study of physics.

Keywords: accessibility, apparatus, inexpensive, unbreakable.

Introduction

Science has developed into one of the greatest and most influential fields of human endeavor. Today, different branches of science investigate almost everything that can be observed or detected and science as a whole, shape the way we understand the universe, planet, ourselves and other living things (Ogunleye and Adepeju, 2011). Science has become an integral part of human culture. Countries that ignore this significant truism are risking the potential aspiration of their future generation. It is therefore worthy to note that development of any nation depends, to a large extent, on the level of scientific education of her citizens.

Throughout the world, national education policies are geared towards creating generally scientific literate citizens. Specifically, the National Policy on Education of Nigeria clearly stated in its aims and objectives that the learner would be given opportunity to acquire basic practical skills for self – reliance and employment, Federal Government of Nigeria (2004). In realization of this laudable objective, practical activities should be an integral part of the teaching and learning of science in secondary schools because it proffers first-hand knowledge of science concepts. One thing that is certain is that science educators agree about the values of practical activities in science teaching. Huxley in Buseri (1989) recognized the relevance of practical activities to the extent that he expressed that "if scientific training is to yield its most eminent results, then it must be made practical".

Physics as a science subject is the study of physical properties of matter and its interaction with energy. It is typically an experimental subject; principles and concepts generated from physics are very useful in interpretation of natural phenomena in sciences. This means that effective practical activities in physics are important because they enable learners build a bridge between what they see, hear, handle (hands-on) and scientific ideas that account for their observations (brains-on). No meaningful physics principle or concept can be taught without adequate practical activity accompanying such presentation using appropriate practical apparatus.

Gbamanja (2002) stated that practical experience in science ensures student – centered learning, allowing effective interaction between the students and the learning materials. It is on this note that Awotua-Efebo (1999) explained that in other for a learner to effectively comprehend and accomplish a given task, the learner should be given the opportunity to actively participate in the teaching-learning interaction. Also, Obomanu and Nbina (2009) added that practical experience in science will improve students' cognitive ability and knowledge. Huan, Haur and Biaowen (2001) stated that the laws of physics are founded on experiments and that experiments are an integral part of a physics education. Therefore, in explaining to a child concept in physics, one must not be solicitous to fill him with abstract information, but one must be careful that the child understands what he learns. This reflects a strong view of relevance of practical activities and how science teaching should be directed. It is expected that upon completion of the secondary school physics programme, the learner should have acquired essential scientific skills and attitude as a preparation for the technological application of physics.

However, it is pertinent to state that most developing nations especially in Africa neglect these components of science education and as a result, they are incapacitated in their quest to achieve optimum developmental strides. Also, these third world countries are mere recipients of technology, perhaps obsolete and dumped by the developed countries. Studies have shown that the teaching of science has virtually been reduced to the dishing out of factual information by teachers which are as a result of insufficient practical, improper conduct of practical or inadequate conventional laboratory facilities (Onwioduokit, 2013) and (Adolphus & Aderonmu 2013). This scenario has relegated scientific inquiry, knowledge, literacy and practical experiences expected of the learners to the background promoting rote learning and memorization of scientific principles. It is quite unfortunate that the current trend of students' performance in physics as a result of lack of laboratories and scientific apparatus for higher rate of content retention, creativity, originality of thought and the inability to report appropriately practical activities has adversely affected student performance in physics.

The implications of the above entails students' lack of good practical knowledge and mastery of the requirement needed in the final senior certificate examination. With all these multifaceted problems, how can Nigeria train efficient scientists, let alone promote scientific literacy in her citizens which is indispensable to development, without experimentation using the appropriate scientific tools? How can we, like Japan, Russia, the United States of America etc, separate ourselves from the nomenclature "third world country" if there are no avenues for encouraging practical activities in our secondary schools which is the platform for scientific consciousness and development? Science will remain an abstract pursuit to learners so long as they are not exposed to its real application in daily lives. Technology will never be appropriate if students are not afforded means of contextualizing it. This should earnestly begin by the use of appropriate science equipment so that the learner can establish generalization based on a particular principle or concept.

Based on these shortcomings, the microscale (microscience kits) practical apparatus were produced. Microscience kits comprises of pre-selected collection of scientific apparatus designed to illustrate particular scientific principles, usually linked to curriculum material. They are also affordable and far cheaper than conventional laboratory apparatus and materials, (UNESCO, 2013). The first large scale microscience kits were produced in 1992 by the Research and Development in Mathematics, Science and Technology Education (RADMASTE) Centre at the University of the Witwatersrand in Johannesburg (South Africa). They are small, virtually unbreakable and inexpensive, and have been designed to enhance the quality, relevance and accessibility of science and technology education, also to involve the learner in applying scientific knowledge to real life situation (Rachmanwati, 2013). These microscience kits have been produced and introduced on a large scale to more than 80 countries including South Africa, Cameroon, Kenya, Ethiopia, Sudan, Tanzania, Gambia etc. This was achieved by introductory workshops for local educators and initiation of pilot projects. The general overall objectives of this project are to:

(i) promote practical science experimentation using microscience kits as an advocacy tools amongst policy makers
(ii) improve science curricula by inclusion of hands – on experimentation for a better understanding of science
(iii) increase the interest of young people in science so as to promote gender equality, scientific literacy and choice of a scientific career, UNESCO (2013).

Although several countries in Africa have subscribed to this new paradigm in science teaching and learning, however, the use of microscience kits has not been employed in Nigerian secondary schools for science teaching. In light of the above, the study was carried out to determine students' performance in practical physics through the usage of microscience kits.

Purpose of the study

The purpose of the study is to determine the impact of microscience kits usage on students' performance in physics practical. Specifically, the objectives of the study are to:

1. Compare the impact of the usage of microscience kits and conventional laboratory approach on students' performance in electricity practical.
2. Compare the effect of the microscience kits usage and conventional laboratory approach on male and female students performance in electricity practical.

Research Questions

The following research questions were stated in conducting the research work;

1. How does the impact of the usage of microscience kits on students' performance on electricity practical differ from the usage of conventional laboratory apparatus?
2. What are the relative effects of the usage of microscience kits and conventional laboratory apparatus on male and female students' performance in electricity practical?

Research Hypotheses

Ho_1: There is no significant difference between the mean performances of students using microscience kits and those using the conventional laboratory kit in electricity practical.

Ho_2: There is no significant difference between the mean performances of male and female students in electricity practical considering microscience kits usage and conventional laboratory apparatus usage.

Methodology

The study was a quasi-experimental study adopting a Randomized Pretest – Posttest experimental design. The population of the study consisted of all Senior Secondary (SS 1) physics students in Port Harcourt Local Government Area of Rivers State. A stratified random sampling technique was employed to obtain a sample size of 40 participants which consisted of 23 male and 17 female SS1 physics students. These students were further grouped into experimental (microscience kit) group and control (conventional laboratory apparatus) group. The experimental group consisted of 20 students (13 male and 7 female), while the control group consisted of 20 students (10 male and 10 female).

Instrument for data collection

The instruments for data collection were developed by the researchers and titled Reporting Physics Practical Package (RPPP) and Test on Verification of Ohm's Law (TOVOL). Reporting Physics Practical Package (RPPP) consists of a lesson note that was taught on conducting and reporting of physics practical while Test on Verification of Ohm's Law (TOVOL) was made of practical activity questions developed on electrical circuit connection to verify Ohm's law.

TOVOL was used for both pre-test and post-test to measure students' performance on conducting physics practical. The instruments were validated by two experts in physics education. TOVOL was subjected to a pilot test applying the test-retest method for an interval of a week to ten (10) physics students outside the area of study. The data obtained was analyzed using the Pearson Product Moment Correlation and a reliability index of 0.81 was obtained making the instrument reliable for the study.

Procedure for Data Collection

The collection of data was systematically organized in three different phases; Pre – treatment phase, Treatment phase and Post – treatment phase.

- Pre – treatment phase: The intention of the researcher was made known to both the students involved in the study. This was done to obtain co-operation from the teachers and laboratory assistance. The microscience kits were distributed to the experimental group while the control group used the laboratory apparatus for a general pre-test.
- Treatment phase: The treatment phase involved the teaching session for both groups on conducting and reporting of physics practical. This consisted of practical demonstrations using the microscience kits for the experimental group and the control group using the conventional laboratory apparatus. Three (3) periods per week of 40 minutes/per period for two (2) weeks was used for the treatment phase for the study.
- Post – treatment phase: After the treatment, the TOVOL was be administered to the groups as post – test.

Method of data analysis

Simple means, percentage and standard deviation were used for the research questions while Analysis of Covariance (ANCOVA) was utilized for the testing of the hypotheses.

Results

Research Question 1.

How does the impact of the usage of microscience kits on students' performance on electricity practical differ from the usage of conventional laboratory apparatus?

Table 1: Performances of students that used microscience kits and conventional laboratory apparatus.

Treatment	Test	No	Mean	Mean Gain	Mean Gain %
Conventional lab kits	Pre test	20	28.798	10.652	36.989
	Post test		39.450		
Microscience kits	Pre test	20	28.987	16.136	55.666
	Post test		45.123		

Source: Researcher's fieldwork, 2014.

From the Table above, it was shown that the students that used the microscience kit in conducting the electricity practical had a gain of 16.136 while those that used the conventional laboratory apparatus in conducting the electricity practical had a gain of 10.652 when the pretest and posttest were compared. The percentage mean gain also revealed that students that used the microscience kit had a percentage mean gain of (55.666) while those that used the conventional laboratory apparatus had a percentage mean gain of (36.989). Based on the analyzed data in the above table, students that used the microscience kit in conducting electricity practical performed better than those that used the conventional laboratory apparatus.

Research Question 2.

What are the relative effects of the usage of microscience kits and conventional laboratory apparatus on male and female students' performance in electricity practical?

Table 2: Showing the Performances of male and female students that used microscience kits and conventional laboratory apparatus.

Treatment	Sex	Test	Mean	Mean Gain	Mean Gain %
Conventional lab kits	Male	Pre test	33.108	10.917	32.974
		Post test	44.025		
	Female	Pre test	24.487	10.388	42.423
		Post test	34.875		
Microscience kits	Male	Pre test	34.038	18.868	55.432
		Post test	52.906		
	Female	Pre test	23.937	13.404	55.997
		Post test	37.341		

Source: Researcher's fieldwork, 2014.

The result shown in Table 2 above revealed that the posttest mean values in terms of gender and utilization of microscience kits (MKS) and conventional laboratory apparatus (CLA) were higher than the pre-test mean values. The performance gain of students that used MKS for male was 18.868 while that of female was 13.404. This indicates that male students that used MSK performed better than their female counterpart. The table also showed the performances of both male and female students that used the CLA. The male students (CLA) had a gain of 10.917, while the female students (CLA) had a gain of 10.388 indicating that the male (CLA) students performed better than the female students.

Hypotheses

Ho_1: There is no significant difference between the mean performances of students using microscience kits and those using the conventional laboratory kit in electricity practical.

Table 3a: Showing the Univariate analysis of mean performances of students that used MKS and CLA.

Source	Type III Sum of Squares	df	Mean Square	F
Corrected Model	6407.825[a]	2	3203.912	67.347
Intercept	20971.520	1	20971.520	440.823
Treatment	300.313	1	300.313	6.313
Test	6107.513	1	6107.513	128.380
Error	3663.163	77	47.574	
Total	174873.000	80		
Corrected Total	10070.988	79		

a. R Squared = .636 (Adjusted R Squared = .627)

As shown in table 3a above, the calculated $F_{1,77}$ value is 6.313 at degree of freedom of 1,77 and probability level of 0.05 against the critical value of 3.840. Since the calculated F value is greater than the table value, the null hypothesis is rejected and the alternative hypothesis is accepted. This indicates that there is significant difference between the mean performances of students using microscience kits and those using conventional laboratory apparatus in electricity practicals.

Table 3b: showing the dependent variable; performance

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Conventional lab kits	34.124	.725	32.690	35.558
Microscience kits	37.055	.737	35.598	38.513

Based on the estimated marginal means at 0.05 level of significance, table 3b indicated that students that used the microscience kits contributed most to the significant difference between the effects of the practical kits.

Ho₂: There is no significant difference between the mean performances of male and female students in electricity practical considering microscience kits usage and conventional laboratory apparatus usage.

Table 4: Showing the Univariate analysis of mean performances of male and female students that used MKS and CLA.

Source	Type III Sum of Squares	df	Mean Square	F
Corrected Model	6114.851[a]	4	1528.713	29.136
Intercept	3054.217	1	3054.217	58.211
Test	5853.960	1	5853.960	111.572
Gender	62.786	1	62.786	1.197
Treatment	117.717	1	117.717	2.244
Gender * Treatment	95.188	1	95.188	1.814
Error	3935.099	75	52.468	
Total	175852.000	80		
Corrected Total	10049.950	79		

a. R Squared = .608 (Adjusted R Squared = .588)

From Table 4, it was shown that the interaction between gender and treatment is not significant since its calculated $F_{1,75}$ value is 1.814 at degree of freedom of 1,75 and probability level of 0.05 against the $F_{1,75}$ critical value of 3.840. Since calculated F value is less than the F table value, the null hypothesis is upheld. This showed that there is no significant difference between the mean performances of male and female students in electricity practical considering microscience kits usage and conventional laboratory apparatus usage.

Discussion of findings

The finding of research one also agrees with the result of Bradley and Vermaak (1996) were they mentioned that students that used the MSK showed overwhelmingly positive attitude towards practical work also indicating an improved conceptual understanding in science experiments. Yoo, Hong and Yoon (2006) also found that Korean High School students perceived that microscience kits for chemistry experiments were convenient, marvelous and interesting and also suitable for doing experiments individually or in a group. Kelkar and Dhavale (2000) also reported that undergraduate students performed experiments with more care and their skills in handling the equipment were markedly improved after adoption of this new technique in their laboratory.

These findings are supported by Bradley and Vermaak (1996) who reported high positive mean values for the African pupils' perceptions of handling and managing the microscale experiments. They felt that microscale experiments were beneficial, fun to do and made them enjoy practical work. In contrast, McGuire, Ealy, and Pickering (1991) found a persistent preference for macro experiments over microscale experiments.

The findings of research two conform to the findings of Orukotan and Balogun (2001) were it was revealed that male students performed better in science than the female students. The study of Raimi and Adeoye (2006) is in agreement with the result of this study were it was mentioned that there is a significant difference between the performance of male and female students in Science subjects in favour of males. Kolawole (2007), Afuwape and Oludipe (2008) also found out that there are significant differences in the cognitive, affective and psychomotor skills of science students in respect of gender. Hyde, Lindberg, Ellis and Williams (2008) stated that boys exceeded girls in complex problem-solving in the high school years. Sainz and Eccles (2011) also discovered that boys in Spanish Secondary Schools perform better and have high self-concept of science Mathematics and computer abilities than girls.

Njoku (2001) confirmed that girls believe that Science is too difficult and not important for their future. Mujtaba and Reiss (n.d) in agreement with the findings of the study revealed that boys were more positive about practical work and are looking forward to spending time in the laboratory doing practical investigations having the opportunities to test out their own ideas than their female counterpart. Contrary to the findings of this study, Macmillan (2013) found that that there was no significant difference in the mean achievement score of male students exposed to practical Physics and that of their female counterparts also exposed to practical Physics. Aina and Akintunde (2013) revealed that there is no significant correlation between male and female performance in physics. This implies that performance of any of the gender can in no way affect the performance of the other. It means one could not predict the performance of female students from male students or vice versa; they are independent of one another. The study of Croxford (2002) is contrary to the findings of this study who believed that girls can perform better than their male counterpart because the intellectual potential of girls is an untapped labour resource for Science and Technology.

Recommendation

In light of the findings of the study, the following were recommended;

1. There is need for physics students to use microscience kits so as to provide practical experience and conceptual understanding of physics concepts.
2. Physics teachers should also give attention and encourage female physics students during practical sessions such that both male and female students can perform better in the study of physics.

Conclusion

Using microscience kits for practical activities in the teaching and learning of physics provides the learner with new skills, increase understanding of concepts and stimulate their interest to do experiments and learn science. Observations using these kits can be clear and quickly done ensuring accurate results if appropriately utilized. Learners will be active participants in the teaching and learning process during practical classes reducing or eliminating the idea that physics is a difficult subject.

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