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Assessing the effects of Biology Practical Activities on Academic Performance of Senior Secondary School Students, Zambia.

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Abstract

The study was designed to explore how practicals work affects the academic performance of learners in biology sciences using pre-test and post-test approach for the quasi-experimental control group (CG). A sample size of 90 students divided into two groups; (N = 45) for the experimental group (EG) taught by incorporating practicals into their learning strategy and (N = 45) for a control group (CG) taught using traditional methods. Data collection in this study was carried out through questionnaires, student pre-test and post-post. The data analysis was done using statistical instruments, such as mean, standard deviation and descriptive autonomous testing statistics of the null hypothesis at $\alpha = 0.05$. From the results, the average means of EG ($\bar{x} = 60 \pm 12.38$) and CG ($\bar{x} = 49 \pm 9.90$) were statistically distinct (t-test; $(0.00) < (\alpha = 0.05)$) indicating that practical biological work substantially enhanced the learner's performance. Also, statistical testing in the performance between boys and girls in the EG obtained a p-value $(0.51) > (\alpha = 0.05)$, which meant that the performance was collectively enhanced. The integration of practical work in teaching biology or any science topics will, therefore, positively improve learner's performance.

Keywords: Practical Learning method, Conventional Learning Method, Learners performance, practical work

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1. Introduction

Overall, practical work has become a well-established and integrated component of secondary school science (Poppe, Markic and Eilks, 2010). In fact, since 1988, the National Curriculum of England emphasis on practical work has made it become a crucial entity of biology, chemistry and physics lessons (Kolucki and Lemish, 2011). Studies have shown that understanding and performance of learners in science, including biology, is accomplished through the integration of practical work into the teaching process (Aladejana and Aderibigbe, 2007).

Using well -designed specialised training, practical work in biology enable learners to investigate, evaluate testable scientific concepts hands-on and develop scientific skills. It allows learners through concepts, theories and models to improve their knowledge base and understanding of the world around them (Millar and Abrahams, 2009). Students, thus, encounter the fundamental and incorporated procedures of science (Padilla, 1990). Numerous researchers have highlighted that practical work is enjoyable for learners and enhance their effectiveness in learning science (Jenkins and Nelson, 2005; Hodson, 1993)

Sometimes, the presentation of the experiential learning approach would only lead the learners to perceived practicals as hard and tedious according to (Manda, 2012). Due to insufficient resources, absence of practical skilled teachers and large teacher-to pupil ratio, some schools do not conduct practicals (Ramnarain, 2014). Sometimes, only a few biology teachers conduct practicals with their learners during the standard learning period. The learners are only exposed to practical work towards examination period when the time isn't adequate to appreciate the essence of them. Biology practicals continue to be a challenge to the candidates, according to Ministry of General Education ((MoGE), 2018) because most of them fail to follow the stipulated procedure or use the given specimens properly. Also, some teachers do not provide the learners with adequate guidance on how to report their results during the practicals sessions (Examination Council of Zambia (ECZ), 2017).

The poor performance of learners in biological sciences at Mindolo Secondary School: 2014 (45%), 2015 (51%) and 2016 (57.3%) in the county of Copperbelt, Zambia motivated the study. Although a slight upsurge in the performance, it is contrary to the performance at the national level (ECZ, 2017. For this reason, the author endeavoured to design a study to determine how practical work would impact on the' performance of the learners per (Hayward, 2003). Furthermore, assess how failure ineffective training in practical skills may lead to poor performance.

2. Literature review

Like any other science, biology is vital for the social and economic growth of any nation. First world nations, for example, China, USA, UK and so on appreciate the advantage of scientific headways since they have embraced the board of knowledge of science, including biology. In perspective of reality, MoGE educational policies vibrantly emphases the essence of science, including biology as a wellspring of information and comprehension of the intricacy of our physical world and different types of life. (Saudi, 2016). The emerging innovations in biology encompass and moves everybody to the learning of Biology. In this way, obtaining new aptitudes, attitudes and values for effective teaching and learning of biology in secondary schools are eminent. In this regard, training students to acquire scientific skills is essential for handling practical works in biology.

The holistic approach to attaining biology'social, ethical and values requires the government to adequately equipped laboratory for efficient, practical activity and conducive atmosphere that creates a positive attitude for teaching and learning. According to (Abrahams and Millar, 2008), by enabling learners to engage actively in practice, the professor should guide and guide learners in the necessary development skills an
lead them in the conceptual comprehension of the practical activities.

As per (Committee on High-School Biology Education, 1989), teaching effective goes beyond just a lecture method. Planning a teaching approach that centres on learners via visual guide, fieldwork, and handling real objects are valuable assets in effective teaching than all talk. Biology is a science that involves both theory and practical work if it must be taught or learnt effectively. In such a case, a laboratory is crucial for effective practical actives in science. (Iloeje, 2005; Killermann, 2010) indicated in his studies that visual sense is the highest of all senses, and it is necessary for effective biology practical activities. Learners tend to appreciate things seen more than spoken. According to (Kildare & Okoro, 2007), a student can easily understand the concepts when he/she is involved in the practical activities that are following procedure, collection data and concluding. A sense of achievement is felt by students and teachers alike when practicals coincide with theory.

ECZ (2005) stressed the noteworthiness of theory and practicals in science projects in the secondary school curriculum in Zambia. Likewise, presenting the learners to adequate practical activities will enable learners to associate and value the theory and practicals aspect of biology. The theoretical and practical parts of biology need not be isolated but taught as segments portions of a subject and not as a different entity.

Albeit practical work is thought to be essential for all students, some studies have indicated that girls and boys vary in the way they respond to experimental work (Gardner, 2008; Gerber, 2015) Practical work is beneficial to learners through interactions, hands-on activities, and application in science" (Hampden-thompson and Bennett, 2013). Gardner (1975) displayed that sex may impact pupils' dispositions towards science which was further attested by research conducted in Ghana (Hampden-thompson and Bennett, 2013) Anderson, (Sjoberg & Mikalsen, 2006), England (Jenkins, 2006), Israel (Trumper, 2006) and Finland (Lavonen , 2008) where boys and girls will, in general, have various mentalities to comparative educating styles. Converse to this, (Kibirige and Tsamago, 2013) showed that in the same learning or teaching environment, the frames of minds of boys and girls towards science would be similar. Hence, because of these contrasting perspectives regarding the performance between boys and girls, the study will investigate how practical activities affect performance based on gender.

3. Statement of the problem

Although the practical learning approach is an efficient way of teaching biology, practicals are still not being performed in seniors secondary school in Zambia, and are the reason for poor performance (ECZ: 2015). In a study, (Haambokoma, 2007) stated that science teachers are shunning from performing biology practicals in most school in Zambia. Teachers still rely on the old-fashioned way of teaching (Ezeliora, 2004) as such lecturing, teacher disposition and dictation. In some cases, teachers may prefer these ineffective conventional teaching approach owning to the absence of laboratories facilitates or necessary skills to conduct practical (Kibirige and Tsamago, 2013). Traditional learning techniques only results in teachers relying highly on textbooks depriving learners stimulation of higher-order thinking and conceptual understanding of biology concepts taught through practical work and experience. In these case, the learners are exposed to learning disposition without an appreciation of practical work during experiments, i.e. as cookery books approach. Therefore, a study was designed to determine how practical work would affect and improve the learners' performance in biology.

4. Methodology

4.1. Research design

The evaluation of the effects of practical work on senior learner performance in biology was carried out using a quasi-experimental model, as per (Campbell and Stanley, 1963). Participants were purposively chosen and divided into two groups designated as the experimental group (EG) and control group (CG). Both groups underwent pre-testing to determine the level of comprehension of content in biology and the calibre of the learners. The topics taught to both groups were Nutrients and Diffusion, where the EG lessons of the EG were presented through a practical approach, whereas the EG were taught solely through the traditional method.

EG **Oa X Ob**

CG **Oa - Ob**

- **Oa;** indicated the observations made of the performance means for the pre-test for both the CG and EG. Statistical testing was performed to determine the calibre of the learner in both groups.
- **X;** indicated the parameter that was used to evaluate the effects of practical learning approach in teaching nutrient in biology for the EG while engaging only a conventional method with CG.
- **Ob;** indicates the observations made after post-test to both EG and CG. Statistical testing between the pre-test and post is conducted to establish the difference in performance.

4.2. Sample of study

The study constituted ninety (90) purposely selected grade 10 biology students split into two groups: EG (N=45; 26 boys and 19 girls) and CG (N=45; 26 boys and 19 girls) from Mindolo secondary schools of Kitwe District, Zambia. Likewise, five (5) biology teachers from the same school were also purposely chosen to represent the population of the sample as per (John and Sons, 2004) concept on the target population. The EG group was taught using a practical approach to learning while the CG was taught using the conventional teaching technique.

4.3. Instruments

The activities designed by the teacher were used to evaluate performance for both EG and CG as pre-test and post-test. The items in the pre-test and post-test were inline with the learning objectives of the fundamental concepts of practical work in biology. A panel of experienced biology teachers in the Department of Biology and lecturer at the local university assessed the tools for reliability and suitability to guarantee the validity of the content. The teacher and student questionnaires were also sued as a second dependent variable to evaluate the effects of practical work in learning of biology.

4.4. Data collection

Data was collected through pre and post-test over four weeks by two dependent variables. Firstly, both the EG and CG took a pre-test to determine the homogeneity in academic calibre. The four-week involved; Activity I; food testing under nutrient; and Activity II: Osmosis under Diffusion. In EG, the learners were taught by practical learning approach where they could handle the apparatus, performed experiments, collected data, analysed data and drew conclusions.

Meanwhile, the CG was taught using conventional, for example, lecture approach and giving notes. Both groups took identical post-test after four weeks of the learning period. Data collection through a second dependent variable was through teacher and pupils' questionnaires.

4.5 Data analysis

The data collected were analysed using Minitab 18 software using descriptive, inferential statistics Since the sample size was minimally manageable, a paired sample t-test was performed to test the statistical significance between the performance means of both FG and CG at the $\alpha = 0.05$. Similarly, a t-test and Mann-Whitney U-test were used to determine performance in boys and girls in EG. The alpha level (α) for both significance tests was set at 0.05, as stated above. The confidence level was at 95% for both tests' groups. Pre-test results were used as a covariate to regulate initial group variations, decrease the variance of errors, and remo ve systemic bias (Dimitrov and Rumrill, no date). The sample size effect was computed using cohen d (Cohen, 1988).

5. Results of the Study

The assessment of the impact of biology practical activities on the academic performance of senior secondary school students was achieved by performing pre-test to both the EG and CG. The purpose of the pre-tested was to establish the learners understanding of the subject matter and determine the statistical difference in the academic performance of the groups. Further, the teaching strategies were designed to be independent variables where the learner performance was examined as a dependent variable the study comprised of ninety participants purposively selected and divided into two groups (*N*=45).

Test of Normality

Using Kolmogorov-Smirnov (KS) (Pallant, 2007) approach testing for normality is conducted to determine if the results a normally distributed and help decide the appropriate statistical parameter for analysis.

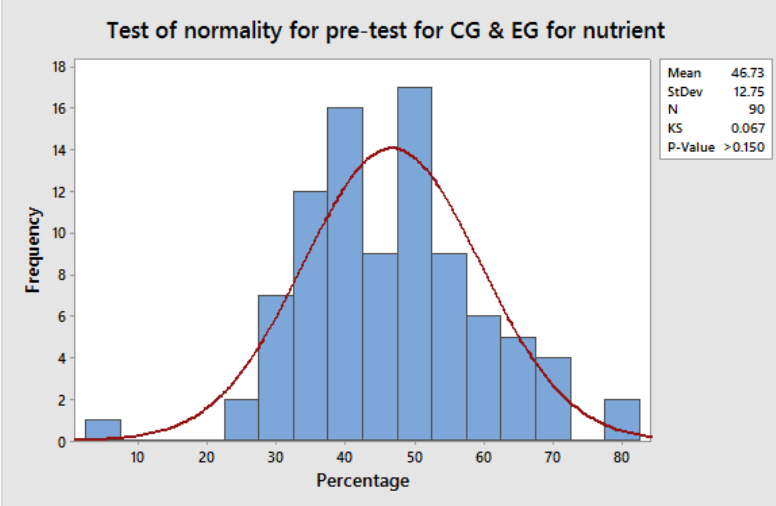


Figure: 4.1. Test of normality

As observed in figure 1, KS values and p-value (0.15) > α = 0.05, the null hypothesis (H_{o1}) cannot be rejected, suggesting that the distribution of the results was Gaussian. Therefore, parametric tools such as independent t-test can be employed to analyse the data to determine if there is be a significant difference in the dependent variables between CG and EG (McMillan and Schumacher, 2010).

Table 1.1: Descriptive Statistics of the pre-test score using a paired t-test

Sample	N	Mean	StDev	SE Mean
CG	45	45.51	12.47	1.99
EG	45	47.96	11.79	1.81

Table 1 shows the performance means of CG and EG for the pre-test scores, which are 45.51 % and 4% with a standard deviation of 12.47% and 11.79% respectively.

Table 1.2: Levene's test

Variable	N	StDev	Variance	Method	Test Statistic	DF1	DF2	P-Value
CG	45	12.465	155.371	Levene	0.05	1	88	0.824
EG	45	11.785	138.892					

Using Levene's test P-value (0.824),> (α = 0.05) signifying that the variances and performance means are statistically the same for the CG and EG indicating the quality of the learners to be the same thus rejecting the null hypothesis.

Research question one: What is the effect of practical work on pupils' performance in biology in senior secondary school?

Table 1.3: Descriptive Statistics of the post-test score using a paired t-test

Sample	N	Mean	StDev	SE Mean	P-Value
CG	45	49.73	9.90	1.48	0.000
EG	45	60.42	12.39	1.85	

The performance means of the post-test for CG and EG were 49.73% and 60.42% with the standard deviation of 9.90 and 12.39, respectively. The p-value (0.000) obtained was less than (α =0.05); therefore, the null hypothesis (H_{01})was rejected signifying a significant difference between the performance mean of the CG and EG in the post-test score. Given the fact, it is sufficing to mention that practical significantly improved the performance of the learners.

Table 1.4: Levene test for variance

Variable	N	StDev	Variance	Method	Test Statistic	DF1	DF2	P-Value
CG	45	9.900	98.609	Levene	0.29	1	88	0.590
EG	45	12.390	153.522					

Levene's methods validated to test for any continuous distribution was conducted to determine the similarity in the variances of the individual groups. P-value (0.590) > (α = 0.05) meaning that there is no significant difference in the variances.

Research Question Two: How does the performance of the experimental group taught using practical method differ with that of the control group taught using lecture approach based on gender?

Since the difference in population size between the male and female in the EG is large, a non-parametric tool Mann-Whitney test was utilised to test the null hypothesis on performance with regards to gender.

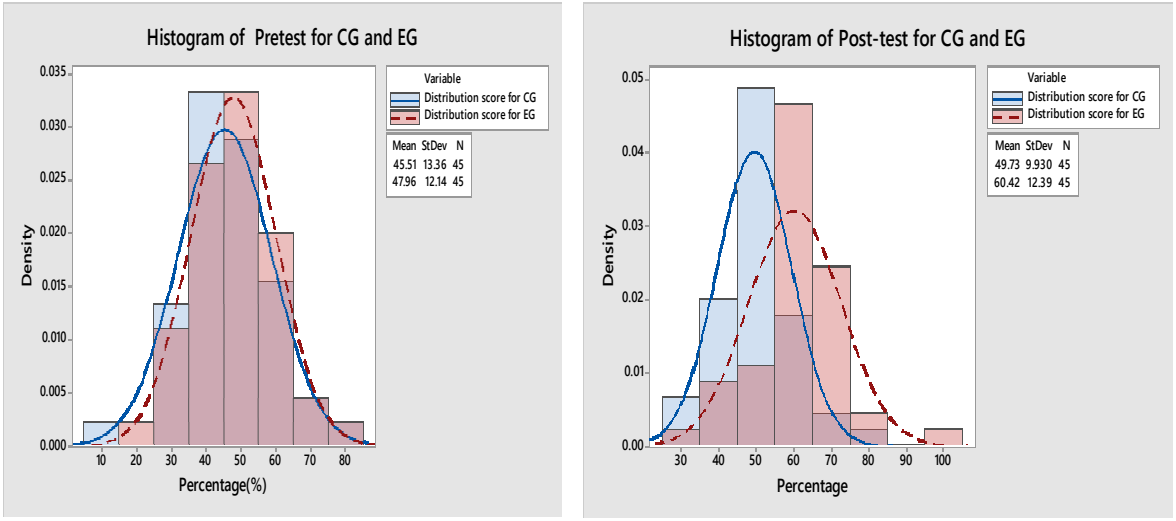
Table 1.5: Mann-Whitney test for performance based on gender in EG

Sample	N	Median	Method	W-Value	P-Value	Difference	CI for Difference	Achieved Confidence
Female	19	63	Not adjusted for ties	466.50	0.505	2	(-5, 9)	95.06%
Male	26	60	Adjusted for ties	466.50	0.505			

From table 1.5, since p-value (0.51) > (α = 0.05), we fail to reject the null hypothesis (H_{01}) suggesting that the performance means demonstrated no statistically significant difference in performance in biology between learners who are taught using experiential learning approach and conventional approach based on gender. Integration of empirical work in the biology learning process yielded better outcomes for both males and females in the EG,

Graphical description of the Pre-Test and Post-Test.

The initial step of subjecting both the CG and EG to a pre-test under similar conditions and activities enabled to established that the learners in both groups exhibited homogenous academic calibre, as shown in figure 2. Figure 2 depicts a histogram that describes learner performance information in a continuous variable according to (Pallant, 2007)



(i) (ii)

Figure 4.2: Performance distribution score (DS) of the learners' pre-test and post-test CG and EG.

Figure 4.2 depicts a comparative performance distribution score after one group was taught by a conventional method (i) and the other by experiential learning method (ii), the performance means for EG (ii) skewed to the right, indicating better performance. It can be deduced from this that the experiential learning method is a better alternative when teaching practical topics in biology, which is shown by improved performances of the learner for both male and females' learner alike.

4. Discussion

5.1 Effect of practical work on students' performance in biology in senior secondary school?

As shown in Table 1.2 and 1.3 practical learning is essential to improving learner's performance in biology. The performance means of EG was significantly higher than that of the CG signifying that learners taught using practical work had a better understanding of the biology concepts converse to those taught without practical work as shown by (Aladejana and Aderibigbe, 2007; Kibirige & Tsamago, 2017) . Practical work offers tacit knowledge that cannot be verbally taught and can only be communicated by nonverbal interactions through hands-on activity, i.e. it is an action-based activity (LaFemina, 2002). Given these facts, it is recommending that practical skills, confidence and positive attitude towards practical work be inculcated during the teachers pre-service and in-service training in biological sciences.

4.2. How does the performance of the experimental group taught using practical method differ with that of the control group taught using lecture approach based on gender?

As highlighted in Table 1.5, a practical learning approach collectively improved the mean performance of both male and female in the EG. In the post-test, both males and female in the EG performed significantly better than those in the CG. The achievement in science topics is collective when both the male and females are offered equal learning opportunities (Bussey and Bandura, 1999). Practical work does not rely upon gender, but it is enhanced by various parameters, for example, sufficient facilitates, practice, confidence and adequately trained teachers and a positive mindset towards sciences.

4.3. What are the factors affecting the implementation of biology practical lessons?

Questionnaires were designed to survey the factors affecting the implementation of biology practical work in secondary schools. The questionnaires participants were biology teachers (N = 5) and students (N= 90; 52 males and 38 female).

Item 1: What are the factors that affect the implementation of biology practicals at Mindolo secondary school?

There is a significant complaint from the teacher perspective about over enrollment. The teacher-pupil ratio is large, which makes it hard for adequate learning, as bayo (2005) stated that a smaller number of pupils enhance efficiency in learning due to easy access, including the slow learner. In a large class, learners can easily sideline

the intended task. Consequently, laboratory facilities may not be enough to accommodate large volumes of pupils and attain efficient practicals work. Lack of interest by some teachers to conduct practicals, as the questionnaire indicated 40% of the teachers thought that practicals did not affect the learner's performance. Besides, some teachers are overloaded, which meant it is hard for them to prepare and later conducts practical work efficiently. In this regard, the teachers are unable to impress upon the learner the intended outcome and appreciation of ordeal.

Item 2: Availability of the laboratory /reagents/equipment for biological practicals.

All the respondents, 100% indicated yes to the availability of the laboratory. 37.6% of respondents (pupils) stated that reagents are always in the laboratory, while 43.0% said sometimes. 16.1% never reported, while 3.2% of the respondents give non-responsive. 88.2% agreed that the school had laboratory equipment, while 11.8% of respondents stated that the school had no equipment. However, all the 5 (100%) teachers confirmed of the school having laboratory and procures materials and reagents for biology practicals.

Item 3: Are practical conducted and how often?

47.3% of the respondents indicated that they did practicals weekly, while 20.4% stated that they did practicals every fortnight. 28.0% said that they did practicals monthly, and 4.3% of the respondents claimed they never did any practicals at all. All 5 (100%) teachers acknowledged having conducted practicals. 40% of the teachers conducted practicals every fortnightly, while 60% only conducted one per practicals monthly.

Item 4: Are practical enjoyable?

60.2% of the respondents agreed to find practical pleasant, while 35.5% of the respondents strongly agreed, 3.2%. As for those that strongly disagreed were 1.1% of the respondents while for those who opposed were 3.2% of the respondents. 4 out of 5 teachers representing 80% agreed while 1 out of 5, representing 20% strongly agreed that the pupils appreciate or enjoy practical work. Although 1.1% of respondent thought that practicals weren't enjoyable, all the respondent felt that practicals are enjoyable.

Item 5: Practical affect learner performance.

37.6% of the respondents agreed to practicals affecting performance while 58.1% disagreed. 4.3% of respondents were non-responsive to the question. In this view, over 50% of the learners thought practicals did not influence the performance of grade 12 biology results. 90.5%of, the respondents indicated yes to practical enhancing biology concepts. 2.2% disagreed while 4.3% were non-responsive to the question. 36.6% of respondents reported yes to the school having textbooks for biology practical. 60.2% said no, while 3.2% were non-responsive to the question. 3 (60%) out of 5 teachers strongly agreed to laboratory practicals work the performance of pupils in Biology while 1 (20%) out of 5 disagreed while 1(20%) out of 5 strongly disagreed. In view, the facts aforesaid, over 50% of the learners thought that the school had no practical textbooks and had no influence on the performance of grade 12 biology results. 40% of the teachers felt that practicals did not influence the performance of the learner.

5. Conclusion

The student in the EG taught using a practical learning approach performed better than those in CG who were instructed using the traditional lecture technique, suggesting that integrating of experimental work into biology teaching would improve performance of learners. Also, improvement is collective for both boys and girls. Experimental teaching strategy, therefore, has a positive effect on the' achievements of learners in biology compared to the conventional teaching method such as lecturing which is ineffective in achieving better outcomes.

6. Recommendations

Based on the outcome of the study, the following are the recommendations;

- Practical learning approach to be incorporated in teaching practical biological topics such as food test, osmosis, etcetera.
- Teachers of biology undergo intensive in-service training and continuous professional development (CPD) with peers in the school department to enhance practical biological skills
- MoGE quick track science teacher with deficient practical skills and motivate the individuals who already skilled and experienced to coordinate practical work in science instructing.
- Pre-service teacher training institutions to have adequate experimental work to cultivate the fundamental and higher order-thinking abilities in new teachers.
- Physical Sciences schools ought to have labs and prepared practical research specialists to help teachers.

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