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Designing a Package to Minimize Errors in Physics Practical Lessons in Nigeria Secondary Schools

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Abstract: The study focused on the design of an Error Correcting Instructional Packages (ECIP) for secondary school physics practical. The study was designed to validate ECIP as a good instrument to reduce errors in physics practical. A Quasi experimental design of the three group pre-test, pos-test control design was employed. The treatment group was taught using the new package (ECIP), the conventional group was taught with the traditional practical teaching approach while the control group was not treated at all. The sample consisted of 60 physics students selected from different Government Colleges. Two null hypotheses were raised for the study and tested using one-way ANOVA. The study ensured the homogeneity of the three groups. The study confirmed the use of ECIP to be very effective at reducing errors committed by students during physics practical. The drastic reduction in the errors committed after the treatment using ECIP inform the recommendations of the usage of this new package (ECIP) in all secondary schools in Nigeria.

Key words: Designing, ECIP, errors, practical lessons, physics

INTRODUCTION

Physics is an inquiry oriented subject, to which practical work is very essential. It involves students' acquisition of series skills such as observing carefully, classifying, interpreting, predicting events, designing experiment, organizing information, reporting completely and accurately and of course generalizing (Akale and Isa-Usman, 1993). The experience in laboratory works reveals that costly mistakes are often made in physics practical, which normally lead to errors. The problems can be traced to how to handle apparatus; the method of recording; how to have better observation and the best way of analyzing the data collected accurately.

Even though the conditions prevailing in different schools vary, a number of general shortcomings appears to have been identified in the handling of physics practical. Generally, students seem not to pay good attention to vital areas of practical works and hence commit errors which sometimes render their works useless. Owolabi (2003) observed that it is almost impossible to obtain a result in measurement which is absolutely free from errors. In physics practical therefore, it appears that errors cannot but occur. The concern here should be how the errors can be reduced to the minimum. If the experimenter obeys the rules guiding practical works, if he observes necessary precautions, if students gain more confidence in physics practical, if they are exposed to various common tips in practical as it is done in schools and errors still become prevalent, it is felt that a systematic and programmed research package is inevitable for solving the problem of errors in physics practical.

Barford (1967) and Raymond (1981) maintained that while Random errors are caused by intrinsic fluctuations in the apparatus, systematic errors may arise from faults or changes in conditions which could be corrected, such as zero error of an instrument. In this case the "standard" or "true value" must be found. When error is removed from a measurement the value of that measurement should improve. This idea of subtracting the zero error either from each measurement or from the average measured values is applicable to systematic error since the effect occur according to a system which, if known can always be expressed by mathematical formulation $X_c = X- e_s$. Raymond (1981) maintained that this depend on the observer, the instrument used or physical environmental conditions of the observational experiment.

Assur and Filator identified different sources of errors such as, Random, Systematic, Personal, instrumental, environmental, Blunder, Estimation and Graphical errors. Experience has shown that more than twenty errors can be practically identified in physics laboratory works. The West African Examination Council (WAEC) an examination body in Nigeria, discovered that the practice of grooming candidates only for examination purpose undermines the aim of conducting practicals in science education (Osho and Ijitola, 1990).

Students are always surprised when they discover that different results are obtained in a single experiment when different people worked on it, using the same apparatus under the same experimental conditions. Their puzzle appeared to be that no effort seems to act as antidote to the committance of errors in physics practical. The problem of common errors in physics practical. The problem of common errors in physics practical therefore, calls for conscientious and urgent solution. It is therefore, desirable that an organized research investigation is carried out on how to minimize the error that occur in physics practical. This will involve specifically developing a package of instruction for physics practical lessons that could directly focus on errors and specific steps for minimizing or correcting them.

Purpose of the study: Performance of students in practical work depends on value accuracy and how best they could avoid mistakes or errors that frequently occur in physics practical work. The study was designed to investigate common errors in students' physics practical works. The study also involved the designing of a model in form of a package which was tested on an experimental group with the expectation that it will influence positively their performance in physics practical works. Common errors which have been a major negative effect on physics experiments were adequately investigated. The reduction in errors committed would lead to better performance in physics practical works.

Hypotheses: Two null hypotheses were formulated for this study.

Ho_1 : There is no significant differences in the errors committed in physics practical before treatment with ECIP.

Ho_2 : There is no significant difference in the errors committed in physics practical after treatment with ECIP.

MATERIALS AND METHODS

Design: The study employed the use of a Quasi experimental design using a pre-test, post-test three group design. The three groups were:

- Experimental group.
- Conventional practical class.
- Control group.

Subjects: The sample for this study consisted of 60 physics students selected from three Government Colleges in Nigeria. Twenty students were selected from each school through simple random sampling technique. Equal number of boys and girls were used for the experiment.

Government colleges were purposely chosen for the exercise for best comparability since they all operate the same way, they run the same programme and they are all mixed schools with the same standard laboratory facilities.

Instruments: Past examination questions of the West African Examination Council (WAEC) was used for physics Practical Questions (PPQ) which covered four common areas in physics practical. They include mechanics, light, electricity and heat. A package titled "Error Correcting Instructional Package (ECIP)" was designed in form of a classroom instructional package or laboratory guide for a specific experiment with explanations on activities to perform. Lesson plans to be used for the experimental group were extracted from the package. These were prepared to make it easier for teachers to properly guide the students during experimental work for better performance. The package also exposed the students to the idea of errors; how to identify them in any physics experiment, how to avoid or reduce them to minimum and how to report experimental results accurately. Face and content validity of the instruments used were ensured. The reliability of the instrument was ascertained by using the split-half method. The Pearson Product Moment Correlation coefficient gave 0.65 and supported with full length using Spearman Brown Prophesy formular to be 0.79. It was adjudged as reliable for the purpose of this experiment.

RESULTS

Ho_1: There is no significant difference in the errors committed in physics practical before treatment with ECIP.

In order to test this hypothesis, the errors in each group were ranked into '1' for presence of error and '0' for no error in the four practical work. Ten different types of errors that could be identified in experimental reports and that are directly measurable were ranked for the purpose of analysis, these include errors due to unit, decimal, axis, scale, points, line of best fit, calculation, estimation systematic and random errors. These errors were collated and tested using one-way ANOVA (F-statistics).

The error analysis before the administration of ECIP as shown in the Table 1 revealed that F-calculated was

Table 1: Summary of ANOVA on errors over three groups before ECIP

Source of variation	df	SS	MS	F-ratio	T-table
Before group	2	24.433	12.217	0.378	3.150
Within group	57	1841.300	32.304		
Total	59	1865.733			

Table 2: Summary of ANOVA on errors over three groups after ECIP

Source of variation	Df	SS	MS	F-ratio	T-table
Between group	2	2165.03	1082.52	36.65	3.15
Within group	57	1683.55	29.54		
Total	59	3848.58			

$p \leq 0.05$

Table 3: Scheffe's summary table for errors in groups after ECIP

Group	x	G_1	G_2	G_3
G_1	14.40		*	*
G_2	24.70			*
G_3	28.65			

*Denote pair of groups significantly difference at 0.05 level

less than the F-table for three groups. There was hence no significant difference in the errors committed by the students before treatment. The mean errors calculated for the three groups were 27.55; 28.15 and 29.10, respectively. This also showed that there was no significant difference in the errors committed by students in the three groups before the treatment stage.

The histogram showed that the three groups were homogenous as shown by the clustering in Fig. 1. The three groups committed nearly the same type of errors.

Ho_2: There is no significant difference in the errors committed in physics practical after treatment with ECIP.

To test this hypothesis, the Analysis of Variance (ANOVA) was computed. Further analyses were carried out on students' practical reports after the treatment (administration of ECIP) Table 2. This was done by ranking the errors in the four practical reports of the students in each group. One-way ANOVA (F-statistics) at 0.05 level of significance was used for the analysis.

The F-calculated value of 36.65 was higher than the F-table value of 3.15 at 0.05 level of significant. The hypothesis was therefore rejected showing that the errors committed by the students in the groups differed significantly from each other. Scheffe's summary table gave a further analysis on the pairs of groups with significant difference.

Table 3 revealed that the difference in the errors committed were significant between groups 1 and 2 (treatment and conventional groups) and between groups 1 and 3 (treatment and control groups). The mean value of 14.40 for group 1 against mean values of 24.70 and 28.65 for groups 2 and 3, respectively showed that students in treatment goup committed less errors in their practical works after the treatment using ECIP. Figure 2 also give further explanation.

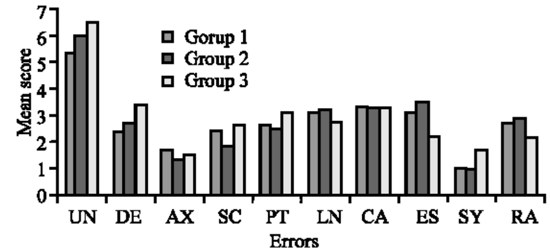

Fig. 1: Post-test error scores in groups, UN: Unit, DE: Decimal, AX: Axis, SC: Scale, PT: Points, LN: Line of best fit, CA: Calculation, ES: Estimation, SY: Systematic, RA: Random

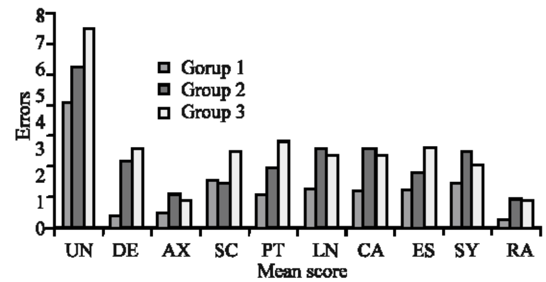

Fig. 2: Post-test error scores in groups

Figure 2 revealed the errors committed by experimental groups after treatment with ECIP were found lesser in all than those in conventional and control groups.

DISCUSSION

The results of the analyses and the figures showed that there are common errors which errors in physics frequently occur during experimental (laboratory) works in physics. The findings revealed that there was no significant difference in the errors committed by the students in physics practical before treatment with ECIP. The mean error calculated on the pre-test experiments was within the same ranges, which testified to the fact that errors committed by the students in the pre-test were nearly the same in the three groups. This also confirmed that the three groups were homogeneous.

Research findings on errors committed during physics practical after the treatment revealed that the Error Correcting Instructional Package (ECIP) designed for the study has positive effect on students' practical works. The result of the post-test showed that there were remarkable improvements in the treatment group over the others.

Even through both treatment and conventional groups improved in their post-test performance over their pre-test experiments, but a remarkable difference was found in experimental group because of the effect of the use of ECIP. The treatment group was found to have significantly improvement over the control group in all the identified errors and significantly improve in most sources of errors over conventional group. Generally, students in treatment group committed less errors in their practical works after treatment using ECIP.

The pairs of groups found to be most significantly different from each other are treatment and conventional groups also treatment and control groups. The improvement in the treatment group confirmed the research of Akinde (1990) who stated that students should be able to measure accurately, make accurate observation (being aware of possible sources of errors); follow instructions accurately and report the result of data collected systematically honestly and accurately. This formed the bases of ECIP that was used for the treatment of group. Hence the appreciable improvement on the errors committed was observed. Amitage (1981) found out that some quantities are always difficult to measure accurately but these can be improved upon as the students follow the necessary steps to improve their skills and avoid what can lead to errors as much as possible.

CONCLUSION

The use of ECIP has been confirmed good enough to minimize errors in Physics experimental work in Nigeria. The study showed sharp reduction in the errors committed by students taught with ECIP (a designed package) compared with conventional approach and control group. The usage of ECIP will also improve the performance of students in physics practical works. Since there were improvement in the performance of students as a result of the use of ECIP and the errors committed were drastically reduced in the treatment group compared with other groups. It was recommended that Error Correcting Instructional Package (ECIP) should be used to teach or instruct students in physics practical in addition to the normal conventional method. The curriculum planners should include remedies to prevalent errors as shown in ECIP into physics curriculum in the Nigerian secondary schools.

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