# Activity-Based Instructional Strategies: Gender Analysis of Students' Academic Performance and Attitude towards Physics Practical

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**Abstract.** The study investigated whether gender has any effect on academic performance and attitude towards Physics practical when students are exposed to activity-based instructional strategies. The study adopted the quasi-experimental design of pre-test, post-test and control group. The sample for the study comprised 74 Senior Secondary two (SS II) Physics students who were randomly selected from three co-educational Senior Secondary Schools in Osun state, Nigeria through multistage technique. Physics Practical Test (PPT) and Physics Practical Attitudinal Scale (PPAS) were the two instruments used to collect relevant data for the study. The hypotheses generated were analyzed using Analysis of Covariance (ANCOVA) and Multiple Classification Analysis (MCA). Decisions were taken at 0.05 level of significance. The findings from the study showed that gender had significant effect on students' performance mean scores in the three groups. The male students in the experimental groups outperformed their female counterparts. The main effect of gender on students' attitude towards Physics practical was not statistically significant. Based on the findings of this study, it was recommended that Physics teachers should be gender inclusive while making use of activity-based instructional strategies to teach Physics practical in secondary schools.

**Keywords:** Activity-Based Instructional Strategies, Performance, Attitude, Gender, Physics Practical

## Introduction

Physics instruction should actively involve the students by gainfully engaging them with learning activities in classroom and laboratory. Students should be allowed to use their own experiences, prior knowledge and perceptions as well as their physical and interpersonal environments to construct knowledge and meaning. According to Jegede (2016), students by nature are curious. They are seen active in the learning process in which they are continually enquiring, testing, speculating and building their own personal constructs of knowledge. Therefore activity-based instructional strategies which are student-centered and activity-oriented in which teacher guides students through problem-solving activity approach to discover answers to instructional problems would give room for students' active participation during Physics practical classes. Two of these activity-based instructional strategies are Predict-Observe-Explain Instructional Strategy (POEIS) and Virtual Laboratory Instructional Strategy (VLIS) which are being investigated in this study.

Predict-Observe-Explain Instructional Strategy is based on the philosophy of practical activities which involves learning by doing. Here, learners perform three different tasks; predict, observe and explain. The POE works best with demonstrations which allow immediate observations. Famakinwa and Bello (2015) asserted that the POE procedure is based on the classic model of research where a hypothesis is stated and reasons are given for why this may be true, relevant data are gathered and results are discussed. It involves students predicting the result of a demonstration and discussing the reasons for their predictions; carrying out and observing the demonstration and finally explaining any discrepancies between their predictions and observations. If their predictions are in agreement with the observations, it will allow

deeper insight and reinforce better understanding of the concept. The POE procedure is an efficient strategy for eliciting students' ideas and also promoting discussion about the ideas.

Virtual Laboratory Instructional Strategy (VLIS) is a computer-based instructional strategy made up of three components: text, video and simulated experiment. The text section exposes the students to the title, aim, theory, apparatus and procedures of the experiments. The video section exposes the students to the steps to be followed in carrying out the experiments. The simulated experiment is a section where students carry out or perform experiments in virtual environment using computer program. Gambari, Falode, Fagbemi, and Idris (2013) reported that the application of the virtual laboratory had positive effects on students' achievements, retention and attitudes when compared to physical laboratory method. Virtual laboratory makes students become active in their learning, provide opportunities for students to understand difficult concepts more easily. Virtual laboratory increases motivation and desire for lessons and laboratory activities in the process of learning (Pyatt & Sims, 2012).

Conventional Laboratory Instructional Strategy is a teacher-centered teaching method in the laboratory where teacher dominates the activities turning the students to passive learners. Bits of information are given by the teacher and the students receive the information passively. It is hand-on experiment where students observe/watch their teacher demonstrating experiment for them; after which the students also repeat what the teacher demonstrated.

Physics being one of the physical sciences taught in senior secondary schools is taught both in theory and practical. In both internal and external examinations, Physics practical is assessed separately as an integral part of the subject. When practicals are not handled the way it ought to be taught it is not likely that performance will correlate positively with the performance in the theoretical aspect. As cited in Achor, Kurumeh, and Orokpo (2012), some researchers are of the opinion that male students' performance in a test of practical/ in practical work enhances their performance in practical science examinations in WAEC/SSCE and NECO/SSCE. Some also found that female students' performance in a test of practical knowledge in internal examination predicted their performance in external examinations. Some researchers opinioned that male students' performance in a test of theoretical knowledge does not significantly predict their performance in practical examinations. While some agreed that theoretical knowledge of science enhances students' performance in the practical aspect of science. But in Achor, Kurumeh, and Orokpo (2012), it was found that irrespective of gender, students score in test of practical and theoretical knowledge do not predict their performance in MOCK-SSCE theory and practical examinations.

The report of Adebisi and Ajayi (2015) on correlation of students' attitude and gender differences on understanding of concept in Physics practical showed that students' attitude is significantly related to understanding of concept in Physics practical. The higher the students' attitude, the higher the understanding of the concept of Physics practical. In the other way the lower the students' attitude to Physics practical, the lower the understanding of the concept to Physics practical. The cause of the negative perception of students towards Physics was identified by Adedayo (2008) to include the fear of the mathematical skills involved, harsh teacher-students' relationship, students' unreadiness to study, preconceived bad information that Physics is a difficult subject and poor method of teaching. Olusola and Rotimi (2012) supported this claim that Physics is perceived as a difficult subject for students from secondary school to university and also for adult in graduate education. This impression greatly affects students' readiness and interest to the study of Physics. However, the reality on ground demands cultivating students' positive attitude towards Physics practical in secondary schools. Physics practical is a sharpen tool for actualization of national technological advancement, it is therefore necessary for teachers to help the students to develop right attitude towards Physics practical. Physics curriculum contents emphasized understanding of concepts, experimentation and right attitude, NERDC (2008).

Some researchers are of the opinion that there are no gender differences in students' performance in Physics practical while some have contrary opinion. Owolabi and Oginni (2013) revealed that gender is not the major issue in Physics practical work as male and female performed equally in their practical or experimental work. This is in agreement with the reported of Adebisi and Ajayi (2015) that there is no gender difference to understanding of Physics practical concept. This implies that the students' performance in Physics practical work as well as understanding of Physics practical concept are not gender biased.

Aina (2013) reported that male students performed better than female students in Physics practical. It was also revealed that male and female performance in Physics practical is independent of each other. It implies that there is no relationship between male and female performance in Physics practical; but male performed better than female in practical work. It was further stressed that female students offering Physics in secondary school should be motivated and properly guided by Physics teacher to enable them catch up with their male counterpart. This is necessary to prepare them well ahead of their tertiary education. After studying the effectiveness of practical work in Physics to improve students' academic performances, Lee and Sulaiman (2018) reported that male students performed better than female students.

Some researchers are of the opinion that the students' attitude towards Physics practical is not a function of the students' gender while some have contrary opinion. Fatoba and Aladejana (2014) found that there was no significant effect of gender on students' attitude in Physics. Likewise, Sakariyau, Taiwo and Ajagbe (2016) discovered that there is no significant difference between the attitude of male and female students towards science. In contrast, Trivedi and Sharma (2013) discovered that there is significant difference in the attitude of boys and girls towards Physics practical work at senior secondary schools and that the attitude of girls is significantly more positive than that of boys. They reported that there was significant difference in the attitude of male and female students in Physics practical in favour of female students.

**Purpose of the Study**

The purpose of this study was to investigate gender influence on academic performance and attitude of secondary school students towards Physics practical using predict-observe-explain and virtual laboratory instructional strategies. Specifically, the study intends to find out whether the gender of students has any effect on their academic performance and attitude towards Physics practical when exposed to Predict-Observe-Explain and Virtual Laboratory Instructional Strategies.

**Research Hypotheses**

The following null hypotheses were generated for the study:

**$H_{01}$:** there is no significant difference in the performance mean scores of male and female students in the three groups before and after the treatment.

**$H_{02}$:** there is no significant difference in the attitude mean scores of male and female students in the three groups before and after the treatment.

## Methodology

**Research Design**

This study adopted quasi-experimental design of the pre-test, post-test and control group. The design is represented schematically as follows:

| | | | |
|---|---|---|---|
| $G_1$: | $O_1$ | $x_1$ | $O_2$ |
| $G_2$: | $O_3$ | $x_2$ | $O_4$ |
| $G_3$: | $O_5$ | $x_3$ | $O_6$ |

Where
$G_1$ - Experimental group 1
$G_2$ - Experimental group 2
$G_3$ - Control group
$O_1$, $O_3$ and $O_5$ are the pre-test observations
$O_2$, $O_4$ and $O_6$ are the post-test observations
$x_1$ - Treatment for group 1 (Predict-Observe-Explain Instructional Strategy)
$x_2$ - Treatment for group 2 (Virtual Laboratory Instructional Strategy)
$x_3$ - Treatment for control group (Conventional laboratory Strategy)

**Population, Sample and Sampling Technique**

The population for this study consisted of all Senior Secondary two (SS II) Physics students in the three Senatorial Districts of Osun State. The Senior Secondary two (SS II) students were considered appropriate for this study because they would have been exposed to a considerable knowledge of Physics in Senior Secondary one (SS I). The sample for the study consisted of 74 Physics students of Senior Secondary two (SS II) in three co-educational Senior Secondary Schools in Osun State, Nigeria. The multistage sampling procedure was used to select the sample. Stage one involved the selection of one Local Government Area from each of the three Senatorial Districts in Osun State using simple random sampling by balloting. The second stage involved the use of purposive sampling technique to select one secondary school with relatively-equipped Physics laboratory from each Local Government Area selected, and the third stage involved the use of students in an intact class of an arm randomly selected from each school considered.

**Research Instruments**

Two instruments were used for the study. The two instruments were Physics Practical Test (PPT) and Physics Practical Attitudinal Scale (PPAS). PPT was a practical test consisting of two parallel tests (alternative A and alternative B) adapted from West African Examination Council past examination papers. There were two practical tests in each alternative. Each of the tests carries 25 marks, making the maximum score obtainable to be 50 marks for each alternative. Alternative A was used for pre-test and Alternative B was used for post-test.

The Physics Practical Attitudinal Scale (PPAS) was developed to measure the attitude of students towards Physics practical. The PPAS had two sections A and B. Section A consisted of students' personal bio-data such as name of school, gender, age range and class while section B consisted of 40 items-questionnaire intended to measure students' attitude towards Physics practical. The PPAS was structured in 4-points Likert scale: Strongly Agree (SA) – 4 points, Agree (A) – 3 points, Disagree (D) – 2 points and Strongly Disagree (SD) – 1 point. Each respondents was made to tick appropriate options, the responses were collated and scored for data analysis.

**Validity of the Instruments**

The face and content validity of the instrument were carried out by experts in Physics education, Test, Measurement and Evaluation and Guidance and Counselling. The reliability of PPT was determined by test re-test method. The two sets of results were collated and analyzed using Pearson Product Moment Correlation Analysis. The reliability coefficient of 0.82 and 0.80 were obtained for alternative A and alternative B of PPT respectively, while 0.73

was obtained for PPAS using Cronbach's Alpha. These values were regarded as high enough to be used for the study.

**Data Analysis**

The data collected were collated and analyzed. The hypotheses generated were analyzed using Analysis of Covariance (ANCOVA) and Multiple Classification Analysis (MCA). All the hypotheses were tested at 0.05 level of significance.

**Results**

**Testing of Hypotheses**

***$H_{01}$:*** *there is no significant difference in the performance mean scores of male and female students in the three groups before and after the treatment.*

In order to test the hypothesis, performance mean scores of male and female students exposed to predict-observe-explain instructional strategy, virtual laboratory instructional strategy and convectional laboratory strategy before and after the treatment were computed and compared for statistical analysis involving Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result is presented in Table 1 below.

**Table 1. 2 X 3 ANCOVA of students' performance in Physics practical by gender and treatment**

| Source | SS | Df | MS | F | P |
|---|---|---|---|---|---|
| Corrected Model | 9067.466[a] | 6 | 1511.244 | 77.981 | 0.000 |
| Covariate (Pretest) | 122.303 | 1 | 122.303 | 6.311 | 0.014 |
| Sex | 108.710 | 1 | 108.710 | 5.609* | 0.021 |
| Group | 8696.918 | 2 | 4348.459 | 224.382* | 0.000 |
| Sex * Group | 176.017 | 2 | 88.009 | 4.541* | 0.014 |
| Error | 1298.440 | 67 | 19.380 | | |
| Total | 68887.000 | 74 | | | |
| Corrected Total | 10365.905 | 73 | | | |

Note: *p<0.05

Table 1 showed that the computed F-value (4.541) obtained for the groups with a p value (0.014) < 0.05 was significant. The null hypothesis is rejected; implying that there was significant difference in the performance mean scores of male and female students exposed to predict-observe-explain instructional strategy, virtual laboratory instructional strategy and convectional laboratory strategy before and after the treatment. Similarly, the main effect of gender ($F_{1,67}$ =5.609, p<0.05) and treatment ($F_{2,67}$ =224.384, p<0.05) on students' performances in Physics practical is statistically significant at 0.05 level in each case. In order to determine the effectiveness of treatment (instructional strategies) at enhancing students' performance in Physics practical based on gender, Multiple Classification Analysis (MCA) was used. The result is presented in Table 2.

**Table 2. Multiple Classification Analysis (MCA) of students' performance in Physics practical by gender and treatment**

| Variable + Category | N | Unadjusted Devn' | Eta$^2$ | Adjusted For Independent + Covariate | Beta |
|---|---|---|---|---|---|
| **Predict-Observe-Explain** | | | | | |
| Male | 14 | 2.19 | | 2.19 | |
| Female | 10 | -3.08 | | -3.08 | |
| **Virtual Laboratory** | | | | | |
| Male | 11 | 1.35 | 0.72 | 1.25 | 0.06 |
| Female | 9 | -1.65 | | -1.54 | |
| **Control** | | | | | |
| Male | 14 | -0.34 | | -0.75 | |
| Female | 16 | 0.30 | | 0.66 | |

| | Multiple R | Multiple R$^2$ | Grand Mean |
|---|---|---|---|
| Predict-Observe-Explain | 0.002 | 0.000 | 27.38 |
| Virtual Laboratory | 0.328 | 0.107 | 44.65 |
| Control | 0.398 | 0.158 | 17.70 |

Table 2 above revealed that male students exposed to predict-observe-explain instructional strategy and virtual laboratory instructional strategy had the higher adjusted mean scores in Physics practical than their counterparts i.e. Male-Predict-Observe-Explain=29.57, Female-Predict-Observe Explain=24.30, Male-Virtual Laboratory=45.90, Female-Virtual Laboratory=43.11. However, the performance of female students (18.36) exposed to conventional laboratory strategy outweighed their male (16.95) counterparts in Physics practical. The treatment and gender explained about 72% (Eta$^2$=0.72) of the observed variance in students' performance in Physics practical.

***$H_{02}$:*** *there is no significant difference in the attitude mean scores of male and female students in the three groups before and after the treatment.*

In testing the hypothesis, attitude mean scores of male and female students in the three groups before and after the treatment were computed and compared for statistical significance using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result is presented in Table 3 below.

**Table 3. 2 X 3 ANCOVA of students' attitude towards Physics by gender and treatment**

| Source | SS | Df | MS | F | P |
|---|---|---|---|---|---|
| Corrected Model | 35415.886 | 6 | 5902.648 | 104.114 | 0.000 |
| Covariate (Pretest) | 352.092 | 1 | 352.092 | 6.210 | 0.015 |
| Sex | 22.476 | 1 | 22.476 | .396 | 0.531 |
| Group | 34638.895 | 2 | 17319.448 | 305.489* | 0.000 |
| Sex * Group | 19.021 | 2 | 9.511 | .168 | 0.846 |
| Error | 3798.510 | 67 | 56.694 | | |
| Total | 1041418.440 | 74 | | | |
| Corrected Total | 39214.396 | 73 | | | |

Note: p>0.05

The result in Table 3 above showed that the computed F-value (0.168) obtained for the groups with a p value (0.846) > 0.05 was not statistically significant. The null hypothesis is not rejected; implying that there was no significant difference in the attitude means scores of male and female students in the three groups before and after the treatment. Similarly, the main effect of gender on students' attitude towards Physics practical was not significant at 0.05 level ($F_{1,67}$=0.396, p>0.05). However, the effect of treatment on students' attitude towards Physics practical was statistically significant at 0.05 level ($F_{2,67}$=305.489, p<0.05).

**Discussion**

The finding of this study showed that gender had significant effect on performance mean scores of students. The male students in the experimental groups outperformed their female counterparts. This implies that the treatments enhanced male students' performance in Physics practical. The male students in Virtual Laboratory Instructional Strategy performed better than the male students in Predict-Observe-Explain Instructional Strategy. This is in agreement with Aina (2013) who reported that male students performed better than female students in Physics practical.

The finding of this study also revealed that the attitude of students towards Physics practical is not determined by gender. That is, the main effect of gender on students' attitude towards Physics practical was not statistically significant. This is in conformity with the finding of Fatoba and Aladejana (2014) who reported that there was no significant effect of gender on students' attitude in Physics. It is also in line with the finding of Sakariyau, Taiwo and Ajagbe (2016) who discovered that there is no significant difference between the attitude of male and female students towards science. This is at variance with the finding of Trivedi and Sharma (2013) who discovered that there is significant difference in the attitude of boys and girls towards Physics practical work at senior secondary schools and that the attitude of girls is significantly more positive than that of boys.

**Conclusion**

From findings of this study, it was concluded that gender had significant effect on students' performance mean scores in the three group. The male students in the experimental groups outperformed their female counterparts. The main effect of gender on students' attitude towards Physics practical was not statistically significant.

**Recommendations**

Based on the findings of this study, it was recommended that Physics teachers should be gender inclusive while making use of predict-observe-explain and virtual laboratory instructional strategies to teach Physics practical in secondary schools.

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