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# Effect of Analogy Teaching Approach on Students' Conceptual Change in Physics

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**ABSTRACT**

**The effects of analogy teaching approach on students' conceptual understanding of the concept of refraction of light in Physics were examined. A 20-item Physics Concept Test (PCT) developed by the researcher was used to collect the relevant data from a sample 111 physics students using pre-test and post-test. The sample was selected from two single sex secondary schools (one male and one female) in Akure Urban of Ondo State of Nigeria. Mean and standard deviation and analysis of covariance (ANCOVA) were employed. The result showed that the use of analogy teaching model has a positive effect on SS 2 Physics students and that female students out-performed their male counterparts irrespective of the teaching method used. The interaction effect of the instructional model and gender was not significant (p < 05). Recommendations include that physics teachers, and all stakeholders in education should endeavor to incorporate analogy instructional model as one of the approaches to be adopted in Nigerian secondary schools since it increases students' interest and learning in sciences especially in physics.**

## INTRODUCTION

Basic knowledge in science, especially physics is a 'sine qua non' for all forms of modern development. To be able to appreciate, control and effectively tap from and utilize the resources from our natural environment, it is imperative to acquire this scientific knowledge – a basic tool of all forms of industrial and technological advancement of any nation (American physical society, 2014).

Aware of this obvious task, many nations, Nigeria inclusive, have recognized the importance of science and technology (S&T) especially physics in its developmental endeavors (Abubakar, 2012). This is because physics is the basic index in understanding the complexities of modern technologies (Aina, 2014). But students' performance in the sciences in external examination has been consistently on the decline (WAEC, 2009 & 2010). Physics is even most badly affected. For instance, in WASC result of May/June 2010, the candidates' population of 469,019 in physics recorded a mean score of 20 and a standard deviation of 9.43 as against a mean score of 26 and a standard deviation of 9.0 in May/June 2009 WASSCE with a candidature of 465,498. This makes students demonstrate very negative attitude towards physics as the toughest of the three conceptual sciences, and they drop it at the earliest opportunity, leading to poor enrollment in physics and physics-related courses in our tertiary institutions (Omosewo, 1999; Opondo, 2014).

Oderinde (1979) stated that the enrollment figures in physics at the secondary school level in the developing countries are quite low. For example, in Nigeria, between 2005 and 2010, on the average, less than 30% of the students who registered for WASSCE entered for physics. Out of these, only 40% passed at the credit level (WAEC, 2010). Some of the reasons for this poor enrollment and performance in physics have been blamed on the way science in general, and physics in particular is taught in secondary schools (Ogunneye & Lasisi, 2008), students' poor attitude towards physics (Lips, 2004), perceived abstract and difficulty nature of physics (Nwankwo, 2014), poor teaching and learning environment and lack of appropriate and modern laboratory equipment (Akuezuilo 1987), poor mathematical background and poor teaching method being adopted by many physics teachers (Nwagbo & Chikelu, 2011). Generally, physics teaching has been marked by such didactic approaches as lecture methods, discussion and so-called guided inquiry method hap-hazardly done and relying entirely on textbook reading as well as rote memorization (Iloputaife, 2001).

To teach for conceptual change therefore involves re-assignment of the concept to those already existing pre-conceived ideas (Kuhn, 1970).

Analogy is defined as a comparison of certain similarities between things which are otherwise unlike (Treagust, 1990). It is a constructivist-based teaching approach designed to provide a powerful means of bringing about this conceptual change in students which involves use of familiar situation (source or analog) to explain a similar unfamiliar phenomenon (target) (Maharaj-Sharma, 2012). Analogy must therefore be familiar if it is to be fruitful, it must be able to prove its competence in bringing about conceptual understanding of the needed concepts (Maharaj-Sharma, 2012). As Ogile and Thomas (2007) opined, when teachers use analogies to bring about conceptual change in students, they are better able to construct more accurate conceptions of complex ideas, making ideas more internally consistent.

In teaching with analogy, science teachers must be careful to help the students realize where the analogy breaks down. In line with Harrison and Coll (2008), they must exercise caution to point out to the students those aspects or areas in which the analogue and the target are different. This is why Brown and Salter (2010) also suggests that it is extremely important that due caution be exercised to be sure that students remember the content and not just the analogy, noting that analogy is only an aid to understanding a concept, content or process and not the concept, process or principle itself.

Gender disparity in science is another issue of great concern and it affects both educational and research sectors. The cause of this problem has been a thing of worry to scientists. But unfortunately, no consensus has been reached about the effect of gender in science achievement. Longe and Adedeji (2003), for instance opined that science and technology (S & T) are male-dominated and that girls shy away from such fields of study. Furthermore, Babajide (2010) also admitted that such conceptual sciences like physics and chemistry are given masculine outlook by educational practitioners. More pathetically, Ogunneye and Lasisi (2008) reported that more ladies are found in Biology and Chemistry than in Physics departments of higher institutions. However, contrary to these views, Ocho (1997) and Nkpa (1997) independently reported that girls outperformed boys in sciences. Still further, Ogunleye and Babajide (2011) reported that gender has no significant effect on students' achievement and practical skills in physics. As a result of this inconsistency of opinion, there is a great need to carry out further studies in order to shade more light on the effect of gender in combination with the use of analogy in science achievement of students.

### Synthesis of the literature

This study has examined conceptual change and the effect analogy has in bringing about conceptual change on physics students. Gender was also reviewed as a moderator variable. It was observed from the literature reviewed that no single approach had been able to bring about conceptual change in sciences especially physics. There were also diverse opinions on the influence of gender on academic achievement and misconceptions

in sciences among students. This study therefore seeks to investigate further into the effect of analogy teaching approach on students' conceptual change in physics.

**Purpose of the study**

Specifically, this research was designed to:

1. Study the effect of instructional analogy model on the performance of SS 2 physics students in comparison with those taught using the traditional method of lecture.
2. Access the influence of gender on students' concept acquisition when taught refraction of light using analogy teaching model.
3. Find the interaction effect of gender and analogy model on students' conceptual change.

**Research questions**

The following research questions guided this study:

1. What are the effects of the use of instructional analogy teaching model on students' conceptual change in refraction of light when compared with traditional methods like lecture?
2. To what extent does gender affect conceptual change in SS 2 physics students?

**Hypotheses:**

Three null hypotheses guided this study:

1. There is no significant effect of analogy teaching approach on students' conceptual change in physics.
2. There is no significant effect of gender on students' conceptual change in physics.
3. The interaction effect of instructional analogy teaching model and gender in bringing about conceptual change in physics is not significant.

**METHOD**

This study was a quasi-experimental design in which the participants were not randomly assigned. Intact classes (to ensure that regular class periods were not altered) were used for the study with the consent of both the school head and the participants.. The specific design was non-equivalent control group design involving pretest-posttest.

The design is symbolically represented as:

MB MANA MA
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MB MCTR MA

Where $M_B$ = measurement before treatment (pretest)
$M_{ANA}$ = treatment using analogy
$M_{CTR}$ = conventional treatment
$M_A$ = measurement after treatment (posttest)

The target population of the study was all the senior secondary class two (SS 2) physics students in all the government owned secondary schools in Akure South local government area of Ondo state. There are 26 secondary schools in the local government area; 22 are co-educational while four are single sex-two males and two females.

A purposive sampling technique was used to select two single sex schools-one all male school and one all female school which have two streams of SS 2 students offering physics. In each of the school, one intact class was given the experimental treatment while the second class was given the conventional treatment. A total of 111 students were used for the study, 55 males and 56 females. Twenty-one males and 27 females were used as control while 34 males and 29 females were given the experimental treatment. The research instrument was a physics concept test (PCT) which comprised 20 short answer items drawn from selected topics on refraction of light in SS 2 physics curriculum. Table 1 shows the table of specification from which the PCT as was drawn.

**Table 1: Table of specification for PCT.**

| Objectives → Contents ↓ | Percentage | knowledge | comprehension | application | analysis | synthesis | total |
|---|---|---|---|---|---|---|---|
| Concept of refraction | 40 | 3(1,2,3,) | 3(4,17,5) | 2(6,7) | - | - | 8 |
| Refractive index | 20 | 1(8) | 2(9,10) | 1(14) | - | - | 4 |
| Lenses | 20 | 1(13) | 2(16,20) | 1(19) | - | - | 4 |
| Applications of refraction | 20 | 1(11) | 2(15,18) | 1(12) | - | - | 4 |
| Totals | 100 | 6 | 9 | 5 | - | - | 20 |

The test items and model answers were face and content validated to ensure that it measures what it purports to measure. The reliability of the test was established using Cronbach Alpha and the value was calculated to be 0.78.

The pretest was administered to the sampled students two weeks before the experiment. The responses were marked and graded. No feedback was given to the students but the scores were reserved for use after the posttest. A period of four weeks were used to carry out the experiment at the end of which an equivalent posttest was again administered to the same set of students and graded as before.

## RESULTS

Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

**Research question 1:**

What are the effects of the use instructional analogy teaching approach on students' conceptual change in refraction of light when compared with the traditional methods?

**Table 2: Mean and standard deviation of students' scores in post treatment responses**

| Group | N | Mean | S.D. | df |
|---|---|---|---|---|
| Experimental | 63 | 31.74 | 8.49 | 62 |
| Control | 48 | 27.13 | 9.03 | 47 |
| Total | 111 | | | |

The analysis of data in table 2 shows that students performed better with a mean of 31.74 and S.D. of 8.49 when taught the concept of refraction using analogy teaching model than when taught the same concept using the conventional lecture method with a mean of 27.13 and a S.D. of 9.03. Hence, the use of analogy in teaching was able to bring about a significant change in concept acquisition in these students.

**Research question 2:**

To what extent does gender effect conceptual change in SS 2 physics students?

**Table 3: Mean and standard deviation of male and female students' scores.**

| Sex | N | Mean | Standard Deviation |
|---|---|---|---|
| Male | 55 | 25.29 | 9.08 |
| Female | 56 | 34.09 | 6.43 |
| Total | 111 | | |

The above result shows that the female students attained conceptual change in SS 2 physics with a mean of 34.09 and a standard deviation of 6.43 better than the males with a mean of 25.29 and a standard deviation of 9.08. That is, the females performed better than the males when taught the concept of refraction of light irrespective of the method used.

**Hypotheses:**

HO1: There is no significant difference between the mean conceptual change scores of Physics students taught refraction of light using analogy teaching method and Those taught using traditional teaching methods like lecture.

HO2: There is no significant difference in the mean conceptual change scores of boys and girls when taught the concept of refraction of light.

HO3: The interaction effect of instructional analogy model and gender on students' conceptual change is not significantly different.

**Table 4: Analysis of covariance (ANCOVA) of students' scores in post treatment response by treatment and sex.**

| Sources of variation | Sum of squares | df | Mean square | P-values | significance | Decision |
|---|---|---|---|---|---|---|
| Covariates | 20.637 | 1 | 20.637 | 0.393 | .53 | |
| Main effect | 3275.842 | 2 | 1636.921 | 31.147 | .00 | |
| Treatment | 748.200 | 1 | 748.200 | 14.237 | .00 | S |
| Sex | 2716.394 | 1 | 2716.394 | 51.687 | .00 | S |
| 2-way interaction | 6.575 | 1 | 6.575 | .125 | .72 | |
| Treatment | 6.575 | 1 | 6.575 | .125 | .72 | NS |
| Explained | 3301.054 | 1 | 6.575 | 15.703 | .00 | |
| Residual | 5570.838 | 106 | 52.555 | | | |
| Total | 8871.892 | 110 | 80.654 | | | |

**Hypothesis 1:**

The result of table 4 showed that the significance of p (.00) due to analogy model of instruction is less than 0.05 level of significance. Since the significance of p (.00) is less than 0.05, the decision is to reject the null hypothesis in favour of the alternative hypothesis, that is, there is significant difference between the conceptual change scores of the SS 2 physics students taught refraction of light using analogy teaching technique and those taught using traditional lecture method in favour of the analogy group.

**Hypothesis 2:**

From the same table 4, the significance of p (.00) is again less than 0.05 alpha level for gender. Therefore null hypothesis 2 is also rejected while affirming the alternative which asserts that the mean conceptual change scores of male and female students when taught the concept of refraction of light irrespective of the method used is significantly different. Hence, gender has significant effect on the conceptual change scores of students.

**Hypothesis 3:**

Examining table 4 once again, one notices that the significant value of p (0.72) is greater than 0.05 alpha level. The decision therefore is not to reject the null hypothesis. We therefore hold the assertion that there is no significant interaction effect of analogy instruction model and gender conceptual change in SS 2 physics students when taught the concept of refraction of light.

**DISCUSSION OF FINDINGS**

Results showed that students taught the concept of refraction of light with experimental analogy model outperformed those taught same concept using conventional lecture method. This is in line with the findings of Harrison (1993) who reported that some abstract concepts in physics such as pressure, electric current, atomic structure and others can only be adequately taught using analogy. Harrison and Treagust (1993) who opined that the use of analogies increases students' confidence.

Table 3 showed that female students performed better than their male counterparts in the PCT on refraction of light administered to them irrespective of the instructional method used. This finding agrees with those of Nkpa (1997) and Ocho (1997) who independently noted that girls are better than boys in sciences. Hardings (1999) who noted that girls are better in essay-type questions than boys. The result is however at variance with Ayogu and Nworgu (1999) who reported that boys are better than girls in physics achievements test (PAT). Another very interesting aspect was the finding of Ivowi (1983), Inyang and Jegede (1991) and Hide and Linn (1988) who reported that gender has no significant effect on students' achievement in the sciences. Since the results of the various researchers are inconsistent in this issue, it is then clear that there may be other factors other than sex that can be contributory to students' performance in physics. Such factors may include attitude, interest, motivation, school's disciplinary tone etc.

From table 4, one noticed that the calculated alpha level of 0.72 was greater than 0.05, thus leading to not rejecting the null hypothesis 3. It was therefore concluded that the interaction effect of gender and instructional analogy on students' conceptual change is not significant. This result agreed with Hyde and Linn (1988) and Ivowi (1983) who reported that gender and instructional approach have no effect on students' conceptual change. Hence, the interaction effect of gender and instructional analogy is not significant.

**RECOMMENDATIONS**

Based on the findings of this study, the following recommendations were proposed by the researcher:

1. Physics teachers should agree with Ausubel, (1968) that the most important single factor influencing learning is what the learner already knows. They should therefore strive to teach in such a way as to resolve the conflict between these alternative conceptions and the scientific views they are

presenting to the students using such instructional model as analogy.

2. Policy makers and curriculum planners should try to organize seminars/workshops to retrain serving science teachers on how to make effective use of such constructivist-based teaching models as analogy in bringing about
conceptual understanding in physics in students. This will improve the performance of students in physics and science in general.
3. Physics teachers should avoid using gender-biased language while teaching physics.

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