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# Effect of Concept Mapping Instructional Strategy on Students' Conceptual Change in Physics

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author IIA designed the study and performed statistical analysis. Author JOA wrote the first draft of the manuscript and managed the analysis of the study. Author BCM managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

This study focused on the Effect of Concept Mapping Teaching Strategy on students' conceptual change in physics. Two research questions guided the study. Two null hypotheses were formulated and tested at the probability of 0.05 level of significance. The study adopted a quasi-experimental non-equivalent control group design. The study was carried out in Agbani Education zone of Enugu State. One hundred and nineteen students consisting of 63 boys and 56 girls from three co-educational schools were selected through purposive sampling for the study. Two intact streams of SSS 2 students in each of the secondary schools were used. The experimental group was taught concepts/principles involving refraction of the light wave using concept mapping while the control group was taught the same topics in optics using the conventional method. Thirty items

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on Test on Physics Concept (TPC) were developed by the researchers. The items were validated by three experts, one in measurement and evaluation and two in the Department of Science Education with a physics background, all from the Department of Science Education University of Nigeria Nsukka. Content validation was also carried out based on the table of specification. The reliability of the items was tested using the Kendall coefficient of concordance (W) with a coefficient of 0.81. Data on students' conceptual change in physics were collected using TPC. Pre-test scores were collected before the treatment while the post-test was administered after the treatment. Research questions were answered using mean and standard deviation while hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). Results of data analyzed revealed that there exists a difference between the mean scores of physics students in Test of physics concepts when taught using concept mapping and lecture methods in favour of the group taught light waves using concept mapping strategy. That there exists no significant difference between the mean scores of male and female physics students in a test of physics concepts when taught using concept mapping and lecture methods. The recommendations among others are that concept mapping and lecture methods should be used interchangeably in the teaching of physics to breach the gap in performance between male and female students and concept mapping instructional strategy should be used to promote conceptual change in physics.

*Keywords: Concept mapping instructional strategy; conceptual change; physics.*

## 1. INTRODUCTION

The students do not enter the classroom with what is called a "blank slate" [1]. They come with already formed ideas in their mind on many topics, including on how they see and interpret their world. These views are strange, even elaborated, but regardless of their content, these views are highly resistant to change. Several researchers have concluded that students start formal physics education with a system of physical conceptions that differ in systematic ways from those of the physicist and experience a significant obstacle to learning physics [2].

In other words, learners have existing mental models that may limit their perception and processing of conflicting information and prevent the adoption of scientific conceptions. These prior ideas about physics topics, developed by students are variously referred to as misconceptions [3], alternative frameworks /conceptions [4]. Physics instructors are thus faced not just with getting students to construct new knowledge, but with getting them to construct this knowledge in the face of strongly-held beliefs (scientific belief). To construct knowledge, students must identify and test their existing understandings, interpret the meaning on their on-going experience and adjust their knowledge framework accordingly [5].

The view above necessitates conceptual change research which highlights the importance of prior knowledge in the acquisition of new knowledge and hence, the importance of instruction to access and build on that knowledge. Conceptual change is also regarded as a new construct that refers to learning that occurs when students' understandings about specific concepts are restructured in many ways that are meaningful [6]. Conceptual change in the learning of science involves the students shifting from naive views, preconceptions or alternative conceptions to accurate understanding driven by strongly supported scientific theories and evidence [7]. Since conceptual change involves modifications in core knowledge and beliefs, it is generally not easily achieved and occurs as a continuous gradual process [7]. Numerous research studies have shown that conceptual change approaches may improve students' understanding of science [7]. Lightwave concepts are some of the aspects of physics where students experience difficulty in comprehending during instruction. This has become evident in the consistent report of physics chief examiners that students do not answer questions on the light wave with scientific reasoning (WAEC, 2009, 2010, 2011 and 2012). Of all the factors linked to students poor achievement in physics, the method used to present physics concepts to the students during instructions seems to be a more influencing factor [8].

Recent studies have revealed new ideas and instructional approaches for the teaching of physics especially with regards to the nature of knowledge which has to do with students possessing previous knowledge. Among them is concept mapping instructional strategy. Concept mapping is a constructivist- based instructional

model which brings about an expansion of students' knowledge structure through proper connection, organization and integration of concepts within a knowledge domain. These connections increase the stability of the new information in the learners' minds. Concept mapping instructional strategy stands on the premise that it is easier to comprehend new information by linking it with the already known information in the knowledge structure. This is due to the powerful visual effect that it has in facilitating understanding and retention of a concept or a conceptual structure.

Another important factor worth considering is gender-related differences in science achievement. Several research studies carried out in Nigeria show this gender disparity, which has been inconclusive. For instance, some studies showed that boys achieve better than girls in physics [9,10]. Agomuoh (2003) showed that gender plays no significant role in physics achievement. But, in the studies carried independently by Ocho [11[and Nkpa [12], it was found that female students achieve better than male counterparts in the sciences. Madu [5] found that male performed slightly better than females in their conceptual shifts. Many reasons have been attributed to this gender disparity. The major reason is the way science is taught in our schools. It is also important to note here that most of the studies on gender differences centred on achievement except one that is on conceptual shift. Because most of the results in gender and achievement are contradicting and there are not much on gender and conceptual shift, a new investigation seems to be called for. Hence, there is a need to compare the effects of concept mapping instructional strategy on students' conceptual change.

### 1.1 Purpose of the Study

1. Compare the effects of the concept mapping and traditional lecture instructional approaches on students' conceptual change in physics.
2. Determine the conceptual change means scores of male and female students taught physics (Light wave) using concept mapping instructional strategy and those taught using the traditional lecture approach.

### 1.2 Research Questions

1. What are the effects of using concept mapping instructional strategy on students' conceptual change in physics (light waves) when compared with the traditional approach?
2. What is the conceptual change means scores of male and female students taught light waves using concept mapping instructional strategy and those taught using the traditional approach?

### 1.3 Research Hypotheses

The following null hypothesis was formulated for testing at ≤P 0.05:

**$HO_1$ :** There is no significant difference in the mean conceptual change scores of students' taught physics (light waves) using concept mapping instructional strategy and those taught using the traditional approach.

**$HO_2$ :** There is no significant difference in the mean conceptual change scores of male and female students taught physics (light waves) using conceptual mapping instructional strategy and those taught using the traditional approach.

## 2. METHODOLOGY

The design of the study is Quasi-experimental design. Specifically, the pretest-posttest non-equivalent control group design was used. The study was carried out in Agbani Education Zone of Enugu State. Agbani Education Zone is made of three Local Government Areas namely, Enugu - South, Nkanu - East and Nkanu - West Local Government Areas.

The population for the study is the total number of students offering physics in senior secondary class two in the zone which is 1,425 students(PPSMB 2013\2014 session). SS2 physics students were used for the study because the students must have been exposed to physics in SS1 and moreover, the units used for the study are taught in SS2. The sample size for this study was made up of 119 SS2 physics students from two senior secondary schools in Agbani Education Zone. Purposive sampling was used to draw the two schools that have at least two streams offering Physics from the total number of 9 co-educational senior secondary schools in the zone. The treatment group, which was exposed to concept mapping, was made up of 77 students while the control group, which was exposed to the conventional instructional

approach, consisted of 42 students. Therefore, the total sample size of 119 consists of 63 boys and 56 girls formed the subjects for the study.

The instrument used for data collection in this study was the Test on Physics Concept (TPC). The test was used to measure the students' prior knowledge (i.e. beliefs and non-beliefs) and subsequent understanding and application of the Physics concept principles. Students' scripts were photocopied and given to three independent scorers who rated the students independently. The scores from the three raters were then used to determine the reliability of the instrument. Since the instrument is essay type, the degree of agreement between the scores of the different scorers was determined using the Kendall coefficient of concordance (W). The reliability of the instrument was found to be 0.81. Based on this reliability index the instrument was deemed suitable for use in conducting the research.

Before the experiment, a pretest was administered to all the students in the two groups of the subjects. This pretest was used to determine the students' conceptual change on refraction of light waves. The treatments (experimental and control) lasted for four weeks. At the end of the treatment session, the post-test was administered to the students for the study. Analysis of covariance (ANCOVA) was used to test the hypotheses, while the mean and standard deviation was used to answer the research questions.

## 3. RESULTS

**Research Question One:**

What are the effects of using concept mapping instructional strategy on students' conceptual change in physics (light waves) when compared with the traditional approach?

As shown in Table 1, the calculated pretest mean and standard deviation values for concept mapping teaching method(experimental group) is 14.83 and 10.25, while the calculated mean and standard deviation value for lecture teaching method(control group) is 14.98 and 10.25. This means that the two groups are in the same conceptual change mean baseline before treatment. However, after the treatment, the mean and standard deviation values for the experimental group are 57.29 and 17.0; while that of the control group are 41.69 and 17.13. This means that the experimental group had a higher conceptual change mean score when compared with the control group with a mean gain score of 15.6. This means that there exists a difference between the mean scores of physics students in TPC when taught using concept mapping and lecture methods.

**Table 1. Summary of descriptive statistics of the mean scores of physics students in TPC when taught using concept mapping and lecture methods**

| Group | N | Pretest | | Posttest | |
|---|---|---|---|---|---|
| | | X | S.D | X | S.D |
| Experimental | 77 | 14.83 | 10.25 | 57.29 | 17.0 |
| Control | 42 | 14.98 | 10.25 | 41.69 | 7.13 |
| Total | 119 | 14.88 | 10.20 | 51.78 | 16.1 |

As shown in Table 2, the calculated value of F= 31.827 with an associated probability value of 0.000. The associated probability value was less than 0.05 level of significance set by the researcher; therefore the null hypothesis was rejected. This implies that there is a significant difference in the mean conceptual change scores of students' taught physics (light waves) using concept mapping instructional strategy and those taught using traditional lecture approach in favour experimental group.

**Table 2. Summary of analysis of covariance (ANCOVA) of the performances of physics students in TPC when taught using concept mapping and lecture methods**

| Source | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Corrected model | 6624.221[a] | 2 | 3312.110 | 15.939 | .000 |
| Intercept | 87926.202 | 1 | 87926.202 | 423.141 | .000 |
| Pretest | 14.592 | 1 | 14.592 | .070 | .791 |
| Method | 6613.558 | 1 | 6613.558 | 31.827 | .000 |
| Error | 24104.099 | 116 | 207.794 | | |
| Total | 349806.000 | 119 | | | |
| Corrected total | 30728.319 | 118 | | | |

*a. R Squared = .216 (Adjusted R Squared = .202)*
*Dependent variable: posttest*

**Table 3. Mean and standard deviation showing students conceptual change by gender and method**

| Group | Gender | N | Pretest score* | | Posttest score | |
|---|---|---|---|---|---|---|
| | | | X | SD | X | SD |
| Experimental | Male | 42 | 14.19 | 8.41 | 60.33 | 18.07 |
| | Female | 35 | 15.60 | 12.18 | 53.63 | 15.16 |
| Control | Male | 21 | 15.09 | 11.30 | 41.48 | 7.03 |
| | Female | 21 | 14.86 | 9.36 | 41.90 | 7.39 |

**Dependent variable: pretest*

**Research Question Two:**

What are the conceptual change mean scores of male and female students taught physics (light waves) using concept mapping instructional strategy and those taught using the traditional approach?

As shown in Table 3 above, the calculated pretest mean and standard deviation scores for males in the experimental group are 14.19 and 8.41, while that of female in the same experimental group are 15.60 and 12.18. However, the posttest mean and standard deviation scores for males in the experimental group are 60.33 and 18.07 and that of the females are 53.63 and 15.16. The pretest mean and standard deviation scores for males in the control group are 15.09 and 11.30, while that of the females in the same group are 14.86 and 9.36. Also, the posttest mean and standard deviation scores for the males in the control group are 41.48 and 7.03, while that of the females are 41.90 and 7.39. It could be observed that the conceptual mean score of the males in the experimental group is greater than that of females in the same group, although the difference will be investigated further in the hypothesis below to ascertain whether or not it is significant or not. In the control group, no difference in mean exist.

**Hypothesis Two:**

There is no significant difference in the mean conceptual change scores of male and female students taught physics (light waves) using a conceptual mapping instructional approach and those taught using the traditional approach.

As shown in Table 4, the calculated value of F = 1.333 with an associated probability value of the value of 0.251. The associated probability value was higher than the 0.05 level of significance set by the researcher; therefore the null hypothesis was upheld. This implies that there is no significant difference in the mean conceptual change scores of male and female students taught physics (light waves) using a conceptual mapping instructional approach and those taught using traditional lecture approach.

## 3.1 Summary of the Findings

1. Instructional treatment (concept mapping strategy) is significant on students conceptual change in light waves;
2. Gender is not significant on students conceptual change in light waves; which means that concept mapping is gender-friendly.

**Table 4. ANCOVA analysis showing conceptual change of students by gender**

| Source | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 7499.643[a] | 4 | 1874.911 | 9.202 | .000 |
| Intercept | 86068.674 | 1 | 86068.674 | 422.402 | .000 |
| Pretest | 29.876 | 1 | 29.876 | .147 | .702 |
| Method | 6338.411 | 1 | 6338.411 | 31.107 | .000 |
| Gender | 271.576 | 1 | 271.576 | 1.333 | .251 |
| method * gender | 352.082 | 1 | 352.082 | 1.728 | .191 |
| Error | 23228.676 | 114 | 203.760 | | |
| Total | 349806.000 | 119 | | | |
| Corrected Total | 30728.319 | 118 | | | |

*a. R Squared = .244 (Adjusted R Squared = .218)*
*Dependent variable: posttest*

### 3.2 Discussions of the Findings

From Table 1, the conceptual change means a score of the experimental group (group taught with concept mapping strategy) was found to be greater than that of the control group (group taught with lecture method). Also, it was found from Table 2, that there is a significant difference in the conceptual change mean scores of the group taught using concept mapping strategy and the group taught using lecture method in favour of the experimental group. The findings are in line with the findings of Orji [13]that found that cognitive conflict instruction makes students change their alternative conception to scientific conception than conceptual change pedagogy. Also, the findings were in line with the findings of Madu [5] and Agomouh [14] that found conceptual change pedagogy superior over traditional teaching method in their separate study.

Table 4 shows that gender does not influence students' conceptual change in light waves. This means that there exists no significant difference between the mean scores of male and female physics students in a test of physics concepts when taught using concept mapping. This implies that concept mapping strategy is gender-friendly teaching strategy. This finding contradicts the finding of Madu [5] that found that male students have superior conceptual shift over the female the students. Also, Agomouh [14] finding revealed that male students have more alternative conception repair when compared with their female counterpart. Although, Orji [13] found that conceptual change pedagogy (5 steps) is more gender-friendly than cognitive conflict instruction that favour male students more than the female.

## 4. CONCLUSION AND RECOMMENDATION

Concept mapping instructional strategy will help to repair students' misconceptions in lightwave and physics in general. Therefore concept mapping should be adopted in the teaching of physics by science teachers, and curriculum planners; and concept mapping should be used in the teaching of physics to breach conceptual change gap between male and female students.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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