# Effect of Collaborative Concept Mapping Instructional Strategy on Secondary Students' Achievement in Difficult Biology Concepts

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## ABSTRACT

This study investigated the Effects of Collaborative Concept Mapping Instructional Strategy (CCMIS) on the Achievement of Senior Secondary Two (SS2) Students in Perceived Difficult Biology Concepts. The aim of the study was to identify the biology concepts students perceived as difficult and to determine the effects of CCMIS on the mean achievement scores of students in the perceived difficult biology concepts. The study was guided by four research questions and three hypotheses. The study adopted a non-randomized Pretest- Posttest Quasi-experimental design. The sample was 276 SS2 biology students selected from six schools from the three education zones in Taraba State using a multi-stage sampling technique. Intact classes were assigned to the experimental and control groups. Data were generated using Perceived Difficult Biology Concepts Inventory (PDBCI) with a Cronbach's alpha coefficient of 0.76 and Biology Achievement Test (BAT) with KR20 of 0.87. 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 alpha level of significance. The findings revealed that students exposed to CCMIS attained significantly higher mean achievement scores in BAT than those exposed to Conventional Teaching Strategy (F=60.73, p=0.00). In addition, male and female students taught using CCMIS did not differ significantly in achievement (F=0.35, p=0.56). Based on these findings, the study recommended among others that biology teachers should use CCMIS to teach students in perceived difficult biology concepts.

***Keywords:*** *Collaborative concept mapping, Achievement in biology, Difficult concepts, Gender, Interaction effect.*

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**Highlights of this paper**

- The investigation of the effects of Collaborative Concept Mapping Instructional Strategy (CCMIS) on the achievement of senior secondary two (SS2) students in perceived difficult biology concepts led to the conclusion that CCMIS significantly improved the academic achievement of students in perceived difficult biology concepts.
- CCMIS is successful in teaching perceived difficult biology concepts to SS 2 male and female students.

## 1. INTRODUCTION

Biology is introduced to students at senior secondary school level in Nigeria as a preparatory ground for human development, where career abilities are groomed, and potentials and talents are discovered and energized (Federal Republic of Nigeria, 2004). The quality and quantity of science education received by secondary school students are geared toward developing future scientists, technologists, engineers, and related professionals (Umar, 2011). It thus appears that for a nation to develop in science and technology, the teaching and learning of biology needs to be improved. This implies that, the performance of students in the subject and in science generally should be of high levels. However, this seems not to be the case in Nigeria as several research works had recorded rather low students' achievement in biology and other science subjects (Olowe, 2010; Samba and Eriba, 2012; Achor and Agbidye, 2014).

Ahmed and Abimbola (2011) lament that the achievement of students in biology for more than twenty five years has been persistently poor in public examinations such as the West African Examinations Council (WAEC) and National Examination Council (NECO). This situation is very disturbing, considering the fact that the students would become future scientists. The implication of a persistent poor achievement in biology means that students who intend to advance their studies in biology- related courses like pharmacy, medicine, biochemistry, environmental sciences, among others, cannot do so as admissions into any higher institution requires students to pass biology with at least a credit (Emaikwu, 2012). Ahmed (2008) fears that the low achievement of students in science subjects at secondary school level poses danger as it could lead to Nigeria not having enough science and technology-related disciplines teachers in the long run.

Adegun and Adegun (2013) attributed students' poor achievements in sciences to poor teaching methods which fail to inspire students' learning. The authors add that the lack of understanding of science concepts results in students finding such concepts difficult to learn. Such difficult concepts are capable of causing students' poor achievement in examinations. Cimer (2011) identified some biology content areas perceived to be difficult to learn by students as: ecology, genetics, physiology, cellular respiration, growth, and chromosomes.

Many researchers agree that there is a demand for a shift in the rethinking of curriculum content and ways in which students are taught (Kolawole, 2007; Okeke, 2007; Adeyemi, 2008). It can be deduced from the authors' submissions that the uninspiring teaching strategies adopted by science teachers have led to under-achievement of students in science subjects, including biology. These studies show that teachers shy away from activity-oriented teaching methods and rely heavily on methods that are easy but most inadequate and inappropriate for teaching many science concepts at secondary school level. Kolawole (2007) argues that while the conventional traditional methods may be adequate for the teaching of humanities, it is quite inappropriate for the teaching of science and calls for a shift to methods that will enable the learners develop and acquire skills essential for scientific and technological development. This, Kolawole suggests, is likely to improve the students' understanding of science concepts which could lead to improving their achievements in external examinations.

This change reflects a move away from the conventional mode of information transmission to that of knowledge construction. This model in which the learner builds his own understanding is known as constructivism

(Epstein, 2013). Constructivism is a strategy of instruction that focuses on the learners' ability to construct his own understanding from experiences and in so doing make meaning of what they learn (Tauritz, 2012). This new trend which is child-centered according to Tauritz, has led to the development of various instructional strategies, amongst which are; discovery learning, analogy, hands-on, minds-on, inquiry, cooperative or collaborative learning, conceptual change and concept mapping, amongst others.

A concept map is a visual representation of a student's understanding of concepts, hierarchically organized and connected by labeled lines. The lines denote the relationship between concepts and the labels on the lines indicate how the two concepts are related (Novak, 2010). Novak and Cañas (2006) describe concept mapping as a graphical tool for organizing and representing knowledge in networks of concepts and linking statements about a problem or subject. Concept mapping has found more and more acceptance during the past decades (Decker, 2013). Concept mapping includes concepts, usually enclosed in circles or boxes of some type where relationships between concepts are indicated by a connecting line linking words. Concept maps are graphical or pictorial arrangements that deal with a specific subject matter. They are useful tools in representing the structure of knowledge in a form that is psychologically compatible with the way in which human beings construct meaning.

Furthermore, studies in biology education indicate that gender, among other factors may be responsible for students' perception of concepts as being difficult. This explains why gender issues have remained a subject of discussion among researchers in education. Teaching activities are presumed to affect male and female students differently in a typical African society where there are prescribed roles for boys and girls in the society. This could give a particular sex an advantage over another. For instance, Olowe (2010) found that females achieved better than males in the science subjects, while Isa and Balarabe (2009) found that males achieved better in science, biology inclusive. On the other hand, Kehinde *et al.* (2006) findings showed that there was no significant difference in science achievement between male and female students. Consequently it appears that influence of gender and students' perception of difficult concepts in biology is still controversial and inconclusive. This controversy further underscores the need for this study, to find out the effect of collaborative and individualized concept mapping instructional strategies on the achievement of male and female senior secondary school students in difficult biology concepts.

### *1.1. Statement of the Problem*

Science teachers have applied various methods and strategies like discovery, questioning, field trips, lecture, discussion, cooperative learning, concept mapping and problem solving in teaching biology yet, poor achievement seems to persist among secondary school students in the certificate examinations throughout the country. This has denied many Nigerian students the opportunity of getting admitted into institutions of higher learning. There are therefore complaints from parents, teachers, curriculum planners and other stake-holders in the educational industry about the deteriorating achievements of students in both internal and external examinations in Nigeria.

Certain perceived difficult biology concepts identified by students in a pre-survey of this study have also been identified by other researchers as contributing to students' poor achievements in biology. Although educators have advocated the use of some of the innovative strategies in teaching difficult biology concepts, there is dearth of research based information on the combined application of these strategies in one study to mediate students' perceived difficult concepts in biology. The problem of this study put in question form then is: What is the effect of collaborative concept mapping instructional strategies on the achievement of SS2 students' in perceived difficult biology concepts?

### *1.2. Research Questions*

The following research questions were raised and answered in the study:

### *1.3. Research Question 1*

What are the biology concepts in the WAEC/SSCE syllabus perceived to be difficult by senior secondary students?

### *1.4. Research Question 2*

How would the mean achievement scores of students taught the same perceived difficult biology concepts using CCMIS and Conventional Teaching Strategy (CTS) differ?

### *1.5. Research Question 3*

What is the difference in the mean achievement scores of male and female students taught the same perceived difficult biology concepts using CCMIS?

### *1.6. Hypotheses*

The following null hypotheses (Ho) were formulated and tested at 0. 05 level of significance:

### *1.7. Hypothesis 1*

*There is no significant difference between the mean achievement scores of students taught the same perceived difficult biology concepts using CCMIS) and CTS.*

### *1.8. Hypothesis 2*

*There is no significant difference in the mean achievement scores of male and female students taught the same perceived difficult biology concepts using CCMIS.*

### *1.9. Research Method*

The quasi-experimental design was used for this study. Specifically, a non-equivalent, non-randomized, control group, involving a pretest- posttest was applied in this study. Quasi-experimental design was considered ideal for this study because participants were already constituted into intact classes hence it was not ethical to randomly select them individually for experimental purposes. Besides, school administrators normally do not allow breaking of classes for random assignment of learners into groups for experimental purposes. An important component of the quasi-experimental study is the use of pre-testing or the analysis of prior achievement to establish group equivalence (Wachanga *et al.*, 2015). It was not feasible to randomly compose and group students, or to disrupt classes already in existence.

### *1.10. Population and Sample*

The population of this study was all the 17,761 SS2 biology students in the three Education Zones of Taraba State. Available data from the Taraba State Teaching Service Board Jalingo (2016/2017) showed that there were 222 secondary schools in the three education zones of the state that offered biology with a population of 17,761 SS2 biology students.

The sample for the study comprised 276 SS2 biology students in the six schools selected from the three education zones of Taraba state (Taraba State Teaching Service Board Jalingo, 2016/2017) using multi-stage sampling technique. This sample was based on six intact classes, comprising one class from each of the six selected schools. At the first stage, purposive sampling technique was used to isolate all the co-education schools offering biology as a subject and with at least one experienced biology teaching staff and a functional biology laboratory. In the second stage, two schools were selected from each zone, using simple random sampling technique of hat and draw, giving a total of six schools from the three educational zones. Thirdly, the selected schools were respectively randomly assigned to the three groups, which were two experimental and one control through hat and draw method. In the fourth stage, simple random sampling technique was used to select one intact SS2 class in each of the selected schools. The total number of 276 students in the six classes constituted the sample for the study.

The criteria for selecting the schools were based on the following guidelines:

1. The school must be a public school.
2. The school must be a coeducational school(with boys and girls).
3. The school must have at least three periods of biology per week, including a double period.
4. The school must have presented students for Senior Secondary School Certificate Examination (SSCE) for at least five years.
5. The school must have qualified teachers with at least a B.Sc and education degree in biology, with at least 5 – 6 years teaching experience.
6. The school must have a functional biology laboratory.

### *1.11. Instrumentation*

Two instruments and a set of lesson plans (intervening instruments) were used by the researcher in the study. They are listed and described as follows:

i. Perceived Difficult Biology Concepts Inventory (PDBCI).
ii. Biology Achievement Test (BAT).

A set of each instrument was submitted to three experts, including some lecturers in biology for face and content validation.

### *i. Perceived Difficult Biology Concepts Inventory (PDBCI)*

This instrument was designed and used in a pre-survey study to assess students' feelings concerning the concepts in biology that SS2 students perceived as difficult or not. The PDBCI was a 31-item inventory. A 4- point Likert type scale labelled: Very Difficult (VD = 4), Difficult (D = 3), Slightly Difficult (SD = 2) and Not Difficult (ND = 1) was used for the rating. Thus a mean value of 2.50 ([4+3+2+1]/4 = 2.50) for an item was considered as difficult whereas below 2.50 was not difficult. Out of the 31 concepts, 14 were scored above 2.5 and were identified by the SS2 biology students as difficult. However, only the first Nine concepts with the highest difficulty ratings of 2.5 and above were purposively selected based on the mean difficulty ratings and taught for ten weeks during the study.The nine concepts perceived by the students as difficult which were classified broadly under tissue respiration and ecology were as follows: tissue respiration concepts were (tissue respiration, aerobic and anaerobic respiration, glycolysis, and Kreb's cycle), while ecology concepts were (ecosystem and ecology, photosynthesis, transpiration, energy flow in the ecosystem, and energy loss in the ecosystem). The concepts were taught for 9 weeks in each of the two experimental and 1 control groups, using collaborative and individualised concept mapping, and conventional teaching method, respectively, as reflected in the lesson plans (see Appendices P, Q and R, pp. 167, 212 and 253 respectively). A reliability coefficient of 0.78 for the PDBCI was obtained using Cronbach's alpha.

### *ii. The Biology Achievement Test (BAT)*

Was adapted from West African Examinations Council (WAEC) past examination question papers of between 1988 and 2015. The Biology Achievement Test items were based on West African Examinations Council (WAEC), which are standardized, since the target of the study is to improve the students' achievement at this level. The test consisted of 40 structured multiple choice questions drawn from the concepts of tissue respiration and ecology, which were perceived and identified by students in a pre-survey study to be difficult. The test items were selected by the researcher based on the senior secondary school biology syllabus.

The two instruments PDBCI and BAT, and the lesson plans used by the researcher in the study were submitted to three experts, including some lecturers in biology for face and content validation.

The PDBCI which consisted of a 31-item inventory was given to two experts in science education in Benue State University and one from Taraba State University. They were asked to check the suitability, language clarity, and relevance of the sub-concepts based on normal classroom teaching, relevance to the objectives they were meant to test as well as the variables under study. One of the experts suggested that an Identification Inventory should be used instead of asking the students to list perceived difficult concepts, as was initially proposed in the instrument by the researcher. This suggestion was implemented. Further advice of the experts enabled the researcher to review the PDBCI which led to the reduction of the items from 35 to 31, to avoid repetitions.

BAT was also given to two biology teachers in secondary schools who were to check for content coverage and see if the questions reflected the objectives of the syllabus. They were also to check for appropriateness of the items for SS 2 students, construction and structure of the questions, as well as clarity of the questions and the options provided. The two secondary school biology teachers had a bachelor's degree each in biology education and one had a Masters degree. They both had a minimum of five years teaching experience. The teachers agreed that the coverage and questions were in consonance with the objectives of the syllabus.

The PDBCI yielded a reliability coefficient of 0.78 using Cronbach's alpha. Kuder ($KR_{20}$) Richard was used for the Biology Achievement Test (BAT). The reliability coefficient (r) for the achievement test items was 0.87. The two instruments were therefore considered reliable for this study, and to have good internal consistency, because according to Pallant (2010) one of the main issues in measuring a scale is the scale's internal consistency reliability, which according to the author, is a measure of how well the items on a test measure the same construct or idea. Pallant affirmed that the alpha coefficients (r) of a scale from 0. 7 upwards is reliable.

## 2. METHOD OF DATA COLLECTION

The researcher visited the selected schools and sought permission from the Principals to enable the staff and the students participate in the experiment. The teachers were the ones that were presently teaching biology in those schools. The teachers were subjected to training so that they could serve as research assistants.

The treatment lasted for a period of ten weeks. During the first week before the commencement of the experiment, the BAT was administered on the sample of 276 in the experimental and control groups for the study as pretest. The main objective of administering the pretest was to ascertain the academic equivalence of the students in the perceived difficult biology concepts before the commencement of the experiment. The tenth week was used for the post-test for all the three groups. The treatment took place once a week in one double period each of 80 minutes.

Two groups were used for the study, namely:

Group A: Collaborative concept mapping instructional strategy experimental group.

Group C: Control group.

The collaborative concept mapping treatment group was engaged in concept mapping in groups of 4-5, using the collaborative concept mapping instructional strategy (CCMIS). Two trained research assistants taught the CCMIS experimental classes using the five collaborative learning elements proposed by Johnson *et al.* (2009) which a teacher has to follow in order to successfully accomplish the experiment in the classroom was adopted and used for the collaborative concept mapping experimental group. These elements are:

i. Positive interdependence.
ii. Face-to-face promotive interaction.
iii. Individual accountability/personal responsibility.
iv. Interpersonal small group skills.
v. Group processing.

STAD, Jigsaw and Circles of Learning models of collaborative learning instructional strategy which are also in line with the formal collaborative learning structure (Johnson *et al.*, 2009) were used for the collaborative concept mapping treatment group (A).

The control group was taught the same perceived difficult biology concepts as in groups A and B, but were not given any of the treatments. In other words, the control group was not exposed to the CCMIS treatments. The normal conventional teaching strategy of "chalk and talk" was used by their regular class teachers for the lessons in the control group.

After the treatment, a post-test was administered in the 10th week to the students using BAT, in order to find out if any change took place in students' achievement in all the groups. The researcher supervised the administration of the instruments through the assistance of the biology research assistants in each school to ensure similarity in test conditions.

### *2.1. Analysis and Interpretation*

Mean scores and standard deviation were used to answer the research questions, while analysis of co-variance (ANCOVA) was used for testing the hypotheses at 0.05 alpha level of significance, with the pre-test scores as covariates. ANCOA was used because it removes the initial differences among groups so that the groups could be considered equivalent since intact classes were used (Ali, 2006).

### *2.2. Research Question 1*

What are the biology concepts in the WAEC/SSCE syllabus perceived to be difficult by senior secondary students?

Table 1 presents the mean difficulty ratings of biology concepts by students. The table reveals that aerobic and anaerobic respiration, tissue respiration, ecology, energy flow in nature, conservation of natural resources, cell and organelles, osmosis, photosynthesis, growth, transpiration, ecosystem, kreb's cycle, energy loss in the ecosystem, and glycolysis all had mean difficulty ratings above 2.50 as and such were considered students' perceived difficult biology concepts. Fourteen concepts had mean difficulty ratings of more than 2.5. However, only the first nine concepts were purposively selected hierarchically according to descending order of difficulty as indicated by their mean difficulty ratings as follows: ecosystem (2.95), tissue respiration (2.92), aerobic and anaerobic respiration

(2.88), glycolysis (2.85), photosynthesis (2.83), ecology (2.81), kreb's cycle (2.76), energy loss in the ecosystem (2.71), and transpiration (2.61).

**Table-1.** Mean perceived difficulty ratings of biology concepts by SS2 students.

| Biology concepts | N | Mean | SD | Remarks |
|---|---|---|---|---|
| Excretory system | 276 | 2.32 | 1.21 | Not difficult |
| Circulatory system | 275 | 2.19 | 1.10 | Not difficult |
| Aerobic and anaerobic respiration | 271 | 2.88 | 1.017 | Difficult |
| Micro organisms | 273 | 2.19 | 1.08 | Not difficult |
| Tissue respiration | 272 | 2.92 | 0.98 | Difficult |
| Genes and chromosomes | 271 | 2.31 | 0.98 | Not difficult |
| Digestive system | 276 | 2.41 | 1.09 | Not difficult |
| Hormones | 274 | 2.30 | 0.98 | Not difficult |
| Tissues and supporting systems | 274 | 2.30 | 0.99 | Not difficult |
| Ecology | 275 | 2.81 | 0.93 | Difficult |
| Skeletal and muscular systems | 275 | 2.37 | 1.19 | Not difficult |
| Energy flow in nature | 274 | 2.58 | 0.99 | Difficult |
| Homeostasis | 274 | 2.39 | 1.08 | Not difficult |
| Reproduction | 273 | 2.25 | 0.93 | Not difficult |
| Classification | 276 | 2.46 | 1.28 | Not difficult |
| Transport of material | 273 | 1.99 | 0.92 | Not difficult |
| Nutrient cycling in nature | 276 | 2.34 | 1.07 | Not difficult |
| Conservation of natural resources | 276 | 2.53 | 0.97 | Difficult |
| Cell and organelles | 276 | 2.52 | 1.10 | Difficult |
| Enzymes | 276 | 2.33 | 1.13 | Not difficult |
| Evolution | 275 | 2.25 | 1.17 | Not difficult |
| Photosynthesis | 275 | 2.83 | 1.08 | Difficult |
| Genetics | 274 | 2.24 | 1.00 | Not difficult |
| Nervous system | 266 | 1.98 | 1.01 | Not difficult |
| Growth | 275 | 2.55 | 1.04 | Difficult |
| Transpiration | 275 | 2.61 | 0.88 | Difficult |
| Ecosystem | 275 | 2.95 | 1.01 | Difficult |
| Osmosis | 275 | 2.55 | 0.96 | Difficult |
| Kreb's cycle | 275 | 2.76 | 1.09 | Difficult |
| Energy loss in the ecosystem | 274 | 2.71 | 1.10 | Difficult |
| Glycolysis | 276 | 2.85 | 1.05 | Difficult |

**Source:** Field study 2017.

All other biology concepts in the table had mean difficulty ratings less than 2.50 therefore they were considered not to be students' perceived difficult biology concepts.

### *2.3. Research Question 2*

How would the mean achievement scores of students taught the same perceived difficult biology concepts using Collaborative Concept mapping Instructional Strategy (CCMIS) and Conventional Teaching Method (CTS) differ?

**Table-2.** Mean achievement scores and standard deviations of students in the CCMIS and CTM groups.

| Group | N | Pre BAT scores | | Post BAT scores | | Mean gain |
|---|---|---|---|---|---|---|
| | | $\bar{x}$ | δ | $\bar{x}$ | Δ | |
| CCMIS | 97 | 11.84 | 4.32 | 26.84 | 6.31 | 15.00 |
| CTM | 91 | 11.89 | 5.42 | 19.77 | 6.05 | 07.88 |
| Mean difference | | -00.05 | | 07.07 | | 07.12 |

**Source:** Field study 2017.

Table 2 presents the mean achievement scores and standard deviations of students in CCMIS and CTS group. The table reveals the difference in the mean achievement scores between the CCMIS and CTS group at pre BAT as

-0.05. The difference at post BAT was shown as 7.07. The mean gained by the CCMIS group was 15.00 while that of the CTS group was 7.88. The difference between the mean gains of students in CCMIS and CTS was 7.12. Result reveals that the difference between the mean scores of experimental and control groups is in favor of the experimental group. This difference in achievement, therefore, can be attributed to the intervention where CCMIS was used.

### *2.4. Hypothesis 1*

*There is no significant difference between the mean achievement scores of students taught the same perceived difficult biology concepts using Collaborative Concept mapping Instructional Strategy (CCMIS) and Conventional Teaching Method (CTS).*

**Table-3.** Summary of one-way ANCOVA report comparing effect of CCMIS and CTM on students' achievement in perceived difficult biology concepts.

| Source | Type III sum of squares | Df | Mean square | F | Sig. | Partial eta squared |
|---|---|---|---|---|---|---|
| Corrected model | 2368.34 | 2 | 1184.17 | 30.86 | 0.00 | 0.25 |
| Intercept | 15958.77 | 1 | 15958.77 | 415.87 | 0.00 | 0.69 |
| prebat1 | 24.22 | 1 | 24.22 | 0.63 | 0.43 | 0.01 |
| gp1 | 2330.39 | 1 | 2330.39 | 60.73 | 0.00 | 0.25 |
| Error | 7099.29 | 185 | 38.37 | | | |
| Total | 112540.00 | 188 | | | | |
| Corrected total | 9467.64 | 187 | | | | |

**Source:** Field study 2017.

Table 3 is summary of one-way ANCOVA report comparing the effect of CCMIS and CTS on students' achievement in perceived difficult biology concepts. The table shows that F (1,187) = 60.73, p = 0.00 for the CCMIS group. The test statistic was therefore considered to be significant since p = 0.00 < 0.05. With this result, the null hypothesis which states that there is no significant difference between the mean achievement scores of students taught the same perceived difficult biology concepts using CCMIS and CTS was rejected. The effect size was shown as 0.25 which indicates that students from CCMIS benefited an average of 25 mean scores more than CTS when taught perceived difficult biology concepts.

### *2.5. Research Question 3*

What is the difference in the mean achievement scores of male and female students taught the same difficult biology concepts using Collaborative Concept Mapping Instructional Strategy (CCMIS)?

**Table-4.** Mean achievement scores and standard deviations of male and female students in the CCMIS group.

| Gender | N | Pre BAT scores | | Post BAT scores | | Mean gain |
|---|---|---|---|---|---|---|
| | | $\bar{x}$ | Δ | $\bar{x}$ | Δ | |
| Male students | 54 | 12.04 | 4.65 | 26.46 | 6.96 | 14.42 |
| Female students | 43 | 11.58 | 3.91 | 27.30 | 5.45 | 15.72 |
| Mean difference | | 00.46 | | 00.84 | | -1.30 |

**Source:** Field study 2017.

Table 4 presents the mean achievement scores and standard deviations of male and female students in CCMIS group. The table shows the difference in the mean achievement scores of male and female students in the CCMIS group at pre BAT as 0.46. The difference at post BAT is shown as 0.84. The mean gain by the male students is 14.42 while that of the female students is 15.72. The difference in the gender mean gain is 1.30, in favour of the female students. The results indicate that the female students gained slightly more, and performed slightly better than their male counterparts when exposed to the CCMIS.

### 2.6. Hypothesis 2

*There is no significant difference in the mean achievement scores of male and female students taught the same perceived difficult biology concepts using Collaborative Concept mapping Instructional Strategy (CCMIS).*

**Table-5.** Summary of one-way ANCOVA on the effect of CCMIS on male and female students' achievement in perceived difficult biology concepts.

| Source | Type III sum of squares | df | Mean square | F | Sig. | Partial eta squared |
|---|---|---|---|---|---|---|
| Corrected model | 71.12 | 2 | 35.56 | 0.89 | 0.41 | 0.019 |
| Intercept | 9471.43 | 1 | 9471.43 | 237.02 | 0.00 | 0.716 |
| Pre bat | 54.25 | 1 | 54.25 | 1.36 | 0.25 | 0.014 |
| Gender | 13.79 | 1 | 13.79 | 0.35 | 0.56 | 0.004 |
| Error | 3756.25 | 94 | 39.96 | | | |
| Total | 73679.00 | 97 | | | | |
| Corrected total | 3827.36 | 96 | | | | |

**Source:** Field study 2017.

Table 5 presents summary of one-way ANCOVA on the effect of CCMIS on male and female students' achievement in perceived difficult biology concepts. The table shows that (1,96) = 0.35 and p = 0.56 for gender. The test statistic was therefore considered not to be significant since p = 0.56 > 0.05. With this result, the null hypothesis which states that there is no significant difference in the mean achievement scores of male and female students taught the same perceived difficult biology concepts using CCMIS was not rejected. The effect size was shown as 0.004 which indicates that the difference in mean achievement scores between gender was 0.4. This is indicative that male and female students equally benefited from CCMIS.

## 3. DISCUSSION OF FINDINGS

This study focused on the effect of CCMIS on students' achievement in perceived difficult biology concepts. In addition to this, the study examined the interaction effect of gender and treatments on achievement in perceived difficult biology concepts.

The findings of the study revealed that the collaborative concept mapping instructional strategy assisted students' understanding of those perceived difficult biology concepts namely; tissue respiration, aerobic and anaerobic respiration, glycolysis, and Kreb's cycle, ecosystem and ecology, photosynthesis, transpiration, energy flow in the ecosystem, and energy loss in the ecosystem, from which the biology Achievement Test items were constructed. This finding is in agreement with earlier researchers (Cimer, 2011; Etobro and Fabinu, 2017). Etobro and Fabinu (2017) in particular similarly found that students usually have difficulties in ecology related concepts which include nutrient and energy recycling in nature, ecosystem, among others. Cimer (2011) reported that ecology, aerobic and anaerobic respiration, and photosynthesis among others were the concepts secondary school students perceived as difficult.

The findings of the present study further revealed that students who were exposed to CCMIS attained significantly higher mean achievement scores in the perceived difficult biology concepts than those who were exposed to the ICMIS and the conventional teaching method. This finding is in consonance with Ogonnaya *et al.* (2016) who found in an investigation on effects of collaborative concept mapping instructional approach on students' achievement in Basic Science that concept mapping fosters students' achievement in basic science more than conventional method. The finding of this study further conformed to earlier findings of Sharma and Singh (2016) on the effect of collaborative concept mapping strategy on students' achievement that achievement of the group exposed to collaborative concept mapping strategy was significantly more compared to the group taught by conventional method.

This finding is also in agreement with Githae *et al.* (2015) finding that collaborative concept mapping teaching approach had a significant effect on achievement in biology in a study on effects of collaborative concept mapping teaching approach on secondary school students' achievement in biology in Nakuru North Sub-county, Kenya. The finding is also in agreement with the earlier finding of Ajaja (2013) that there was a significant effect of CCMIS on achievement and retention in biology and Kolawole (2007) submission that collaborative concept mapping strategy group of students significantly gained higher mean achievement scores in mathematics than those taught using conventional methods.

In contrast, however, Etobro and Fabinu (2017) finding included pests and diseases of crops as well as reproductive system in plants among the perceived difficult concepts, which in the present study were not perceived difficult by students. This study is also at variance with the findings of Achor and Agbidye (2014) who reported that excretion, cells, skeleton, states of matter, measurement and air were rated by the JSS2 students as difficult, perhaps because according to the students, some of these concepts were not taught to them.

While research on collaborative concept mapping has found results that confirm the possibilities and advantages of concept maps, some studies have reported conflicting results concerning the positive effects of collaborative concept mapping instructional strategy (Basque and Lavoie, 2006; Nesbit and Adesope, 2006; Gao, 2007). However, recent findings presented in the literature confirm that CCMIS is effective when students have been trained appropriately and can use concept maps in a mature rather than naive way (Basque and Lavoie, 2006; Novak and Cañas, 2006). Thus, training activities must include collaborative concept maps instead of exclusively focusing on individual concept mapping.

The difference between this present study and other previous studies that also worked on the effect of collaborative concept mapping instructional strategy is that this study has shown the usefulness of CCMIS on improving students' achievement particularly in perceived difficult biology concepts. This was revealed by the higher mean achievement scores of the CCMIS experimental group in the post- test. Students were thus able to effectively construct cognitive structures (maps) by forming links between their existing and new knowledge while interacting with peers and then establishing meaningful understanding of the perceived difficult concepts. In other words, building concept maps in a collaborative environment may lead to greater learning, superior maps, resulting in higher achievements, as was observed from this study. Collaborative concept mapping may have helped students to organize/structure knowledge and facilitate acquisition of metacognitive skills. A collaborative concept mapping strategy may also have further supported idea-sharing and the refinement of understanding of the perceived difficult concepts, as was observed in this study. This finding is attributed to the fact that students working in small groups tend to learn more of what is taught than when the same content is presented in other instructional formats. This implies that CCMIS is a potentially powerful instructional strategy that fosters meaningful learning and group knowledge construction which helps the building of co6mon ground among learners. It is also true that collaborative concept mapping facilitates the exchange of information which made the viewpoints of individual collaborators more clear and encouraged participation. The implication of this finding to science teaching is that biology teachers may need to provide instructional guides to promote peer interactions to construct group maps especially on perceived difficult biology concepts in biology classes.When the students fully understand the collaborative concept mapping instructional strategy, they can take much more benefit from the group concept mapping activity to improve their achievement.

Results from this study indicate that both male and female students performed well when exposed to the CCMIS in learning the perceived difficult biology concepts irrespective of their gender.

This finding is consistent with the finding of Adeyemi and Cishe (2016) who reported that gender has no significant main effect on students' achievement when exposed to collaborative concept mapping. The finding was consistent with Ogonnaya *et al.* (2016) conclusion that collaborative concept mapping instructional approach boosted the achievement of male and female students in basic science.

## 4. CONCLUSION

The findings of this study led to the conclusion that Collaborative Concept Mapping Instructional Strategy (CCMIS) significantly improved the academic achievement of students in perceived difficult biology concepts. It is evident from the study that students' interactions in the classroom could result to more understanding of knowledge irrespective of students' gender.. This means that CCMIS would be successful in teaching perceived difficult biology concepts to SS 2 male and female students.

## 5. RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

i. Biology teachers should use collaborative concept mapping instructional strategy to teach perceived difficult biology concepts at the senior secondary school level because they have been found to be effective in teaching these aspects of the subject.

ii. Publishers of biology textbooks at the secondary school level should incorporate CCMIS for teaching different aspects of biology especially perceived difficult biology concepts. This will enable biology teachers to use CCMIS activities which will expose students to activities that can enhance understanding of the perceived difficult biology concepts.

iii. Teacher trainers like Colleges of Education and Universities should develop a curriculum for training professional teachers in the art of collaborative concept mapping so that they can learn to use the interactive strategy to teach perceived difficult biology concepts.

iv. Seminars, workshops and symposia should be organized by Biology Teachers' Association of Nigeria (BTAN), the Taraba State Chapter of Science Teachers Association of Nigeria (STAN), the Taraba State Ministry of Education and the Taraba State Post Primary Schools Management Board (PPSMB) to enlighten biology teachers on the effectiveness of CCMIS in teaching perceived difficult biology concepts.

v. Both male and female students at the senior secondary school level should be exposed to CCMIS in teaching especially the perceived difficult biology concepts, since their achievement was not gender bias in this study.

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