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Effect of Concept-Mapping Instructional Strategy in Remediating Senior School Students' Misconceptions in Ecology in Oyo, Nigeria

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Abstract

Students held misconceptions about many biology concepts and theories such as ecology, genetics, evolution, respiration, and cell, among others, and these can be traced to ineffectiveness and inappropriate use of instructional strategies. This study therefore, examined the effect of concept-mapping instructional strategy in remediating senior school students' misconceptions in ecology. The quasi- experimental research design was adopted for the study while Multistage sampling technique was used to select the 114 senior school biology students that participated in the study. Concept Map on Ecology (CME) and Basic Ecological Concepts Achievement Test (BECAT) were used for data collection. Percentages and chi-square were used to answer the research questions while Chi-square was used to test the null hypotheses. The findings of the study revealed that biology students in secondary schools held many misconceptions on ecology. Concept-mapping instructional strategy remediated 61.9% of the misconceptions held by students. In addition, there was no significant difference in the number of misconceptions held by male and female students exposed to concept-mapping instructional strategy. The study recommended that concept-mapping instructional strategy should be used concurrently with other innovative instructional strategies to remediate students' misconceptions in ecology and other related biology concepts.

Introduction

The place of science in the development of every sphere of human life cannot be overemphasized. This is because scientific knowledge forms the basis for human successful existence on earth. Owolabi (2004) submitted that science constitutes an integral part of human society, which influences the biotic and abiotic components of the environment. The interesting world of organisms has made the field of science particularly, biology a stimulating field of enquiry. The knowledge of biology consists not only of a collection of facts, but also more importantly the way these facts are associated with and interpreted in general theories applied to human life (Umar, 2011).

Martins and Hine (2015) stated that biology is composed of numerous sub-disciplines, including fields, such as zoology, botany, genetics, medicine, agriculture, anatomy and histology. Other disciplines as reported by Joshi and Green (2013) are embryology, physiology, genetics, molecular biology, biochemistry, ecology and so on. Ecology is the branch of biology, concerned with the study of interrelationship between living organisms and their external environment.

Ecology deals with the study of countless interactions, actions, co-actions and reactions between the biotic and abiotic components of the environment along the various material cycling mechanisms within the ecosystem. The field of ecology also involved interdisciplinary sub-areas such as mathematics ecology, evolutionary ecology, marine ecology, industrial ecology and ecological genetics and this has made the discipline more general within science education as many occupations and academic fields had in recent times embraced ecological principles in problem solving (Ogundare, 2017).

Meanwhile, several researchers (Abe & Owoeye, 2017; Agboghoroma & Oyovwi, 2015; Etobro & Fabinu, 2017) have identified ecology as a hard-to-teach and hard-to-learn biology concept for senior school biology teachers and students, respectively. Furthermore, the West African Examinations Council Chief Examiners' report (2015, 2016) revealed that candidates performed poorly in questions relating to ecology due to the neglect of such questions; inability of candidates to completely express themselves using appropriate ecological technical terms; and misconceptions of ecological concepts. In consonance, Abubakar and Jimin (2018) identified the misconceptions of basic biology concept as the main factor affecting students' performance in biology.

Misconceptions have been recognized as a major factor affecting students' understanding and performances in different fields of study (Adegboye, Bello, & Abimbola, 2017; Coll & Treagust, 2003). The term misconception refers to any conceptual idea that differs from the commonly accepted scientific consensus. Novak (2003) observed that every human has misconceptions of one form or the other, which could persist for years without even realizing they are misconceptions. This is because misconceptions are highly resistant to change, persistent, difficult to quench and cannot be removed easily by traditional instructional methods (Sungur, Tekkaya & Geban, 2001; OpenScholar, n.d.).

Therefore, the identification of misconceptions and other barriers to study is an important and obvious stage in the remediation of students' poor performance and bridging the achievement gaps that exist among students with numerous mental abilities (Adeoye & Abimbola, 2016). Sequel to this, Okoli (2003) concluded that until the reasons for students' misconceptions are understood, improvement will not be realizable in terms of instruction and performance. Hence, to equipped students with the right conceptions, it is imperative for all teachers to adopt new and innovative ways to identify and correct students' misconceptions (Burgoon, Heddle & Duran, 2011).

To this end, several instructional strategies have been explored by researchers with the aim of identifying the most suitable strategy that can perfectly eliminate students' misconceptions. For instance, Haslam and Treagust (2010) conducted a study on diagnoses of secondary school students' misconceptions in photosynthesis and respiration, and discovered that many students could not comprehend the relationship between photosynthesis and respiration in plants. Cetin, Ertepinar and Geban (2015) investigated the effects of the conceptual change text-based instruction on ninth grade students' understanding of ecological concepts and found that conceptual change text-based instruction was better than traditional instruction. Elangovan (2017) discovered that students exposed to realistic simulations developed significantly less misconceptions in mitosis and meiosis as compared to the comparison group. Furthermore, Dashe and Nor (2020) investigated the effect of concept mapping and mind mapping strategies on creativity in ecology among senior school students in Nigeria and concluded that concept-mapping instructional strategy was more effective in enhancing students' achievement. In contrast, to existing literature, the present study used concept map as a strategy to remediate students' misconceptions in ecology.

A concept map, is a diagram showing the relationships among concepts (Novak & Canas, 2008). It is a graphical structure containing nodes that are interwoven by labeled and directed arcs. When making a concept map, the emphasis is on the relationships among concepts. Concepts are symbolized as boxes or circles which are connected with labeled arrows in a downward branching hierarchical structure to show the interconnectivity of each concepts (Novak & Canas, 2008). According to Dhull and Verma (2020), concept maps can be used to summarize part of a book, connect historical events, describe how a business is run, develop a personal care plan or patient treatment, describe how the body works, or the interconnectedness of a wetland's ecology. In the present study, concepts maps were developed and designed to teach ecological concepts related to community, population, biosphere, habitat and ecosystem.

The gender orientation of learners as male and female is an important variable to consider when investigating the conception, alternative conceptions and misconceptions of concepts. This is because the perception of male and female students may vary since each individual is saddled with the responsibility of constructing their own knowledge. Temizkan (2003) stated that male students had fewer misconceptions than female students. In addition, Svandova (2013) observed a significant difference between male and female students' knowledge about photosynthesis and plant respiration. However, Aderogba (2006) posited that gender had no impact on students' achievement. Bello and Abimbola (1997) conclude that there is no gender influence on students' achievement in evolution when concept-mapping was used as an instructional strategy. In contrast, the present study, investigated the effect of concept-mapping instructional strategy in remediating senior school students' misconceptions in ecology in Oyo State, Nigeria and consider gender as a moderator variable.

Purpose of the Study

The primary purpose of this study was to investigate the effect of concept-mapping instructional strategy in remediating senior school biology students' misconceptions in ecology. Specifically, the study intended to:

1. identify students' misconceptions in ecology;
2. determine the differences in the number of misconceptions remediated when students are taught ecology using concept-mapping instructional strategy and conventional method of teaching;
3. examine the influence of gender on students' misconceptions when taught ecology using concept-mapping instructional strategy.

Research Questions

In this study, answers were provided to the following research questions:

1. What misconceptions do biology students held in ecology?
2. Is there any difference in the number of misconceptions remediated when students are taught ecology using concept-mapping instructional strategy and conventional method of teaching?
3. What differences exist in the number of misconceptions on ecology remediated by concept-mapping instructional strategy among male and female students?

Research Hypotheses

The following hypotheses were tested in this study:

H_{01}: there is no significant difference in the number of misconceptions remediated when students are taught ecology using concept-mapping instructional strategy and conventional method of teaching.

H_{02}: there is no significant difference in the number of misconceptions on ecology remediated by concept maps among male and female students.

Method

Research Design

Quasi- experimental design involving a pretest, posttest, non-randomized control and non-equivalent intact group was employed for this study.

Population, Sample, and Sampling Technique

The population for this study comprised all senior secondary school students in Oyo State, Nigeria. The sample for the study comprised an intact class of 114 senior secondary schools two biology students drawn from two co-educational schools in Oyo using multi-stage sampling technique.

Research Instrument

The stimulus instrument for the experimental group in this study was Concept Map on Ecology (CME) while the response instrument was Basic Ecological Concepts Achievement Test (BECAT) both of which were designed by the researchers and used to determine students' misconceptions and achievement in ecology. The CME were developed on community, population, biosphere, habitat and ecosystem because other related ecological concepts are embedded in the aforementioned concepts. The BECAT was divided into sections A and B. Section A contained information on the bio data of the students while section B consisted of 18 short answer essay questions on ecology. Table 1 shows the BECAT table of specifications which was prepared using Bloom's taxonomy of educational objectives.

Table 1. Basic Ecological Concepts Achievement Test Table of Specifications

	Cognitive domain							
Contents	Knowledge	Comprehension	Application	Analyse	Synthesis	Evaluation	Total No. of items	Percentage
Community	1	1	1				3	16.67
Population	2	1					3	16.67
Biosphere	1	1		1			3	16.67
Habitat	1	1	1	1			4	22.22
Ecosystem	1	1	1		1	1	5	27.78
Total	6	5	3	2	1	1	18	100
Percentage	33.33	27.78	16.67	11.11	5.56	5.56	100	

Validation of the Instrument

The face and content validity of the instrument were determined by experts in the field of biology, science education and experienced biology teachers in senior secondary schools in Ilorin, Kwara State. Table of Specifications was used in the construction of the BECAT which was subjected to test-retest method of validity. A reliability co-efficient of 0.79 was obtained for the BECAT using Pearson product-moment correlation statistics.

Procedure for Data Collection

The researchers sought the consent of all the participants involved in the study using an informed consent form. The study lasted for a period of five weeks. The first and fifth week were used for the administration of BECAT as pretest and posttest in the experimental and control groups respectively while treatment administration took place in the second, third and fourth weeks. At the commencement of treatment in the experimental group, copies of CME were given to each student and they were guided to identify and list the organizational levels of ecology that is the basic ecological concepts. Thereafter, the students were called in turns to mention sub-concepts that are associated with each of the basic ecological concepts as reflected in the CME and each of the sub-concepts were defined accordingly. The research Assistant in the control group used prepared lesson plan and their usual conventional method(s) of teaching ecology, this was done without any form of interference from the researchers.

Data Analysis Techniques
The data collected were analyzed statistically using percentages and Chi-square statistics.

Results

Research Question 1: What misconceptions do biology students held in ecology?

Table 2 indicated that students held several misconceptions on many ecological concepts and sub-concepts namely; Population, Community, Ecosystem, Habitat and Biosphere. A total of 168 misconceptions were identified from students' responses. In addition, Table 2 revealed that most of the respondents that held misconceptions could not express themselves using appropriate ecological technical terminologies and English related words.

Table 2. Students' Misconceptions on Ecology

S/N	Misconceptions	No. of Respondents
1	Abiotic factors are animal that lives in water and also is an omnivores thing	1
2	Abiotic factors are the factors that affect ecosystem systematically	1
3	Abiotic factors are the living factor affecting community	1
4	Abiotic factors are the living thing affecting ecosystem or community	1
5	Abiotic factors are the particular environment which contain living organism	2
6	Abiotic factor can be defined as the living factor affecting people	1
7	Abiotic factor can be defined as the living things that live inside water	1
8	Abiotic factor is a form of ecosystem of live	1
9	Abiotic factors are measured by biosphere, environment, and atmosphere	1
10	All creatures are in a population	2
11	All plants and Animal together is pop population	1
12	Ammenter is an instrument used in measure of abiotic factors	1
13	Atmosphere can be defined as part of the earth contains living things	2
14	Atmosphere can be defined as the part of the earth of the earth contains living things	2
15	Atmosphere has the largest number of living organism living in it	1
16	Atmosphere is a portion where plant grows	2
17	Atmosphere is defined as part of the earth contain living things	1
18	Atmosphere is the first place which is reach from the earth	2
19	Atmosphere means the kind of living organisms living above the earth crust	2
20	Biosphere and atmosphere are the factors affecting ecosystem	1
21	Biosphere and ecology affecting population	1
22	Biosphere can be defined as the part of the earth which mainly comprises of the non-living organism	2
23	Biosphere consists of the hydrosphere and lithosphere only	1
24	Biosphere is a major component found in any habitat	2
25	Biosphere is also one of the branches of biology	1
26	Biosphere is an area where the oxygen, nitrogen are and people cannot dwell in it because of the certain non-living thing	1
27	Biosphere is one of the five atmosphere we have	2
28	Biosphere is where the earth started	2
29	Bush burning and lack of appetite affect aquatic habitat	1
30	Calorimeter and spring range are used in measuring abiotic factors	1
31	Climatic rainfall, chemical, pressure, light, calorimeter are the instrument used in measuring abiotic factor	1

32	Community can be defined as a particular place live, it can be either be rural community or urban community	2

S/N	Misconceptions	No. of Respondents
33	Community can be defined as a place where lives/ it is a place comprises many people	1
34	Community can be defined as the gathering of people in one society	1
35	Community is a place where people live and living thing engaged in for there habitat	1
36	Community is a place where people reside	2
37	Community is a place where two or more people live in order to earn a living	2
38	Community is a place where we live and enjoy life	1
39	Community is a surrounding or group people combine themselves into one group	2
40	Community is an area of land or environment in which people live	2
41	Community is defined as act of counting number of people	1
42	Community is like Communication which is the act of talking to people that related to you	1
43	Community is simply defined as rural area where people live	1
44	Community is the number and associated in the communication of the word to involved in the good and follow by rule and regulation	2
45	Community is the surrounding we live	2
46	Digestive and ingestion are components of ecosystem	2
47	Earth planet is component of ecosystem	1
48	Ecology can be defined as the maintenance of plant trees and shrubs in a society	2
49	Ecology can be defined as the system by which plants and animals survive	1
50	Ecology can be defined as where organism live generally	1
51	Ecology can be defined where a particular people organism e.g. for monkey they dwell in their ecology environment (like land or the environment)	2
52	Ecology is the classification of animal	1
53	Ecology is the classifications of plants and animals	1
54	Ecology is the life and living thing of other organism	1
56	Ecology is the study of animal	2
57	Ecology means to used systematically to observed something in a good way or good behavior	2
58	Ecosystem can be defined as the common together of two Latin word which ECO mean peaces and system	1
59	Ecosystem can be defined as the group of organism living	1
60	Ecosystem can be defined as the place where plant, trees and shrubs are found in a society	2
61	Ecosystem can be defined as the system in which the population/amount of organism is calculated	2
62	Ecosystem can be defined as where an organism live generally	2
63	Ecosystem can be described as the system due to the ecology of biology	1
64	Ecosystem is a living space	1
65	Ecosystem is a particular arear a place where we cooperation in a manner place	1
66	Ecosystem is a place where living organism live	1
67	Ecosystem is affected by people living therein	1
68	Ecosystem is defined as the group living organism	1
69	Ecosystem is defined in the same way as ecology	1
70	Ecosystem is made up planets	1
71	Ecosystem is the classification of plant in the internal and external part	1
72	Ecosystem is the radiation of plant and animals basic on their environment	1
73	Ecosystem is the study of living things	2
74	Ecosystem is the study of plant and their environment	1
75	Ecosystem is the study of plants and their animal	2
76	Ecosystem is the system of the animal or man	1
77	Ecosystem itself affect populations	1
79	Ecosystem means something that have internal and external in a skeleton system and having intestine	1
80	Famine and drought are the factor affecting ecology	1
81	Gene pool and alleles affect population	1
82	Group of animals are population	1

83	Habitat is a combination of many people	1
84	Habitat is a forest	1
S/N	Misconceptions	No. of Respondents
85	Habitat is a forest and it is a place that only fish live	1
86	Habitat is a place that animals live	2
87	Habitat is a place that creatures live	1
88	Habitat is place where animals and fishes live	2
89	Humans forms ecosystem	1
90	Humidity, Poverty and lack of shelter affect population	1
91	Hydrosphere has the large number of living organism living in it	1
92	Hydrosphere is the portion of water on land	2
93	Hydrosphere can be defined as the part of place where organism live	1
94	Hydrosphere is a layer found in between atmosphere and biosphere of the earth surface	2
95	Hydrosphere is a place where above the atmosphere	1
96	Hydrosphere is a where the air is deep down the world	2
97	Hydrosphere is an instrument used in measure of abiotic factors	1
98	Hydrosphere is the layer very close to the atmosphere in the ozone layer	2
99	Living organism form ecosystem by eating each other	1
100	Micrometer is used in measuring abiotic factor	1
101	Population forms society	2
102	Population is a biome formed from the same species inhabiting in an area.	1
103	Population is a particular or the member of a country	1
104	Population is affected by animal living there	2
105	Population is affected by employment opportunity of people	2
106	Population is an area where living things occur.	1
107	Population is the number of animals	1
108	Population is the number of people living in a community	2
109	Population is the number of people/organism	2
110	Population is the same as community	2
111	Population is the same as habitat	1
112	Rainfall affect terrestrial habitat	1
113	Some ecosystems are limitless resources and provide an opportunity for limitless growth of a population	2
114	Stroke recorder is used in measuring abiotic factor	1
115	Terrestrial habitat is a place where aquatic animals live and it contains of water	1
116	Terrestrial habitat are the liquid portion where fish and other animal live	1
117	Terrestrial habitat can be defined as the place where different animal live and stay inside the water	2
118	Terrestrial habitat is a place where living organism is living	2
119	Terrestrial habitat is affected by number of fish there in	1
120	Test tube, beaker, funnel cuadrat are used in measuring abiotic factors	1
121	The place where people stay and enjoy themselves is called habitat	1
122	Variation is one of the factor affecting ecology	2
123	Hydrosphere are the living water in an ecosystem	1
124	Water pollution affect terrestrial habitat	1
125	Type of water in the hydrosphere affect people's healthy	1
126	Density of water and saltiness affect the community	1
	Total	**168**

Research Question 2: Is there any difference in the number of misconceptions remediated when students are taught ecology using concept-mapping instructional strategy and conventional method of teaching?

Table 3 indicated that biology students in the experimental and control groups held 94 and 74 misconceptions respectively before the administration of treatment. However, there was a drop in numbers of misconceptions held by students in the experimental (68) and control (58) groups respectively after their exposure to concept-mapping instructional strategy and conventional method of teaching. Thus, 26 (61.9%) and 16 (38.1%) of the identified misconceptions among the experimental and control groups were remediated through exposure of students to concept-mapping instructional strategy and conventional method of teaching, respectively.

Table 3. Contingency Table of Number of Misconceptions in the Pretest and posttest of Experimental and Control Groups

Group	Pretest	Posttest	No of Misconception Remediated	Percentage of Misconceptions Remediated
Experimental	94	68	26	61.9%
Control	74	58	16	38.1%
Total	168	126	42	100

Hypothesis 1: There is no significant difference in the number of misconceptions remediated when students are taught ecology using concept-mapping instructional strategy and conventional method of teaching.

Table 4 revealed that the calculated $\chi 2$ (2, 113) =1.98, 124.34 was not significant at 0.05 alpha level. Hence, the hypothesis was not rejected. Therefore, it implies that, despite the reduction in the number of misconceptions remediated through the use of concept-mapping instructional strategy and the conventional method of teaching, the difference was not significant.

Table 4. Chi-square Analysis of Difference in the Number of Misconceptions Held by Students

Group	Observed	Expected	N	df	Cal. Value	Table Value	Sig.	Remark
Experimental	68	63	64					
				113	1.98	124.34	NS	Not rejected
Control	58	63	50					

Research Question 3: What differences exist in the number of misconceptions on ecology remediated by concept-mapping instructional strategy among male and female students?

To provide an answer to this question, research hypothesis 2 was generated from the question.

Research Hypothesis 2: There is no significant difference in the number of misconceptions on ecology remediated by concept maps among male and female students.

Hypothesis 2 was tested using Chi-square statistics. Table 5 indicated that the calculated $\chi 2$ (2, 64) =11.53, 82.59 was not significant at 0.05 alpha level. Hence, the hypothesis was not rejected. This implies that there was no significant difference in the number of misconceptions held by male and female students.

Table 5. Chi- square Analysis of Difference in the Number of Misconceptions Held by Male and Female Students

Group	Observed	Expected	N	df	Cal. Value	Table Value	Sig.	Remark
Male	48	34	31					
				63	11.53	82.59	NS	Not rejected
Female	20	34	33					

Discussion

The study revealed that students held several misconceptions on many ecological concepts and sub-concepts which are related to population studies, community, ecosystem, habitat and biosphere before their exposure to the treatment. Probable reasons for this finding hinge on the nature of ecological concepts, which include biotic, environmental, habitat and community studies which students constantly interact with and thus, construct their individual conceptions based on their daily interaction with the environment. In addition, most of the students could not express themselves using appropriate ecological terminologies and English words. This finding was in congruent with the studies of Novak (2003), Okoli (2003) and Burgoon, Heddle and Duran (2011).

Furthermore, the result of this study revealed that there was no significant difference in the number of misconceptions remediated when students are taught ecology using concept-mapping instructional strategy and conventional method of teaching. Though, concept-mapping instructional strategy remediated many of students' misconceptions in comparison to the conventional method of teaching, it was however not significant, because misconceptions are highly resistance to change. Also, this might have been responsible for the incomplete elimination of students' misconceptions despite their exposure to the treatment. This finding is an indication that there is no perfect instructional strategy(ies) that can perfectly eliminate students' pre-conceptions and

misconceptions. This result corroborated earlier studies of Cetin, Ertepinar and Geban (2015), Sungur, Tekkaya and Geban (2001), Haslam and Treagust (2010) who indicated that misconceptions are highly resistant to change.

Result also showed that there was no significant difference in the number of misconceptions on ecology remediated by concept maps among male and female students. This result implies that neither concept-map nor misconceptions were gender sensitive. This result may equally be because all the students were exposed to concept-mapping instructional strategy the same time and constructed their individual idiosyncratic knowledge, irrespective of gender. It may equally be because the teacher and teaching environment were not gender bias. This finding was in accord with studies carried out by Agboghoroma and Oyovwi (2015) and Aderogba (2006).

Conclusion

The study concluded that students held many misconceptions on ecology. Concept-mapping instructional strategy did not significantly remediate all of students' misconceptions in ecology. Also, students' gender orientation as male and female did not significantly influence the number of misconceptions on ecology held by biology students.

Recommendations

Based on the findings of the study, the following recommendations were advanced:

- Concept-mapping instructional strategy should be used concurrently with other innovative instructional strategies to remediate students' misconceptions in ecology and other biology concepts.
- Authors of biology textbook should be sensitive to misconceptions about ecology and incorporate concept-maps and glossaries to explain ecological concepts such as population, habitats, ecosystem and so forth.
- Male and female students should be given opportunity in biology classrooms to create, construct and learn from one another to ensure a gender bias free learning environment.

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