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Students' Conceptions of Ecology in Senior Secondary School Biology

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Abstract
The purpose of the study was to determine students' conceptions of ecology in senior secondary school biology. Three research questions were formulated to guide the study. Ex-post facto research design was adopted for the study. The population of the study consisted of 5,780 senior secondary school two (SSS2) biology students in all the government owned educational secondary schools in Nsukka Education Zone in Enugu state, Nigeria. The sample size of the study comprised of 357 senior secondary two (SS2) students drawn from the population using multi-stage sampling procedure. The researchers developed Ecology Conception Test (ECT) which consists of 10 essay items was used as instrument for data collection. The reliability coefficient of 0.871 for the instrument was ascertained using Cronbach Alpha. Frequency and percentage were used to answer research question one and students' responses were described based on research question two. The findings of the study showed that the level of students' conception is low; 68.8% students have NC while students with AC are 15.5%; and students with PU across all item is 6.2% whereas students with SC have 9.5%. Based on the findings of the study, recommendations were made.
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1.0. Introduction

Biology is viewed as an aspect of science that deals with the study of everything that is, or was once, alive whether it's a plant, animal or microorganism. This implies that biology helps us understand the living world and the ways its many species (including humans) function, evolve, and interact (Rogers, 2020). It is of no doubt that advancement in medicine, biotechnology, ecology and many other areas of biology have brought improvements in the quality of life (Chinweuba-eze, 2021). Ecology as one of the crucial concepts in biology thought in senior secondary schools in Nigeria. Ecology deals with the study of living organisms in relation to their environment which seeks to understand the vital connections between plants and animals and the world around them (Ihekwoaba, Chinweuba-eze, & Nduji, 2020; Lawlor, 2021). This means that ecology is the scientific study of the circulation and abundance of organisms, the interface among organisms, and the connections between organisms and their abiotic environment. To this end, the importance of ecology cannot be over emphasised since it helps enrich our world and is crucial for human wellbeing and prosperity. Ecology also helps provide new knowledge of the interdependence between people and nature that is vital for food production, maintaining clean air and water, and sustaining biodiversity in a changing climate.

Ecology is one of the topics taught in senior secondary schools in Nigeria. However, despite the laudable importance of ecology to man and his environment, students do not show the required conception towards ecology as outlined by West Africa Examinations Council (WAEC) Chief Examiners Report, specifically 2016, 2017 and 2021 examinations. The summary of the report include; majority of the candidates avoided question on ecology; inability of candidates to state the source of energy when describing the energy flow in a fresh water habitat in question; lack of understanding in the way questions are asked and how to join them with other subjects and topics; inability to state the characteristics of decomposers; and inability to describe the process of conversion of food to chyme. This an indication that most biology students do not possess the right conception of ecology. Hence, the importance of this study students' conception of ecology in biology.

To better understand students' conception, Piaget explained four (4) factors that influence how children learn and grow, which include schema, assimilation, accommodation and equilibration (Piaget, 1972). Piaget describes schema as both the mental and physical actions involved in understanding and knowing. Schemas are categories of knowledge that help us understand the world. Secondly assimilation is viewed as the process of taking new information into our already existing schemas. When existing ideas or schemas are modified as a result of new information or new experience, Piaget called it accommodation (Nduji, Onuyah, Madu & Okeke, 2022; p.44). Fourthly, equilibration is believed to occur when children strike a balance between assimilation and accommodation. The striking balance is geared towards assimilation of information to suit an individual's own existing mental schemas and adaptation of thoughts so as to accommodate information. This implies that equilibration takes place so as to direct and guide the prior knowledge student came to class with.

A student may either have sound conception (SC) or partial understanding (PU) or alternative conception

(AC) or no conception (NC) about a concept (Nduji, 2019). Sound conception refers to a students' correct understanding of an idea. It may also refer to accurate or knowledgeable information about a topic. Learners with partial understanding (PU) have insufficient or biased knowledge of a concept. Students at the PU level of conception make prediction either with confidence or no confidence based on explanations they constructed about the concept (Nduji, & Madu, 2020). Alternative conception represents learners' ideas which are inconsistent with right conception. For instance, many students thought that ecology deals with the study of tissues and mitochondria. No conception deduces the wrong or no idea about the concept. No conception also entails a skewed or ineffective proposition hierarchy (Helm & Novak, 2008). This implies the failure of a student to formulate an answer.

Previous researchers have revealed that students hold incomplete or inaccurate conception in some concepts in biology like; plant reproduction (Lampert, Scheuch, Pany, Müllner & Kiehn, 2019), biological images as representational devices (Yolanda Postigo & López-Manjón, 2012), cell structures and functions (Chiou, Liang, & Tsai, 2012), natural selection (Balgopal, & Montplaisir, 2011). Thus, there comes the need to investigate on students' conception, specifically on ecology since other studies are on different biology concept. Hence, the purpose of the study was to determine students' conception of ecology in senior secondary school biology Nsukka Education Zone, Enugu State in Nigeria.

2.0. Statement of the Problem

Many students possess naive conception as opposed to sound conception specifically on ecology. This is evident by WAEC chief examiner's reports of students in Senior Secondary Certificate Examination specifically 2016, 2017 and 2021. The inability of these students to possess sound conception of ecology may impede their desired growth, understanding and achievement in biology as well as their career path in science related courses. Therefore, the need to investigate the levels of students' conceptions of ecology among senior secondary school biology students.

Also, reports on previous studies have not clearly established students' conceptions in senior secondary school biology. Based on these inconclusive findings by the earlier studies, the need for the present study becomes paramount. The problems of this study in question form include; what is the level of students' conceptions on ecology in senior secondary school biology? How did the biology students conceive the concepts in ecology?

3.0. Research Questions

The following research questions were posed to guide the study;

i. What is the level of students' conception of ecology in senior secondary school biology?
ii. How did the biology students conceive the concepts in ecology?

4.0. Method

The design of the study was descriptive research design. This study was carried out in Nsukka Education Zone of Enugu State. Nsukka education zone is made up of three (3) Local Government Area (LGA) with total number of 61 government owned senior secondary schools which include; Nsukka LGA (30), Igbo-Etiti LGA (16) and Uzo-Uwani LGA (13) (Post Primary School Service Commission Onitsha [PPSMB] 2022). The population of the study comprised of 3,280 senior secondary school two (SSS2) biology students in all the government owned educational secondary schools in Nsukka education zone during 2021/2022 academic session. The sample size of the study was 333 senior secondary two (SS2) students drawn from the population. The sample size was determined using confidence level of 95 per cent based on the population size as opined by Cohen, Manion and Morrison (2011). Multi-stage sampling procedure was used in composing the sample. At the initial stage, no sampling was done at the LGA level. This is because the researcher intends to use all the 3 LGAs in the study area. In the second stage, simple random sampling technique was used to select 5 government owned schools from each of the three (3) LGAs. This gave a total of 15 schools drawn from the 61 government owned schools in Nsukka Education Zone. Thirdly, proportionate stratified random sampling was used to draw number of students to be studied in each school that was sampled from each LGA resulting to the total number of 333 students.

The instrument used for the study was Ecology Conception Test (ECT) to measure students' conception of ecology. The instrument was developed by the researcher. ECT had 12 items with a marking guide. The researcher got marking guide for the instrument from three biology experts from the department of microbiology, one biology educator from the department of science education and one biology teacher all in the University of Nigeria, Nsukka, except the biology teacher who teaches at University Staff Secondary School, Nsukka. In the marking guide, each item was arranged and scored in four-point scale (ie. 4, 3, 2 and 1). However, 4 were assigned to scientific conception; 3 were assigned to partial understanding; while 2 and 1 were assigned to alternative conception and no conception respectively. Sound conception shows the most accepted understanding.

Partial understanding indicates learners' abandonment of his/her naïve conception. Alternative conception represents naïve conception proper. ECT has an answer that would expose the learner's alternative or scientific conception. The instrument was validated by three experts from the Department of Science Education, University of Nigeria, Nsukka. Two of the validators are purely measurement and evaluation specialists while the third validator is from Biology Education. The items of the instrument were properly modified based on the observations of these experts. The trial testing was done using 30 biology students from Urban secondary school Akunanaw in Enugu south LGA in Agbani Education Zone, Enugu State. However, the school used was outside the study area, but has similarities to some extent that are necessary for the study such as same class and curriculum. Cronbach Alpha formula (α) was used to estimate the internal consistency reliability of the ECT. The choice of this reliability estimate was because ECT was non-dichotomously scored. With this formula, the internal consistency index of the instrument was calculated to be 0.871. The data obtained were used to determine students' conception on ecology. Prior to the proper commencement of the study, the researchers briefed the researcher assistants on the purpose of the study. Also, the researchers visited the sampled schools to collect the data for the study. At the course of the visit, the copies of the instrument were administered to the students through the assistance of the biology teachers in the respective sampled schools. The administration of the instrument was done once and retrieval of the instrument was on the spot. Frequency and percentage were used to answer the research question one while students' responses were described for research question two. The item wise analysis was done to determine the students' conceptions that might have taken place.

5.0. Result

5.1. Research Question One: What is the level of students' conception of ecology in senior secondary school biology?

Table 1: Frequency and Percentage analysis of Levels of Students' Conception of ecology in Senior Secondary School Biology

Item No.	SC f(%)	PU f(%)	AC f(%)	NC f(%)	Total f(%)
1	117(35.1)	11(3.3)	68(20.4)	137(41.1)	333(100)
2	147(44.1)	58(17.4)	68(20.4)	60(18.0)	333(100)
3	63(18.9)	14(4.2)	48(14.4)	208(62.5)	333(100)
4	21(6.3)	11(3.3)	10(3.0)	291(87.4)	333(100)
5	6(1.8)	18(5.4)	52(15.6)	257(77.2)	333(100)
6	2(0.6)	17(5.1)	47(14.1)	267(80.2)	333(100)
7	5(1.5)	8(2.4)	79(23.7)	241(72.4)	333(100)
8	3(0.9)	14(4.2)	52(15.6)	264(79.3)	333(100)
9	5(1.5)	16(4.8)	47(14.1)	265(79.6)	333(100)
10	5(1.5)	42(12.6)	58(17.4)	228(68.5)	333(100)
11	2(0.6)	14(4.2)	43(12.9)	274(82.3)	333(100)
12	2(0.6)	25(7.5)	47(14.1)	259(77.8)	333(100)
Overall No. of student	**32(9.5)**	**20(6.2)**	**52(15.5)**	**229(68.8)**	**333(100)**

NC= No Conception; AC= Alternative Conception; PU= Partial Understanding; SC= Sound/Scientific Conception; f= Frequency; %= Percentage

Table 1 shows that in item1 of Ecology Conception Test (ECT) instrument, 117 students have sound conception (SC) and 11 students have partial understanding (PU) whereas 68 students have alternative conception (AC) and 137 students have no conception (NC) of item1. Also, in item2, 147 students have SC and 58 students have PU while 68 students have AC and 60 students have NC of item2. In item3, 63 students have SC and 14 students have PU while 48 students have AC and 208 students have NC of item3. In item4, 21 students have SC and 11 students have PU while 10 students have AC and 291 students have NC of item4. In item5, 6 students have SC and 18 students have PU while 52 students have AC and 257 students have NC of item4. In item6, 2 students have SC and 17 students have PU while 47 students have AC and 267 students have NC of item6. In item7, 5 students have SC and 8 students have PU while 79 students have AC and 241 students have NC of item7. In item8, 3 students have SC and 14 students have PU while 52 students have AC and 264 students have NC of item8. In item9, 5 students have SC and 16 students have PU while 47 students have AC and 265 students have NC of item9.

In item10, 5 students have SC and 42 students have PU while 58 students have AC and 228 students have NC of item10. In item11, 2 students have SC and 14 students have PU while 43 students have AC and 274 students have NC of item11. In item12, 2 students have SC and 25 students have PU while 47 students have AC and 259 students have NC of item12. The above discussion indicates that items 1 to 4 have highest number of students with SC compared to other items. This reveal students' conception of ecology concept is dependent on

the nature of question in each item. However, from the summation of students' response across all item statements of ECT, it indicates that 229(68.8%) students have NC while students with AC are 52(15.5%); and students with PU across all item is 20(6.2%) whereas students with SC have 32(9.5%). This implies that students with NC of heat energy are higher since it has the highest frequency and percentage values. Also, students with SC have the lowest frequency and percentage values. These are students that can respond to ecological questions no matter how twisted the questions may appear to them.

6.0. Discussion of the Findings

The findings of the study showed that most students had no conception of ecology while very few students had alternative conceptions, partial understanding, and scientific/sound conception respectively. This indicates that small fraction of students possesses the correct understanding of ecology in Biology. This finding is in agreement with the findings of Nduji, Onuyah, Madu and Okeke (2022) who showed that the level of students' conception of heat energy in physics is low since only 5.6% have Sound Conception, 6.7% have Partial Conception, 13.7% have Alternative Conception while 74% have No Conception. Kağnıcı and Sadi (2021) whose study revealed that the STEM activity–enriched learning model had no improvement on students' conceptions of learning Biology (COLB) is inconsonance with the findings of this study. Also, Sander, Jelemenská, and Kattmann (2016) who veiled that biology students tend to refer to processes as rarely a concern to them. Therefore, the scientific conceptions of ecosystem, imbalance and the dynamics of biodiversity would be difficult for them to understand. On the contrary, Töman (2018) disagrees with the findings of this study by revealing that students at secondary level relate the concepts related to ecology to their everyday use, high school and university students have more scientific definitions in their descriptions. However, the difference between the findings of both studies may be attributed to different geographical scope, research design and method of data analysis used. Töman (2018) used mean and standard deviation for data analysis, descriptive design and *Bayburt* province of Turkey as the geographical scope. While the present study used frequency and percentage for data analysis, and ex-post facto research design.

7.0 Qualitative description of students' response

7.1 Research Question Two: How did the biology students conceive the concepts in ecology?

The focus of this research question is not to use any data with the aid of table to compare students' performance or point out those items in which students indicated the correct conception or the items they did not show the correct conception. But to discuss on the students' response based on; how they responded to the questions; why they responded that way; and what made them respond in that way. However, the discussion was organized into three categories. They include the following: ecology; ecosystem, habitat and biome; abiotic factors and adaption.

7.1.1 Ecological concept

To understand ecology, the student should know at least the definition of ecology (ie. ecological niche, ecological succession and ecological efficiency) (Claudia, 2021). However, in this study some students who attempted the questions failed to understand the sound meaning of the concept. Thus, they conceive specific ecology as; the branch of science that deals with the teaching and learning of trees and human being; the study of echo or sound in the human body; the branch of biology that deals with the study of tissues and mitochondria; an aspect of biology that teaches how to live and maintain the internal system of the body; the study of environmental system using echo as a device; the study of the relationships between micro-organism and living organisms. However, few students took into consideration that ecology is the branch of biology that deals with the study of the relationships between living organisms and their environment. Also, most of the students who responded to the description of what ecological niche is, were able to show sound conception of the concept which is that ecological niche is the position of a species within an ecosystem, describing both the range of condition, necessary for persistence of species and its ecological role in the ecosystem. Meanwhile, most students have PU, AC and NC about what the description of ecological niche is. Some students' conceptions are stipulated as follows; is the position of a species within a habitat which determines the role of an organism within such habitat; describes the ecological role of human in the ecosystem and its relation with abiotic components; an uncomfortable location of organism in an ecosystem so as to move towards adaption of some factors in the environment. This incorrect conception could be from students thought that ecological niche is repostponing of specie in a habitat by human to suit his or her environment for easy adaptation.

On defining ecological succession, students who attempted this part gave the incorrect understanding of it. For instance, many students were of the opinion that ecological succession is defined as; is the inheritance a specie gets as a member of a given ecosystem; the transfer of ecological benefits to the a given population of habitat; the success achieved through the study of the living organism and its relationship with their environment; an essential benefit gotten from species or organisms living within the terrain of a biomes and ecotype. These incorrect answers fall within the PU, AC and NC about the students' understanding of ecological succession. These students gave incorrect response about ecological succession because most of them sees it as the

phenomenon that has to do with transfer of some ecological benefit with the environment. However, some students showed sound conception of ecological succession by given the definition as sequential occurrence of communities over a period of time in the same in area.

In giving the meaning of ecological efficiency, many students gave the wrong consideration (i.e. PU, AC, NC) of ecological efficiency. Respondents gave their explanation as; the effectiveness of that link between plants and animal in an ecosystem; ratio of the specie functionality and their ecosystem; the ratio between energy flow and ecosystem; the ratio between food chain and reproduction extent in an ecosystem. This incorrect understanding here could be as a result of students thought that, ecological efficiency deals with the ratio of organisms and their functionality within an ecosystem. On the other hand, some students showed sound conception of ecological efficiency by given the definition as the ratio between energy flow at different points in a food chain.

Also, few students considered ecotype as plant species with a wide range of genetic distribution which evolve into a local population (ie. SC). However, many students explained that ecotype is; the type of ecosystem that deals with biotic and abiotic factors; the type of ecosystem that is devoid of sharing a genetic link into a local population; plant species with a wide range of specie distribution which revolve into a biome. This incorrect conception could be from students thought that the definition of ecotype can simply be defined from its nomenclature (that is; eco and type) meaning a categorizes of living together in an ecosystem. Thus, the reason for the above response.

7.1.2 Ecosystem, habitat and biome

To have the SC of ecosystem, one must understand the concept of biomes and habitat (Walt, 2021). However, many students who attempted this part gave the incorrect understanding (ie. PU, AC, NC). Many respondents wrongly stated the differences that exist between habitat and biome. Their explanations are as follow, thus; habitat is location of a specie within an ecosystem whereas a biome is comprised of multiple ecology; habitat is a single species that benefits mutually in an ecotype while a biome is comprised of the conditions necessary for ecological niche to develop; habitat is location of a specie within a population of abiotic factor whereas a biome is comprised of multiple ecology. The above incorrect explanations of the differences that exist between habitat and biome could be as a result of wrong understanding of these concepts by students. Some of the students gave the differences between habitat and biome from what they think these concepts represent. However, few students were able to show the SC about the differences between habitat and biome by stating that habitat is physical environment a species lives in whereas a biome is comprised of multiple habitats.

In giving the meaning of population of a habitat, most students gave the SC definition of population of a habitat as all members of a single species that lives together in a habitat. On the other hand, some students showed incorrect understanding of what population of a habitat means. They gave their meaning as; all members of a animals that lives together in a biome; a single species that lives together in an environment; all members of a single species; all families of a single species that lives under biotic factor. The above incorrect explanations could be as a result of students' layman perception of population.

Students who responded to explaining what the flow of energy through living system is failed to understand that the flow of energy through living system is primary producer – 1st level consumer – 2nd level consumer – 3rd level consumer. However, many students viewed the flow of energy through living system as follows; 1st level consumer – 2nd level consumer – 3rd level consumer; producer, animal and micro-organisms which cases decay of organism; grass, animal, human being and micro-organisms which causes decay of organism. These incorrect conceptions of students could be attributed to their experience on how man eat produce from plants and when dead decay by invasion of micro-organisms.

Students who attempted on giving the differences between ecosystem and habitat failed to understand that in an ecosystem, the environment is the same for all organisms living in a particular area while in a habitat organism varies based on existing in different soil conditions, temperature and many more. However, many students viewed the differences between ecosystem and habitat as follow; in an ecosystem, the ecology is the same for a specie in a particular area while in a habitat, organism varies based on existing in a particular soil condition; for an ecosystem, all organisms are living in a particular area while in a habitat, all organism exist in same temperature. The reason for these incorrect conceptions could be as a result of students' failure to understand what ecosystem and habitat deals with.

7.1.3 Adaption of organism and abiotic factor

For proper understanding or SC of adaption of organism and abiotic factor, the student must be able to conceptualize the meaning of adaption of organism and abiotic factor. Besides, most students who responded on this part failed to show that they possess SC here. For instance, many students' views on the description of how consumers obtain energy and nutrients as by photosynthesis; some were of the opinion that it's through application of manure to plants. This indicates that most students have the incorrect conception of how consumers obtain energy and nutrients. The reason for these incorrect conceptions could be as a result of students' failure to understand that by eating plants or animal organism is how consumers obtain energy and

nutrients which is the SC.

In giving the meaning of abiotic factor, most students gave the incorrect definition of abiotic factor. For instance, abiotic factor are; components of an ecosystem that is not needed for growth of an organism; the non-living part of an ecological system that an organism cannot do with; the non-living components of an ecosystem; part of ecosystem that an organism or population needs for growth based on the soil condition; non-living components of an ecosystem that a population needs for reproduction of the same species of organism. These incorrect conceptions of students could be attributed to students' inability to understand that abiotic factor are the non-living components of an ecosystem that an organism or population needs for growth, maintenance and reproduction which is the SC.

Students who attempted on giving definition on what adaptation is failed to understand that adaptation is the ability of plants or animal to change and survive in their environment. However, many students defined adaptation as; the ability of animal to maintain in their environment; inability of plants or animal to change in their habitat; ability of plants or animal to survive in their environment; ability of animal to move out of their environment. These response shows incorrect understanding of students (ie. PU, AC & NC) about adaptation.

8.0 Conclusion

Based on the discussion of the findings, the following conclusions were made, thus; the level of students' conception is low since 9.5% of the students have SC, 6.2% have PU, 15.5% have AC while 68.8% have NC. Students' conception level is determined by the nature of item statement.

9.0 Recommendation

Based on the findings, the researchers made the following recommendations, thus;

1. Biology instructors should strive to have the necessary scientific understanding of ecology. This will assist students in reaching a sound conceptual level.
2. Because the nature of the item effects students' idea, biology teachers should be cautious about how items on ecology are arranged.
3. The way students think about a concept should be examined and integrated in the biology curriculum by curriculum developers.

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