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Alternative Conceptions as Determinant Factor for Students' Explanation of Biological Phenomena of Genetics

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Abstract
Alternative conceptions are erroneous ideas about natural phenomena that students construct before formal instructions. These ideas are different from what is generally accepted in the scientific community. They are caused by cultural and social factors. These factors affect the child in his/her process of growing up and eventually culminate in conceptions which he/she brings to the classroom. Studies have shown that these alternative conceptions are deeply rooted and if neglected can hinder effective teaching and learning. This study sought to determine if the method of teaching use by biology teachers in our secondary schools can address these alternative conceptions to enhance achievement in biology. The design used for the study was quasi-experimental design. Two research questions and one hypothesis guided the study. The sample was made up of 282 SS3 biology students. The instrument was a 30-item multiple choice Biology Achievement Test (BAT) on genetics. The BAT was face and content validated by experts in Measurement and Evaluation and Biology Education. Also, a reliability co-efficient of 0.82 was obtained for BAT using Kuder Richardson Formula 20. Percentage was used to answer the research questions and hypothesis was analyzed using Pearson's r. The study revealed that alternative conceptions exist in genetics and that significant majority of students did not shift in their alternative conceptions even after formal instructions by the teacher. The researcher recommended conceptual change instructional model as an intervention package that will enable students understand biological concepts appropriately so that they can explain biological phenomena adequately.
Keywords: Alternative conceptions, Biological phenomena, Genetics.

Introduction

Many people view biology as the easiest of the science subjects. In spite of this assumed easy nature of the subject, evidence abound that lends support to the claim of low of level of performance in biology in secondary schools. This has been attributed to several factors among which are prior conception/ideas held by the students before formal instructions. Most of these ideas called alternative conceptions are erroneous and are not accepted in the scientific community (Iloputaife 2001). Alternative conception is an idea or conceptions prior to instruction period. They are caused by cultural and social factors. These factors influence the child in his/her process of growing up and eventually culminate in the conceptions which he/she brings to the classroom (Iloputaife 2001, Mbajiorgu 2003, Ilo 2018). Students construct prior ideas of natural phenomena before formal instruction in sciences. Most of these ideas are unscientific and hinder effective teaching and learning of science concepts (Hewson and Hewson, 1984). Posner, Strike, Hewson, and Gertzog (1982) refer to these prior conceptions as a filter through which new information is processed and understood. When students understanding of science was investigated by Osborne and Wittrock (1983), their study revealed that children have different ideas which are un-harmonized with scientific knowledge. This created confusion and barrier on how to handle those erroneous problems in the classroom practice. Nworgu (1996) stressed that students bring to school learning, ideas, expectations and beliefs concerning natural phenomena, which they have developed prior to their school learning. Alternative conceptions are deeply rooted and hinder effective teaching and learning (Webb, 1992). The implication is that the students' alternative conceptions may influence their observations, inferences they draw and what they understand from a formal learning situation.

Alternative conceptions exist in biology,(Ilo, 2018) Genetics is one of the concepts studied in biology, according to Bridget (2016), the study of genetics can be intellectually fascinating, but also has plenty of practical applications. From the use of DNA in court cases to the discovery of new therapies for genetic diseases, a thorough understanding of the human genome can have medical, social, and legal impacts. The rapid advances in genetic research, popularity of the topic and the direct role that genetics plays in human health and reproduction make it a scientific discipline everyone needs to understand. Yet, several studies reveal that students fail to critically understand the genetics knowledge taught in the classroom. This lack of understanding translates to the inability to apply basic knowledge to their everyday lives, (Lewis & Wood-Robinson 2000, Lewis & Kattmann 2004).

Many concepts in biology including genetics can be perceived as difficult to learn by high schools students and this negatively affects their performances, (Tekkaya, Ozlem and Sungur, 2001). A study by Mbajiorgu, Ezechi, and Idoko, (2006) revealed that science is a difficult subject to understand and grasp. Regardless of age, culture, and education background, as many as students carry their own understanding of science; genetics is not an exception in this matter. Genetics is a very broad and complicated concept. Significant advances in genetics in

recent decades have dramatically increased the impact of genetic information and technologies on society. Genetic issue now plays a large role in health and public policy, (Miller 1998). In spite of this increased exposure to genetics, recent studies of the general public's genetics knowledge show a relatively low understanding of genetics concepts, (Human Genetics Commission 2001; bates 2005).

Lewis and Katmann (2004) also stated that genetics is considered to be one of the most difficult concepts in biology and the mechanisms are hard to understand because it is difficult to make the ideas to be tangible without the help of special instruments. The study further revealed that students come to the classroom with their own conceptions of genetics from their own experience and observations. The uses of the words genes, DNA, chromosomes, are interchanged in trying to explain how traits are passed from one generation to the next. Study by Lewis and Katmann , (2004) reveal that students come to the classroom with their own conceptions(prior knowledge) of genetics from their own experience and observations and It is important to know student's misconceptions, presuppositions, and prior knowledge in genetics. If teachers are not aware of these misconceptions, it creates a barrier that leads to confusion and incoherence, (Lewis and Kattman, 2004).

Science of genetics has contributed in area of animal and crop husbandry to produce desirable breeds of animals and varieties of crops. Genetics has also contributed in the fields of medicine. Genetics is used in determining of paternity of a child, whose fatherhood is being legally disputed. It is used genetic counseling to counsel intending couples to know their blood groups, genotypes, rhesus factor status in order to avoid producing children with genetic defects like sickle cell anaemia, haemophilia and albinism etc. In spite of the contributions of genetics, students still find genetics difficult to understand (Mbajiorgu 2000). The poor performance as observed in biology over the years is as a result of students not understanding difficult concepts in biology which genetics is one (WAEC Chief Examiners report in Biology Nov/Dec. 2007). One of the sources of students having difficulty in understanding genetics is the students' prior conceptions/alternative conceptions and worldview presuppositions. Take for instance in a typical Igbo culture of southeastern Nigeria, recurrent infant mortality in a specific family is attributed to spiritual phenomenon referred to as "ogbanje spirit." It is believed that a demon spirit, ogbanje, possessed the children and causes them not to want to live on earth. As a result, the first child to die will reincarnates in a subsequent child, who in turns dies, and so on. Such deaths are believed to reoccur except where the parents perform some rites in order to appease the gods. These rites are believed to stop further deaths. This is what a scientific explanation will refer to sickle cell phenomenon. Students lack the understanding because of their previous knowledge from their parents and their cultural background. Some students yet have wrong notion about genetic concepts of albinism as punishment from the gods. Ignorance of facts about sex determination made students believe that blame should go to the woman especially if she continuously delivers baby girls. If the students alternative conceptions are not addressed, they may take these ideas along as they progress. The implication is that the students' alternative conceptions may influence their observations, inferences they draw and what they understand from a formal learning situation. Studies have shown that these alternative conceptions are deeply rooted and if neglected can hinder effective teaching and learning (Iloputaife 2001). Not only should the teachers be aware of these alternative conceptions, but also the students. When students recognize these ideas being able to change or enhance them will be easier. Students might be able to make the connections themselves. Being able to discuss their ideas can help breakdown what is wrong and right about the alternative conceptions. The students can actively construct and reconstruct their knowledge with the discussions, (Mbajiorgu, Ezechi, Idoko 2006). Teachers need to accept that these presuppositions are present and that they need to use it towards their advantage and the prior knowledge of the students does have a basis which needs to be clarified. Teachers should not be discouraged in teaching genetics, but rather use the prior knowledge of their students. It is important because students need to be able to understand the basics of genetics in order to be literate in growing technology of science. Genes are not just this cultural idea, but a powerful scientific idea. Students will need to be science literate citizens so as they may understand their health in the present and in the future, (Venille, Gribble, & Donovan, 2004).

This work intends to find out if the method of teaching used by biology teachers in our secondary schools can address these alternative conceptions, and make students shift from their erroneous conceptions and accept the right scientific concepts.

In terms of content coverage, the researcher selected genetics. The selection of genetics was based on the alternative conceptions held by students on genetics concepts as reported in literature (Mbajiorgu, 2003). The topics selected under genetics include chromosome mutation, sickle cell anaemia, Albinism and sex determination.

Research Questions

1. What percentage of secondary school class III (SS3) students have alternative conceptions on genetics before formal instruction took place?
2. What percentage of senior secondary class III (SS3) students who had alternative conceptions on

genetics changed their initial conceptions after formal instructions had taken place?

Hypothesis

1. There is no significant relationship between alternative conception and achievement in genetics.

Research Method

The design used for the study was quasi- experimental design. The work was carried out in Enugu Education zone of Enugu State. The population comprised all the senior secondary class three (SSIII) students, who were offering biology in all the state owned secondary schools in the zone in 2016/2017 academic session. There are 23 secondary school schools in the zone with a population of three thousand, seven hundred and eighty eight students (3788). SS3 were chosen because genetics is in the part of syllabus meant for the SS3 class.

The sample consists of 282 SS3 biology students, randomly selected from four schools out of the 23 schools. Purposive and random sampling was used. The instrument used to collect and generate data was a Biology Achievement Test (BAT). The BAT is a 30-item multiple test developed by the researcher. The alternative conceptions identified in literature were used as distracters in the preparation of BAT. The instrument was used for both pretest and posttest but was rearranged during post testing. The instrument was face and content validated by two experts in biology education and one expert in measurement and evaluation. The reliability of the instrument was determined using Kuder-Richardson's formula-20 (K-R-20). The internal consistency obtained for BAT was 0.82.The pretest was administered to the students before the study started. The students were allowed to respond to the instruments for 35-40-minutes. The researcher returned to the school after one month when students have been taught the topics in genetics covered by BAT, and administered the same instrument to them. The teachers did not receive any training or lesson note from the researcher. There was no special kind of teaching. The research questions were answered using percentage, and the hypothesis was analyzed using Pearson's r.

Results

Results obtained from the analyzed data were presented below based on the research questions:

Research Question one

What percentage of secondary school class III (SS3) students have alternative conceptions on genetics before formal instruction took place?

Table 1 Percentage distribution of students with alternative conceptions on genetics before formal instruction.

	Students with alternative conceptions	Students with scientific views	Total
Percentage	95.84%	4.16%	100%
Number of Students	270	12	282

Table 1 show that before formal instruction, 95.84% of students had alternative conceptions in genetics while 4.16% had scientific views on genetics. This shows that alternative conceptions exist in genetics.

Research Question Two

What percentage of senior secondary class III (SS3) students who had alternative conceptions on genetics changed their initial conceptions after formal instructions had taken place?

Table 2: Percentage distribution of students' position after formal instruction

	Students who changed their alternative conceptions	Students who did not change their alternative conceptions	Total
Percentage	32.0%	68.0%	100%
Number of students	90	192	282

Table 2 shows that 32.0% of the students shifted to scientific views after formal instructions while 68.0% did not shift from their position after formal instructions.

HYPOTHESIS

There is no significant relationship between alternative conceptions and achievement in genetics

Table 3: Item Analysis of Alternative Conceptions and Students Achievement in Genetics

		Alternative conception	Achievement
Alternative conception	Pearson correlation	1	-.224
	Sig.(2 tailed)		.693
	N	5	5
Achievement	Pearson correlation	-.224	1
	Sig. (2 tailed)	0.063	
	N	5	5

Person product moment correlation coefficient was used to determine the strength and magnitude of the relationship between student's achievement and alternative conceptions at P > 0.07 level of significance.

The calculated correlation coefficient between student's alternative conceptions and achievement to be -.224 with a *p* level of 0.693 (2-tailed). Here we could say the following: there is a statistically significant negative correlation between alternative conception and achievement (r = -.224, $p < .05$) in statistics, a perfect negative correlation means that there is perfect negative correlation, is represented by the value -1.00. Negative correlation means that there is a perfect negative correlation or relationship between two variables. In this case, as alternative conceptions increases, the achievement decreases in exactly the same level or proportion. Also, as alternative conception decreases, achievement increases in exactly the same level or proportion.

Discussion

Result presented in table 1 reveals that majority of students possessed alternative conceptions on genetic concept before formal instructions. This finding agrees with the findings of Iloputaife (2001) and Mbajiorgu (2003) and Ilo (2018) that students bring to school learning, ideas, expectations and beliefs concerning natural phenomena which they have developed prior their school learning. The findings also gives support to what was earlier stated by Hewson and Hewson (1984) that students construct prior ideas of natural phenomena before formal instruction in science and most of these ideas are unscientific and hinder effective teaching and learning of science concepts. In view of the researcher, the fact that student have alternative conceptions on biology concepts may explain the reason why students still achieve poorly in biology examinations.

Table 2 revealed that significant majority of the students tended to be consistent and did not shift in their alternative conceptions after formal instruction. It is more likely that the alternative conceptions held by these students possessed the feature indicated by Mintzes, Wandersee & Novak (1998) that alternative conceptions are tenacious and resistant to extinction. In view of the researcher, majority of the students did not shift in their alternative conceptions because of the method of teaching used by the teacher. The lecture method of teaching used by most teachers in our secondary schools has no provision for ascertaining the student's prior conceptions about natural phenomena. Thus it is relatively ineffective in teaching and learning science. This agrees with the view of Iloputaife (2001), that alternative conceptions are deeply rooted and not easily changed using traditional approaches to instruction. The implication is that these alternative conceptions are likely to persist unless some attempts are made to intervene and bring about conceptual change.

Conversely, the null hypothesis stated and tested showed there was a statistically significant negative correlation between alternative conception and achievement. As alternative conceptions increased, the achievement decreased in exactly the same level or proportion. Also, as alternative conceptions decreased, achievement increased in exactly the same level or proportion

Conclusion

From the result the following conclusion can be made:

1. Students have alternative conceptions in genetics
2. Significant majority of students did not shift in their alternative conceptions even after formal instructions by the teacher.

Recommendation

Conceptual change instructional model as an intervention package

Tanner and Allen (2010) defined conceptual change as a learning process in which existing conceptions (idea or belief about how the world works) held by students is often shifted and restructured, often away from an alternative conceptions and towards the dominant conceptions held by experts in the field. Conceptual change instructional model is a constructivist package that lays emphasis on active role of learners in the process of constructing their own knowledge. It is teaching strategy which accepts a child's ownership of idea. Central to this constructivist package is that the learner constructs meaning from new information and event as a result of interaction between that individual's alternative conceptions and his/her current observations. Thus students learn not by receiving the message but interpreting the message. This implies that students must take some responsibility of their learning. They have to put their own ideas. It is therefore imperative that every biology

teacher have a good knowledge of alternative conceptions held by students at the onset of every lesson and then use conceptual change instructional model to create cognitive conflict which will make the students drop whatever erroneous conceptions they have and pick the correct scientific concepts. This will ensure better understanding of biology concepts and improve students' performance in biology examination

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