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Identification of Biology Students' Misconceptions in Genetics Among Secondary School Students in Nembe Local Government Area in Bayelsa State

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ABSTRACT

This study investigated identification of Biology students' misconceptions in genetics among secondary school students in Nembe Local Government Area of Bayelsa State. A descriptive survey design was adopted for the study. Sample size of 361 students from a population of 3 798 was determined using Taro Yamane formula. Four schools were selected using purposive sampling technique from 16 secondary schools in Nembe Local Government Area. Two research questions and one null hypothesis guided the study. The instrument for data collection was a Genetic Concept Diagnostic Test. The face and content validity was moderated by the researchers' supervisors and three lecturers in science education department in Rivers State University. A test-retest method of reliability was used to test the reliability of the instrument, a reliability coefficient of 0.77 was obtained using Pearson Product Moment Correlation. The data collected was analyzed using frequency and percentage for research questions while the hypothesis was tested using independent t-test at 0.05 level of significance respectively. Results from the study showed that students had misconceptions in genetics, which was not influenced by gender. Therefore, it was recommended that Biology teachers first identify students' misconception before employing student-centered teaching approach to remedy the misconceptions for meaningful learning to take place.

Keywords: Misconception, Genetics, Identification, Gender, Diagnostics Test

INTRODUCTION

Research into students' misconceptions has been of great concern to educators especially those in science education because the incidence or re-occurrence of this problem has greatly affected the academic performance of student in both external and internal examinations. Misconceptions as revealed by many researchers is seen as naive or erroneous ideas Elbert-May, Hodder, Luckie and William (2004), alternative conceptions Gonzalez (1997); Mulford and Robinson (2002), preconceptions Clement (1982), alternative framework Taber (2000), inaccurate prior knowledge Kendeou and Van den Broek (2008) and interpretations that are not scientifically accurate Baher (2003) as cited in Galvin (2015). The term misconceptions also include the students' beliefs, as well as ideas they hold that are inconsistent or in conflict with scientifically proven facts that are generally accepted by scientist, bearing in mind the social environment like peers, family and society are a major contributory factor from which most of the students' misconceptions are emanating from.

Misconceptions according to Adeniyi and Fisher as cited in Tekkaya (2002) are often times characterized as pervasive, stable (cut across age, ability, gender and cultural boundaries), well embedded in the cognitive ecology of the student, resistant to change and can remain intact in the student even throughout their studies to the extent that it can affect their life choices regarding that particular subject matter. Moreover, misconceptions do not change unless they are directly, repeatedly and purposively addressed, as opined by Taylor and Kowalski (2014), misconceptions matters because all new knowledge is interpreted, analyzed and stored relative to existing knowledge, thereby addressing the existence of misconceptions is essential

in science education. Misconceptions as already established is often seen as barriers that impedes on the student's cognitive ability, they are a major factor affecting students' understanding of science which they carry on to higher institutions Coll and Treagust (2003). Most times, misconceptions can go undetected or simply ignored by science teachers which can have a long-term consequence on the student. According to Tekkaya (2002) the prevalence of misconceptions among students does not only presents a serious obstacle to learning, but also interfere with further learning.

Genetics is one aspect of biology which deals with the study of heredity and variations. It is one topic in biology that cannot be overlooked especially in terms of having misconceptions because it involves the diversity of organisms, the driving force behind evolution and the adaptation of a species to its environment. It also involves the process of transmitting of certain inherited characters from parents to offspring via genes which is responsible for the similarities as well as the differences or variations in individuals Ramalingam (2005). The study of genetics which started as far back as the 1950's has brought about many innovations like the discovery of the double helix structure of deoxyribonucleic acid (DNA) commonly known as the "double helix", creation of recombinant DNA (rDNA), production of vaccines for the treatment of many diseases, genetically modified organisms (GMO) food production, DNA sequencing and cloning example is Dolly the sheep, Synthego (2022). It is however important to note that genetics as a topic is very essential and having a good understanding of its concepts and mechanism will help students not only in explaining their existence, possession of certain character or traits, inheritance of certain genetic diseases and disorder but also the evolving nature of genetics in terms of certain technological advancement made in agriculture and medicine through genetic engineering and hybridoma technology.

Genetics is perceived as a difficult topic to learn as asserted by Baher, Johnstone and Hansell (1999) and Tekkaya, Ozkan and Sunguri (2001), they reported that certain concepts like monohybrid cross, dihybrid cross, linkages, genetic engineering, hormones, genes, chromosomes and Mendelian genetics are considered difficult. In view of Galvin and O'Grady (2012), these topics are perceived difficult as students tend to have some misconceptions about them. The reason for this perceived difficulty can be linked to the teachers, students and the instructional resources used in teaching can create these misconceptions. Genetics is one topic that requires an in-depth understanding of the processes as well as the biological terminology used because of its abstract nature. It is on this basis that the research work is set to investigate the misconceptions in genetics held by biology students in secondary schools in Nembe local government area.

In order to address students' misconceptions, it is imperative not only to identify them but also, determine the type of misconceptions that they possess and how it can affect the teaching and learning process. According to National Research Council (NRC 1997) misconceptions can be categorized as follows:

1. Preconceived notions which are conceptions rooted in everyday life experiences.
2. Nonscientific beliefs which include views students learn from sources other than scientific education, such as religious or mythical teachings.

3. Conceptual misunderstanding arises when students are taught scientific information in a way that does not provoke them to confront paradoxes and conflicts resulting from their own preconceived notions and nonscientific beliefs.
4. Vernacular misconceptions arise from the use of words that mean one thing in everyday life and another in a scientific context.
5. Factual misconceptions are falsities often learned at an early age and retained unchallenged into adulthood.

Having established the fact that misconceptions do exist and the various types that are prevalent, it is important that to address the problem of misconceptions, firstly they should be properly identified. Moreover, identification is a mandatory aspect to be considered especially as it serves as a basis in the development of an appropriate teaching strategy that can help provide students with accurate conceptual knowledge Tekkaya (2002). Secondly identification requires probing into the students' cognitive content by obtaining information about their conceptual understanding through several ways. However, in other to identify students' misconceptions, it is advisable that assessment based on the current topic should be carried out during the process of teaching/learning thereby keeping the teachers' abreast of the occurrence of misconceptions early enough rather than at the end of the term. According to Tekkaya (2002) misconceptions developed during the lessons if they are not detected and corrected immediately, they will adversely affect the students' subsequent learning, hence teachers need to probe students understanding before and after instruction Tsui and Treagust (2010), by making use of various forms of assessment tools like quizzes, assignments, class activities, discussions etc which can be employed for early detection.

Some of the assessment tools that can be used to identify students' misconceptions includes interviews which are often used in many researches to tease out the students' meaningful understanding of a particular concept Tekkaya (2002), others include diagnostic instruments such as multiple-choice item test, open ended item test, true/false item test, two, three or four-tier diagnostic item test and essay writing. Although the multiple-choice and true/false item test can be easily marked but lack the ability to give further insight into students' conceptual understanding. In recent times, many researchers like Tsui and Treagust (2010) have suggested the use of the two or three-tier diagnostic test in identifying students' misconceptions because of its usefulness in probing students' understanding or misunderstanding of scientific concepts and ideas which gives a more holistic picture of students conceptual learning in terms of scientific reasoning. Furthermore, this method is considered more appropriate because at the first-tier students' specific content knowledge is required, which at the second or third-tier, reasons, explanation and level of confidence for the first-tier answers gives an indication of the students' certainty of the answers provided. This method according to Treagust (1988) in Tsui and Treagust (2010) scoring of two-tier items is considered correctly answered if a student's choice of the first and second tier in each item are both correct, this method ensures that the likely occurrence of guessing is greatly reduced and offers a more stringent method of scoring. Also, to support the use of a three-tier diagnostic instrument, Soeharto, Csapo, Sarimanah, Dewi and Sabri (2019) were of the opinion that a three-tier test are considered more

accurate in not only identifying students' misconceptions, but also detecting students' lack of understanding by making use of the level of confidence in the answers given by the students. In this method as opined by Gurel, Eryilmaz and McDermott (2015) students' answer to each item is considered correct when a correct answer, correct reason is given with a high confidence, likewise a students' answer is considered as misconception when a wrong answer, wrong reason is given with a high confidence, which according to Soeharto, Csapo, Saromanah, Dewi and Sabri (2019) is very beneficial to researchers, as it helps gives a more accurate percentage of misconceptions.

Research Questions

The study was guided by the following research questions,

1. What are the conceptions held by biology students in genetics?
2. What are the types of misconceptions held by biology students in genetics?

Hypothesis

There is no significant difference in the misconceptions in genetics held by male and female biology students in secondary schools in Nembe Local Government Area, Bayelsa State.

METHODOLOGY

The study adopted a descriptive survey method. The population of the study was the 3 798 Senior Secondary Biology students in Nembe Local Government Area of Bayelsa State. The Senior Secondary School two class was purposively selected for the study. The Taro Yamane formula was used to obtain a sample size of 361 students (male and female) in the SS2 class using. Purposive sampling technique was used in selecting four schools for the study from 16 secondary schools in Nembe Local Government Area. Criteria for selection of the schools for the study included: schools that offer biology, mixed gender, have qualified teachers and good teaching and learning infrastructure like laboratory.

The research instrument for data collection that was used in this study was a misconception diagnostic test instrument titled "Genetic Concept Diagnostic Test" (GCDT). The GCDT is a fifteen (15) item multiple-choice test in genetics consisting of questions arranged in a three-tier, for identifying students' misconceptions in genetics. The instrument was validated using a face and content validity method by the researchers' supervisors and three lecturers from Science Education department in Rivers State University. The reliability of the instrument was determined through a test-retest method for measure of its stability which was administered to twenty (20) students randomly selected from a different sample other than the one intended for the study; this was done within two weeks interval. The correlation of the scores from the first and second test was determined using Pearson Product Moment Correlation (PPMC), the Coefficient index of 0.77 was established. Data collected were analyzed to obtain the frequency and percentages for research questions, while for hypotheses testing, T-test was used to test the null hypotheses formulated for the study.

RESULTS

Research Question 1

What are the conceptions held by biology students in genetics?

Table 1

Frequency and Percentages of Conceptions in Genetics

Items	Scientific Concept (SC)		Lack of Knowledge (LK)		False Positive (FP)		False Negative (FN)		Misconceptions (MS)		Total	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
1	15	4.2	46	12.7	12	3.3	97	26.9	191	52.9	361	100
2	25	6.9	54	15.0	12	3.3	123	34.1	147	40.7	361	100
3	61	16.9	36	10.0	155	42.9	14	3.9	95	26.3	361	100
4	159	44.0	36	10.0	68	18.8	48	13.3	50	13.9	361	100
5	28	7.8	36	10.0	48	13.3	86	23.8	163	45.2	361	100
6	22	6.1	98	27.1	32	8.9	17	4.7	192	53.2	361	100
7	22	6.1	83	23.0	79	21.9	0	0.0	177	49.0	361	100
8	93	25.8	93	25.8	93	25.8	14	3.9	68	18.8	361	100
9	14	3.9	93	25.8	64	17.7	14	3.9	176	48.8	361	100
10	79	21.9	61	16.9	66	18.3	54	15.0	101	28.0	361	100
11	43	11.9	90	24.9	32	8.9	126	34.9	70	19.4	361	100
12	245	67.9	25	6.9	37	10.2	20	5.5	34	9.4	361	100
13	46	12.7	89	24.7	68	18.8	50	13.9	108	29.9	361	100
14	104	28.8	68	18.8	50	13.9	43	11.9	96	26.6	361	100
15	25	6.9	42	11.6	149	41.3	45	12.5	100	27.7	361	100
Mean	**65**	**18.1**	**63**	**17.5**	**64**	**17.8**	**50**	**13.9**	**118**	**32.7**	**361**	**100**

The result in Table 4.1 shows the conceptions held by Biology students in genetics. The result shows that conceptions held by the students were scientific concepts, lack of knowledge, false positive concept, false negative concept, and misconception. As shown, an average of 65 students (18.1%) had Scientific Concept. Secondly, an average of 63 students (17.5%) lacked knowledge of genetics. Thirdly, an average of 64 students (17.8%) had a false positive concept. Fourthly, an average of 50 students (13.9%) had false negative concept in genetics while an average of 118 students (32.7%) had misconception in genetics.

A closer look at Table 4.1 reveals that the students had highest level of scientific concept on item number, 12 (Is it possible for parents with dark skin colour to have a child with albinism?). This is evident by a frequency of 245 for item 12. Majority of the students had false negative concept on items 2 (Heredity is the transmission of inherited characters via gene from one of the offspring's parents) and 11 (In humans, sex determination is by inheritance of sex organs). This is evident by frequencies of 123 and 126 respectively for items 2 and 11 under false negative concept. Similarly, most of the students had false positive concepts on items 3 (The height of an individual is determined by the father) and 15 (all humans share the same DNA). This is evident by frequencies of 155 and 149 respectively for items 3 and 15 under false positive concept. The result further shows that misconception in genetics was predominant among the students. This is evident by the highest average number of students (118) having misconception compared to other concepts.

Research Question 2

What are the types of misconceptions held by biology students in genetics?

Table 2

Frequency and Percentages of Types of Misconceptions in Genetics

Items	Preconceived Notion (%)	Conceptual (%)	Factual (%)	Total
1	143 (74.9)	27 (14.1)	21 (11.0)	191 (100)
2		135 (91.8)	12 (8.2)	147 (100)
3	67 (70.5)	28 (29.5)		95 (100)
4	50 (100.0)			50 (100)
5	112 (68.7)	34 (20.9)	17 (10.4)	163 (100)
6	63 (32.8)	129 (67.2)		192 (100)
7		110 (62.1)	67 (37.9)	177 (100)
8		68 (100.0)		68 (100)
9		137 (77.8)	39 (22.2)	176 (100)
10		59 (58.4)	42 (41.6)	101 (100)
11	56 (80.0)	14 (20.0)		70 (100)
12	34 (100.0)			34 (100)
13	79 (73.1)	22 (20.4)	7 (6.5)	108 (100)
14		96 (100)		96 (100)
15	50 (50)	50 (50)		100 (100)
Mean	**73 (72)**	**70 (55)**	**29 (20)**	**118**

The result in Table 2 shows that three major types of misconception were predominant among the students. These were preconceived notions, conceptual and factual misconceptions. The result shows that most students had preconceived notions on items 1 (Genes are the sole determinant of traits in an individual) and 5 (DNA is a test for the paternity and maternity of a child). This is evident by frequencies of 143 and 112 respectively having preconceived notion for items 1 and 5. Similarly, majority of the students had conceptual misconception on items 2 (Heredity is the transmission of inherited characters via gene from one of the offspring's parents), 6 (The skin colour of an individual which is an acquired variation can be transmitted to its offspring), 7 (Can the genetic code of an organism be changed) and 9 (single genes codes for most traits). This is evident by frequencies of 135, 129, 110 and 137 respectively having conceptual misconception for items 2, 6, 7 and 9. Furthermore, an average number of students had factual misconceptions on item 7 (Can the genetic code of an organism change). This is evident by frequency of 67 having factual misconception for item 7.

Hypothesis 1

There is no significant difference in the misconceptions in genetics held by male and female biology students in secondary schools in Nembe Local Government Area, Bayelsa State.

Table 3

Independent t-test for Effect of Gender on Misconception

	t	df	p-value	Mean Difference	Std. Error Difference
Equal variances assumed	-.953	359	.341	-.185	.194
Equal variances not assumed	-.952	350	.342	-.185	.194

The result in Table 3 shows the independent t-test for effect of gender on misconception in genetics held by male and female biology students. The result shows

t (359) = -.953; $p > 0.05$. Since the p-value is greater than 0.05, the hypothesis is accepted. This is an indication that there is no significant difference in the misconceptions in genetics held by male and female biology students in secondary schools in Nembe Local Government Area, Bayelsa State. This implies that male and female students had no difference in terms of misconception held in genetics.

DISCUSSION OF FINDINGS

The findings of the study as revealed in Table 4.1 showed the prevalence of misconceptions in genetics which is a clear indication that misconceptions do occur especially in topics like genetics that is often considered to be difficult and broad, which is as a result of its abstract nature with some of the students exhibiting lack of knowledge, false positive and false negative as the case may be, the findings is in support with that of Maryuningsih, Hidayat, Riandi and Rustaman (2020) on application of genetic problem base online discussion to improve genetic literacy of perspective teachers, the study cited that genetics is seen as a topic which is difficult to teach and learn because of its abstract nature, thereby understanding the concept of genetics, terminologies, cytological processes as opined by Altunoglu and Seker (2015) are complex, hence the existence of these misconceptions. Also the occurrence of three types of misconception identified as seen in Table 4.2 is a clear indication of not only its existence but also how it affects the teaching/learning process, the results supports the findings of Meyers (2007) on examining how teaching strategies alter the misconceptions of middle school science students, which revealed that misconceptions can occur when students are trying to make sense of a situation or phenomena in their environment, which usually happens at a very early age, also the findings is in line with Galvin (2015) who was of the opinion that the formation of these misconceptions occurs as the students make contact with the physical and social world around them, which could emanate from peers, family, society, media, language and different teachers. This is a clear indication of the effect of students' prior knowledge which is greatly influenced by their social environment that has formed their cognitive schema in genetics, which has led to the type of misconceptions identified in the students.

Analysis from Table 3 shows that gender had no effect or difference in terms of misconceptions held by biology students in genetics, which implies that gender does not play much role in students' misconception but rather the existence of these misconceptions is basically related to their cognitive ability and understanding of the concept. This finding supports the research of Hamdan, Osman and BouJaoude (2016) on identifying misconceptions and difficulties to design a learning progression in genetics, the study revealed that students' misconceptions in genetics was highly influenced by their grade level as well as their inadequate understanding of major genetic concepts, which was highlighted by a low level of progression in their conceptual understanding of major genetic concepts that cut across all grade level. This shows that gender has nothing to do with the student's academic performance but rather their performance was because of their cognitive ability to understand and change their prior conception in genetics.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made.

1. Biology teachers should take into cognizance the possibility of misconceptions occurring and ensure early identification of these misconceptions before and during the learning process.
2. Biology teachers should be mindful of the type of misconceptions held by students and ensure they are properly addressed.
3. Biology teachers should first identify students' misconception before employing student-centered teaching approach to remedy the misconceptions for meaningful learning to take place

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