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Analogies used in presenting genetics in senior secondary school biology textbooks in Nigeria

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Abstract

The field of genetics is often believed as a subject or a topic in biology that is difficult to learn and comprehend. The study aimed to identify the analogies used in the presentational format in illustrating genetics in selected biology textbooks in Osun State, Nigeria. The study adopted a descriptive survey research design. The population for the study comprised all the nine biology textbooks presently recommended by the Osun State Ministry of Education for implementing the biology curriculum. The study sample comprised six out of the nine recommended biology textbooks in Osun State using a simple random sampling technique. An instrument developed by Curtis and Reigeluth titled *Biology Textbook Genetics Analogy (BTGA)* was adapted and was used to collect data for the study. The study concluded that verbal analogies, simple analogies, and advance organizer analogies are the predominant analogies used in textbooks. It was also concluded that textbooks should include and balance the ratio of the different types of analogies being used.

Keywords: Analogy, Biology Textbook, Genetics, Senior Secondary School, Osun State (Nigeria)

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1. Introduction

Science is a system of acquiring knowledge based on the scientific method, as well as the organized body of knowledge gained through research (Rocard, 2007). According to Farabee (2002), science is an objective, logical, and repeatable attempt to understand the principles and forces operating in the natural universe. Biology is the study of living things interacting with their non-living components. Agogo and Naakaa (2014) believe that biology is a fascinating study that ranges from microscopic cellular molecules to the biosphere, surrounding the earth's surface and its living organisms. Biology is a branch of science that deals with the study of living organisms. Biology is primarily concerned with the nature of organisms and their relationship to each other and their environment. Biology as a subject helps to enable one to understand major biological processes that take place within oneself e.g. respiration, excretion, reproduction, digestion, gaseous exchange, circulation, and genetics. Scientific concepts are better understood when teaching proceeds from known to unknown, one way to make this possible is to employ the use of analogy.

Venville and Donovan (2008) defined analogy as the process of identifying similarities and differences between two objects or processes. It is the process of comparing one thing with another thing that has similar features to explain it. Analogies are often used in science to explain and name unknown cases via already known ones. Abimbola (1998) defined analogy as a method of describing things that are known in terms of things that are not known, it helps students to understand the subject matter of a particular topic effectively. Teachers unconsciously use analogies whenever they begin an explanation with "it's just like"…, "it's similar to"… or "think of it this way"… to explain a concept to their students. Analogies build a conceptual bridge between what is familiar and what is new which are often complex, and hard to visualize. It plays an important role in helping students to construct knowledge i.e. reasoning, transfer knowledge across different concepts, increase student learning and interest, develop the cognitive domain of the student, integration, and activation of prior knowledge with the help of mental reasoning.

1.1. Conceptual background

Some teaching models were developed for the effective use of analogies in teaching Science Education such as the General Model of Analogy Teaching (GMAT) model. Teaching with Analogies (TWA) model (Glynn, 2008) and Focus Action Reflection (FAR) model (Harrison & Cole, 2008). The TWA model is commonly used among them because it explains the instructions to be followed by teachers in analogy-based teaching. Illustrating with the use of analogy, the known concept is known as "Analog" and the new concept is known as "Target" Some examples of analogies are: The human heart (target) and a pump (analog), the eye (target) illustrate the camera (analog) both are sensitive to bright light, cell wall and its organelles (target) illustrates with prison or factory and its wall (analog), activation energy (target) is like a hill (analog), the DNA molecule (target) is shaped like a twisted ladder (analog), genes (target) is like a pen of a flash drive (analog), DNA structure (target) is like a twisted pearl necklace (analog), the recessive gene (target) is like a white sheet of paper (analog) and the dominant gene is like a coloured dye, ribosomes (target) are like ladders (analog) because they connect together to create proteins, life (target) is like a train journey (analog), a vacuole (target) is like a water bottle (analog), a catalyst (target) is like a minister (analog) and atom (target) is like a football (analog).

Metaphors and Similes are used as tools to represent analogy; however, the analogy is more elaborate than both metaphor and simile. Following are some types of analogies: opposite analogy, cause and effect analogy, object and related object analogy, opposite and classification analogy, and performer and action analogy. Curtis and Reigeluth (1984) categorized analogies based on the following five criteria: presentational format (verbal – analogy is presented in verbal format only, pictorial – the analogy is presented in pictures only and pictorial+verbal – the analogy is presented in verbal and pictorial format), level of enrichment (simple – analogy is formed with a simple sentence, enriched – further explanation between analog and target are given, extended – limitation are put on similarities between analog and target), position in the text (advanced organizer – analogies are used

at the beginning of a unit, embedded activator – analogies that require additional interpretation within a unit, post synthesizer – analogies are presented at the beginning of a unit), Analogical relationship: Structural Analogy: Parallels are drawn between appearance, physical organization, and structures. Functional Analogy: Parallels are drawn with the way something behaves, functions, and operates. Structural and Functional Analogy: Both structural and functional parallels are drawn. Content Condition (concrete to concrete) Analogy - both the analogies and the target are concrete. Abstract to Abstract Analogy - both the analogies and the target are abstract. Concrete to abstract Analogy - the analogy is concrete but the target is abstract. One of the most difficult concepts in biology is genetics because it has terms that are not commonly used outside the genetics classroom and this makes it look like a foreign language. Genetics is the study of genes, genetic variation, and heredity in living organisms. The field of genetics has expanded to cover many areas beyond merely the study of inheritance. A good understanding of genetics now requires knowledge about the structure and function of the cell and its organelles (Chattopadhyay, 2017).

1.2. Related studies

Chu (2008) opined that the field of genetics is often believed as a subject or a topic in biology that is difficult to learn and comprehend. Etobro and Fabinu (2017) maintained that many concepts or topics in biology, including water transport in plants, protein synthesis, respiration and photosynthesis, gaseous exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormonal regulation, oxygen transport, genetics, genetic engineering, and the central nervous system can be perceived as difficult to learn by secondary school students. Whereas Tekkaya, Özkan, and Sungur (2001) found out that hormones, genes and chromosomes, mitosis and meiosis, the nervous system, and Mendelian genetics were considered difficult concepts by secondary school students. Genetics is an important subject to learn in contemporary days where its applications are numerous and even the cause of many debates (the Chu, 2008). Nevertheless, due to the nature of the subject matter and the way learning processes occur, and, perhaps, the way it is being imparted, the understanding of genetic ideas of the majority of students is thought to be very poor and full of misperceptions and alternative views.

Textbooks are vital parts of instructional materials that cannot be ignored in the teaching and learning process. Nowadays, despite the improvements in science, technology, and communication, textbooks retain their importance for students and teachers alike in classroom environments. Throughout the schooling process, science and technology textbooks are some of the most frequently used effective teaching materials (Yener, 2012). It is a well-known fact that students and teachers have confidence and are highly reliant on textbooks. This is why Nigerian biology teachers also depend on textbooks for the appropriate content materials, which satisfy the requirements for the West African Examinations Council (WAEC) and the National Examinations Council (NECO) syllabi in different biology topics. Therefore, analysis in a variety of ways of the textbooks used by students and teachers will contribute to the literature on biology education.

Yener (2012) postulated that analogy is mostly used for understanding non-concrete concepts and complex issues. An analogy is an elucidation that compares a fact that is unknown and unaccustomed with another known and accustomed one. The unknown fact is the target while the known fact is the analogue (Duit, Roth, Komorek & Wilbers, 2001). The analogy compares the similar characteristics of the target and analogue and then a transition from the known information area to the unknown information area is made (Harrison & Cole, 2008). It is against this background that this study was designed to assess the analogies used in presenting genetics in Senior Secondary School biology textbooks in Osun State, Nigeria, hence this study.

Science uses technical languages that are different in some cases from the everyday language use of the learners. Many students do not do well in science particularly in biology as a result of the language used in communicating the various scientific concepts. Many researchers (Lemke, 1990; Halliday & Martin, 1993; Fang, 2005) have identified the teacher's language use as a barrier to the

students' understanding of biology, especially genetics. Also, there are several ways language can make understanding genetics more difficult, such as alternative meanings of words, students' lack of appropriate vocabulary, the specialized vocabulary used by teachers, and English as a second language. Mastropieri and Scruggs (1991) are even of the opinion that many types of research have shown that language can interfere with students' test results and interaction between students and their teachers. This study, therefore, focuses on the analogies used in presenting genetics in selected biology textbooks.

1.3. Purpose of the Study

The general purpose of the study is to assess the analogies used in presenting genetics in Senior Secondary School biology textbooks in Osun State. The specific objectives of this study are to:

(a) identify the analogies used in the presentational format in illustrating genetics in selected biology textbooks;

(b) describe the analogical level of enrichment in presenting genetics in selected biology textbooks; and

(c) compare the analogical position in presenting genetics in selected biology textbooks.

1.3.1. Research Questions

The following research questions were raised for the study:

(a) What are the presentational formats of analogies used in presenting genetics in senior secondary school biology textbooks?

(b) What are the levels of enrichment of analogies used in presenting genetics in senior secondary school biology textbooks?

(c) What are the analogical positions of presenting genetics in senior secondary school biology textbooks?

2. Materials and Methods

The study adopted a descriptive survey research design. This was to assess the analogies used in presenting genetics in senior secondary school biology textbooks in Osun State.

2.1. Participant

The population for this study comprised all nine recommended biology textbooks by the Osun State Ministry of Education for the implementation of the biology curriculum in the State's Senior Secondary Schools. The study sample comprised six out of the nine recommended biology textbooks in Osun State using a simple random sampling technique.

2.2. Data collection instrument

An instrument developed by Curtis and Reigeluth (1984) titled Biology Textbook Genetics Analogy (BTGA) was adapted. It was designed to obtain information about the name of the textbooks, numbers of analogies seen, concepts in genetics, the presentational format (verbal, pictorial, or pictorial verbal), analogy position (Advanced Organiser, Embedded Activator, or Post Synthesizer), and the level of enrichment (Simple, Enriched or Extended), also this instrument provided information on textbooks with analogies, the frequency percentage (%) of textbooks with analogies, textbooks without analogies, frequency percentage (%) of textbooks without analogies. The research instrument was validated with the professional help of two other curriculum experts in the Department of Science and Technology, Faculty of Education, Obafemi Awolowo University, Ile-Ife for both face and content validity. These experts read through the contents and made necessary corrections. The final draft of the instrument was eventually drafted based on the experts' corrections and advice

2.3. Data Analysis

Analogies identified in the six selected biology textbooks served as data. The data gathered were analyzed using descriptive statistics of frequency and percentages.

3. Results

The result of the analysis of analogies used in presenting genetics in selected biology textbooks in Osun state, Nigeria is presented in frequency and simple percentages.

Table 1

Analogies in Selected Genetics in Biology Textbooks

Genetics Analogies	Textbooks with Analogies	Frequency (%) of Textbooks with Analogies	Textbooks without Analogies	Frequency (%) of Textbooks without Analogies
Alternative forms	A, B, C, D, F	5(83.3)	E	1(16.7)
Two sets of Chromosomes	A, C, D, E, F	5(83.3)	B	1(16.7)
Not pure breeding	A, D, E	3(50.0)	B,C, F	3(50.0)
Thread-like	A, B, C,D, E	5(83.3)	F	1(16.7)
Two threads	A, E	2(33.3)	B, C,D, F	4(66.7)
Resemble a double helix	A,D	2(33.3)	B, C, E, F	4(66.7)
Two long chains	A, C, D, F	4(66.7)	B, E	2(33.3)
Carriers of a trait	A, C, D, F	4(66.7)	B, E	2(33.3)
Position of genes	A, B, C,D, E	5(83.3)	F	1(16.7)
Chains	A, F	2(33.3)	B, C, D, E	4(66.7)
organism like the parents	A C	2(33.3)	B, D, E, F	4(66.7)
Thread forming	A,C	2(33.3)	B, D, E, F	4(66.7)
Reduction division	A	1(16.7)	B, C, D, E, F	5(83.3)
The transmission of biological characters from parent to offspring	A	1(16.7)	B, C, D, E, F	5(83.3)
Pure breeding	A, B, C, D, F	5(83.3)	E	1(16.7)
Dice throwing	A, C	2(33.3)	B, D, E, F	4(66.7)
Like chromosomes	A	1(16.7)	B, C, D, E, F	5(83.3)
Like different pairs of chromosomes do	A	1(16.7)	B, C, D, E, F	5(83.3)
Like chromosomes do	A, C, E	3(50.0)	B, D, F	3(50.0)
Like a ladder	A, F	2(33.3)	B,C, D, E	4(66.7)
Color stains	B,	1(16.7)	A,C,D,E,F	5(83.3)
Dance of chromosomes	B	1(16.7)	A,C,D,E,F	5(83.3)
Kind of inheritance	A, E	2(33.3)	B,C,D,F	4(66.7)
Visible Expression of Character	A, E, F	3(50.0	B, C,D	3(50.0)
Specific genetic constitution	F	1(16.7)	A,B,C,D,E	5(83.3)

The lists of textbooks used for the study include;

i) TEXTBOOK A- Macmillian Mastering Series Biology for Senior Secondary Schools by A. B. Odaibo, A. B.; Ugwumba, O. A. & Egbinola, G. A. Macmillian Nigeria publishers Nigeria, 2010.
ii) TEXTBOOK B- Complete Biology for Senior Secondary Schools by J. Avis *et al*. Pearson Publishers. 1st Published, 2014.
iii) TEXTBOOK C- Essential Biology for Senior Secondary School by Michael, M. C. Tonad Publishers. Eighth Edition, 2018.
iv) TEXTBOOK D- Modern Biology for Senior Secondary Schools by Sarojini. Africana First Publishers. 2016.
v) TEXTBOOK E- Comprehensive Certificate Biology for Senior Secondary Schools 3 by Ambuno Sunday; Egunyomi, A;& Osakwe, V. C. University Press PLC Ibadan, New Edition, 2008.
vi) TEXTBOOK F- College Biology by Idodoi-Umeh, Cambridge Univ. Press. Fourth Edition, 2015.

The total number of analogies in each of the textbooks was identified. It should be noted that no literature has revealed a specified number or proportion of adequacy of analogies to be used in textbooks. Hence, this analysis only presents a comparison between analogies used in different recommended textbooks in the study area.

Table 2

Total Analogies Identified for Various Textbooks

TEXTBOOK	NUMBER OF ANALOGIES	PERCENTAGE (%)
A	21	28.8
B	6	8.2
C	11	15.1
D	11	15.1
E	9	12.3
F	15	20.5
Total	73	100.0

Key: $\frac{\text{Number of Analogies in textbook}}{\text{Total number of Analogies in all textbooks}}\ x\ 100$

The table above revealed that for the total analogy identified in the textbooks, it was revealed that textbook A had more analogies than the other textbooks with 28.8%, and it was revealed that textbook C had the next highest analogy with 15.1% followed by textbook D with 15.1% of the analogies and then textbook F with 20.5% of the analogies. It was revealed that textbooks E and B have the least analogy with 12.3% and 8.2% respectively.

3.1. Research Question One: What is the presentational format of presenting genetics in senior secondary school biology textbooks?

To analyze this research question, three presentation formats were acceptable. These are, pictorial format, verbal format, and pictorial + verbal format.

Table 3

Analogies Based on Presentational Format in Biology Textbooks

Textbook	Pictorial Freq (%)	Verbal Freq (%)	Pictorial + Verbal Freq (%)
A	4(19.0)	16(76.1)	1(4.7)
B	0 (0.0)	6(100)	0(0.0)
C	0(0.0)	10(90.0)	1(9.1)
D	1(9.1)	10(90.9)	0(0.0)
E	1(11.1)	8(88.9)	0(0.0)
F	6(40.0)	7(46.7)	2(13.3)

% of analogy = $\frac{\text{Number of presentational format of analogy found in each textbook}}{\text{Total number of analogies in a textbook}}$ x 100

The table above indicated that for textbook A, analogies in pictorial format were 19.0% of the whole textbook while the verbal format had 76.1% analogies of verbal format and 4.7% verbal and pictorial analogies. The pictorial format for textbook B was 0.0%, the verbal format for textbook B was 100%, and the pictorial+verbal format of textbook B is 0.0%. For textbook C, the pictorial format was 0.0%, the verbal format was 90% while the pictorial+verbal format for textbook C was 9.1%. The pictorial format for textbook D was 9.1%, the verbal format for textbook D was 90.9% while the pictorial+verbal format for textbook D was 0.0%. The table also revealed that the pictorial format for textbook E was 11.1%, the verbal format was shown to be 88.9% and the pictorial+verbal format of textbook E was 0.0%. The pictorial format of textbook F was 40.0%, the verbal format of textbook F was 46.7% and the pictorial+verbal format of textbook F was 13.3%.

It was then concluded verbal format is the predominant presentational format used by recommended Biology textbooks in the study area.

3.2. Research Question Two: What is the level of enrichment of analogies used in presenting genetics in senior secondary school biology textbooks?

Note: To analyze this research question, the verbal and pictorial+verbal analogies were categorized into simple, enriched, and extended analogies. The analysis was presented in the table:

Table 4

Analogies Based on Level of Enrichment in Biology Textbooks

Textbook	Simple Freq(%)	Enriched Freq(%)	Extended Freq(%)
A	16 (76.2)	5(23.8)	0 (0.0)
B	5(83.3)	0(0.0)	1 (16.7)
C	7 (63.6)	2 (18.2)	2 (18.2)
D	7(70.0)	2(20.0)	1(10.0)
E	7(87.5)	1(14.3)	0 (0.0)
F	7 (77.8)	2 (22.2)	0 (0.0)

$$\% \text{ of analogy} = \frac{\text{Number of the level of enrichment of analogy found in each textbook}}{\text{Total number of analogies in a textbook}} \text{ x } 100$$

The table above indicated the analogies used by the textbooks based on the level of enrichment, it was revealed that the simple format used in textbook A was 76.2% while the enriched analogies were 23.8% and the extended analogies were 0.0%. The simple format of textbook B was 83.3%, the enriched format of textbook B was 0.0% while the extended format of textbook B was 16.7%. For textbook C, the table revealed that the simple format was 63.6%, the enriched format of analogies was 20.0% and the extended format for the textbook was 18.2%. The simple format of textbook D was 70.0%, the enriched format was 18.2% while the extended format of textbook D was 10.0%. The simple format of textbook E was 87.5%, the enriched format of textbook E was 14.3%, and the extended format of textbook E was 0.0%. The simple format of textbook F was 77.8%, the enriched format was 22.2% while the extended format was 0.0%,16.7%,18.2%, 10.0%, 0.0%, 0.0% for textbooks A, B, C, D, E and F respectively.

For the level of enrichment, the study revealed that textbooks A, B, C, D, E, and F have a simple percentage of 76.2%, 83.3%, 63.6%, 63.6%, 77.8%, and 46.6% respectively.

It was concluded that the simple format was the predominant format of the level of analogical enrichment used by the selected textbooks in the study area.

3.3. Research Question Three: What are the levels of the positional format of analogies used in presenting genetics in senior secondary school biology textbooks?

Note: To analyze this research question, the verbal and pictorial+verbal analogies were categorized into the advanced organizer, embedded activator, and post synthesizer analogies. The analysis was presented in the table:

Table 5

Analogies Based on Positional Format in Biology Textbooks

Textbook	Advanced Organizer	Embedded Activator	Post Synthesizer
A	3 (14.3)	11 (52.4)	7(33.3)
B	0 (0.0)	4 (66.7)	2 (33.3)
C	1 (9.1)	9 (81.8)	1 (9.1)
D	3 (30.0)	4 (40.0)	3 (30.0)
E	1 (12.5)	7 (87.5)	0 (0.0)
F	5 (55.6)	3 (33.3))	1 (11.1)

$$\% \text{ of analogy} = \frac{\text{Number of positional format of analogy found in each textbook}}{\text{Total number of analogies in a textbook}} \times 100$$

The table above showed the analogical positions of identified textbooks. It was indicated that for textbook A, the advanced organizers which were used before the statements were seen to be 14.3% while embedded activators which were added in the middle of the sentences for textbook A was 52.4% while post synthesizers were 33.3%. The advanced organizer format of textbook B was 0.0%, the embedded activator format of textbook B was 66.7%, and the post synthesizer format of textbook B was 55.6%. For textbook C, the advanced organizer format was 9.1%, the embedded activator format was 81.8%, and the post synthesizer format was 9.1%. The advanced organizer format of textbook D was 30.0%, the embedded activator format of textbook D was 40.0%, and the post synthesizer format of textbook D was 30.0%. The advanced organizer format of textbook E was 12.5%, the embedded activator format of textbook E was 87.5%, and the post synthesizer format of textbook E was 0.0%. The advanced organizer format of textbook F was 55.6%, the embedded activator format of textbook F was 33.3% and the post synthesizer format of textbook F was 11.1%. For the positional analogy, it was revealed that the embedded activator was the predominant analogical position by the textbooks in the study area.

For the analogical position, the embedded activator was the predominant analogical position used in the textbooks with percentage scores of 52.4%, 66.7%, 81.8%, 36.6%, 77.8%, and 20.0% respectively.

4. Discussion

The result of the analysis showed that based on the presentational format of the analogies, it can be seen that verbal presentation of analysis was the most predominant format of presentation of analogy used by recommended textbooks in the study area. the pictorial+verbal format was the least used format used by the textbooks in the study area. This was in agreement with the works of Curtis and Reigeluth (1984) and Newton (2003) whose works showed that verbal presentation format with 84.0% and 78.3% respectively. It was also in accordance as the pictorial analysis was absent in the works of Curtis and Reigeleth and Newton respectively. The findings were also following the work of Dikmenli (2015) whose work had a high amount of presentation format (76%) on Cell concepts. This could result in a deficiency as it is believed that students remember pictures more than what is read. The implication of this is that analogies that could improve students' retention through images are not well utilized by the textbooks in the study area. Bean, Searles, Singer, and Cowen (2015) stated that the pictorial verbal format of analogy is more effective in understanding concepts as opposed to just the verbal format of presentation.

Based on the level of enrichment, the study indicated that the most frequently used analogy was the simple analogy which does not provide a link with any other form of analogy or engage students mentally. The study agreed with Dikmenli (2015) whose work showed that the analogies were mostly in the simple format followed by enriched and then extended enrichment. Research has shown

the limitations of simple analogies as it is believed it can lead to misconceptions because students have to link facts by themselves (Thiele, Venille & Treagust, 1995), Dikmenli, 2015). Glynn (1991) believed that extended and enriched analogies will help students link concepts more and improve their interest and motivation toward various topics. Curtis and Reigeluth (1984) and Newtons (2003) work on analogies also revealed that the simple analogy is the consistent analogy used by the textbooks in the study area. Newton's Study in 2003 revealed that the textbooks analyzed do not have the extended format of analogy.

Analogies on the positional format showed that most of the analogies in the analyzed textbooks are embedded activators. This was also in agreement with the work of Akcay (2015) whose work revealed that embedded activators had a percentage of 92.4%. This also agreed with Newton (2003) and Curtis and Reigeluth (1984) whose analogical position had 76.0% and 100% respectively which was more than all other analogical positions. Dikmenli (2010) and Curtis and Reigeluth (1984) believed that analogical terms such as Embedded activator (EA) and Advance organizer (AO) are the best forms of analogies that can be used by textbooks in the study area. Research has shown that embedded activator is more convenient for students as other types require experience and preliminary knowledge.

5. Conclusion

Results showed that Textbook A had more analogies than the other Textbooks with 28.8%. Furthermore, Textbook C had the next highest analogy with 15.1% followed by textbook D with 15.1% of the analogies and then Textbook F with 20.5% of the analogies. It was revealed that Textbooks E and B had the least analogy with 12.3% and 8.2% respectively. The result also revealed that verbal analogy was the predominant form of analogies in the recommended biology textbooks as textbooks A, B, C, D, E, and F had 76.1%, 100%, 90.0%, 90.9%, 88.9%, 46.7% of verbal analogies respectively. For the analogies on the level of enrichment, the simple analogy was predominant with textbooks A, B, C, D, E, and F having 76.2%, 83.3%, 63.6%, 70.0%, 87.5%, and 77.8% analogies respectively. For the analysis based on the positional format, embedded activator was the predominant form of analogies in the recommended biology textbooks with textbooks A, B, C, D, E, and F having 52.4% 66.7%, 81.8%, 40.0% 87.5%, and 33.3% analogies respectively.

The study then concluded that verbal analogies, simple analogies, and advance organizer analogies are the predominant analogies used in textbooks. It was also concluded that textbooks should include and balance the ratio of the different types of analogies being used. As it has been established that visual images help to enhance learning, the lack of enough pictorial analogy in the textbook will hinder the efficiency of the textbook in teaching and learning while the dominant use of simple analogy will not encourage thinking by the students.

6. Recommendations

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

i) Textbook authors should use more analogies in their books so that the readers would be brought to their real-world to aid understanding.

ii) Difficult and abstract concepts in Genetics should be taught using analogies to improve the understanding of students

iii) The use of analogies should be inculcated into the teaching subjects of the school curriculum.

iv) Textbooks should ensure even spread of the use of analogies to improve learning.

v) Advanced organizers and pictorial analogies should be used more as they are more effective in teaching and learning.

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APPENDIX I

FACULTY OF EDUCATION

OBAFEMI AWOLOWO UNIVERSITY

BIOLOGY TEXTBOOKS GENETICS ANALOGY (BTGA)

Instruction:

The researcher read through the topic "Genetics" in the selected Biology textbooks thoroughly, identify the analogies used in the selected textbooks, list out all the identified analogies, list the name of the textbooks, figure out the numbers of analogies identified, classify the analogies used in the presentational format, analogical position, level of enrichment, and finally calculate the percentage % used and unused analogies in selected Biology textbooks in Osun State.

SECTION A: TEXTBOOK ANALOGIES

Target	**Genetic Analogies**	**Textbooks with Analogies**	**Frequency (%) of Textbooks with Analogies**	**Textbooks without Analogies**	**Frequency (%) of Textbooks without Analogies**
Alleles	Alternative forms				
Diploid	Two sets of Chromosomes				
Hybrid	Not pure breeding				

Chromosome	Thread-like				
Chromatids	Two threads				
DNA	Resemble a double helix				
DNA strands, (nucleotide chain)	Two long chains				
Gene	Carriers of a trait				
Loci	Position of genes				
Nucleotides	Chains				
Offsprings	Organisms like the parents				
Interphase division	Thread forming				
Mitosis	division of the same number of chromosomes				
Meiosis	Reduction division				
Hereditary	The transmission of biological characters from parent to offspring				
Homozygous	Pure breeding				
Heterozygous	Like different pairs of chromosomes do				
Histone	Like chromosomes				
Probability	Dice throwing				
Segregation	Like chromosomes do				
Arrangement of DNA structure	Like a ladder				
Giemsa stain	Colour stains				
Metaphase	Dance of Chromosomes				
Traits	Kind of Inheritance				
Phenotype	Visible expression of Character				
Genotype	Specific genetic constitution				

APPENDIX II

COMBINED LIST OF ANALOGIES IN ALL TEXTBOOKS

To answer the research questions, the combined list of analogies used by all the textbooks were presented below. These include;

i) Alternative forms

ii) Two sets of Chromosomes

iii) Not pure breeding

iv) Thread-like

v) Two threads
vi) Resemble a double helix
vii) Two long chains
viii) Carriers of a trait
ix) Position of genes
x) Chains
xi) organism like the parents
xii) Thread forming
xiii) Division of the same number of chromosomes
xiv) Reduction division
xv) The transmission of biological characters from parent to offspring
xvi) Like different pairs of chromosomes do
xvii) Pure breeding
xviii) Dice throwing
xix) Like chromosomes
xx) Like chromosomes do
xxi) Like a ladder
xxii) Colour stains
xxiii) Dance of Chromosomes
xxiv) Kind of Inheritance
xxv) Visible expression of Character
xxvi) Specific genetic constitution

APPENDIX III

THE LISTS OF TEXTBOOKS USED FOR THE STUDY INCLUDE;

i) TEXTBOOK A- Macmillian Progressive Biology for SS1-3 by A. B. Odaibo *et al*. Macmillian Nigeria publishers.
ii) TEXTBOOK B- Complete Biology for Senior Secondary Schools by J Avis et al. Pearson Publishers.
iii) TEXTBOOK C- Essential Biology by M. C. Michael. Tonad Publishers.
iv) TEXTBOOK D- Modern Biology for Senior Secondary Schools by Sarojini Africana First Publishers.
v) TEXTBOOK E- Comprehensive Certificate Biology for SS1-3 by Ambuno Sunday, *et al*. UPPLC.
vi) TEXTBOOK F- Excellence in Biology for SS1-3 with workbook and teachers' guide. By Fakeye *et al*. Cambridge Univ. Press.

APPENDIX IV

SECTION B:

ANALOGY BASED ON PRESENTATIONAL FORMAT IN BIOLOGY TEXTBOOKS

TEXTBOOKS	**PRESENTATIONAL FORMAT**		
	P	**V**	**P+V**
	Frequency (%)	**Frequency (%)**	**Frequency (%)**

A			
B			
C			
D			
E			
F			

KEYS

PRESENTATIONAL FORMAT

P - Pictorial format: This is represented in the text in pictorial form, whereby the relationship is explained in pictures only.

V - Verbal format: Analogies are represented in the text in verbal form, whereby the relationship is explained in words.

P-V - Pictorial and Verbal format: This is represented by pictures accompanied by words

APPENDIX V

SECTION C:

ANALOGY BASED ON LEVEL OF ENRICHMENT IN BIOLOGY TEXTBOOKS

TEXTBOOKS	**LEVEL OF ENRICHMENT**		
	S **Frequency (%)**	**EN** **Frequency (%)**	**EX** **Frequency (%)**
A			
B			
C			
D			
E			
F			

KEYS

LEVEL OF ENRICHMENT

S - Simple: These are analogies with similarity statements made between the analog and the target with no further explanation of the similarity provided. E.g. The DNA molecule is shaped like a twisted ladder.

EN - Enriched: These are analogies with further explanation of the similarities between an analog and a target given.

Ex - Extended: These are mixtures of simple and enriched analogies, limitations are put on the similarities between an analog and a target.

APPENDIX VI

SECTION D

ANALOGY BASED ON POSITIONAL FORMAT IN BIOLOGY TEXTBOOKS

TEXTBOOKS	**POSITIONAL FORMAT**		
	AO **Frequency (%)**	**EA** **Frequency (%)**	**PS** **Frequency (%)**

A			
B			
C			
D			
E			
F			

KEYS

POSITIONAL FORMAT

AO - Advanced Organizers: These are analogies used at the beginning of a unit.

EA - Embedded Activator: These are analogies used to explain a subject requiring additional interpretation within a unit.

PS - Post Synthesizer: These are analogies presented at the end of the unit in a summarizing capacity.