

Assessment of Analogies Used in Presenting Genetics in Senior Secondary School Biology Textbooks in Osun State, Nigeria

Oyinwola O. Esther¹, Agboola O. Sola², & Ojediran I. Ayodele¹

¹Department of Science and Technology Education, Faculty of Education, Obafemi Awolowo University, Ile-Ife, 22005, Osun State, Nigeria

²Institute of Education, Faculty of Education, Obafemi Awolowo University, Ile-Ife, 22005, Osun State, Nigeria

Corresponding Author: ojediranayo27@gmail.com

Abstract

The study assesses the analogies used in the presenting genetics in selected Biology textbooks used in Osun State, Nigeria. The study adopted descriptive survey research design. The population for the study comprised all the nine Biology textbooks presently recommended by Osun State Ministry of Education for implementing Biology curriculum. The study sample comprised of six (Textbooks A, B, C, D, E and F) out of the nine recommended Biology textbooks using 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. Result 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 textbook A, B, C, D, E and F had 76.1%, 100%, 90.0%, 90.9%, 88.9%, 46.7% of verbal analogies respectively. The study concluded that the verbal analogies, simple analogies and advance organizer analogies are the predominant analogies used in the sampled textbooks. It was recommended that textbook authors should use more analogies in their textbooks; difficult and abstract concepts in Genetics should be taught and advance organizer and pictorial analogies should be used to enhance effective teaching and learning of Biology.

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

Introduction

Science is a system of acquiring knowledge based on scientific method, as well as the organised 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 its non-living components. Agogo and Naakaa (2014) are of the opinion 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 to their environment. Biology as a subject helps to enable one 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 process. It is the process of comparing one thing with another thing that has similar features in order 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 term 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, hard to visualise. 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 cognitive domain of the student, integration and

activation of prior knowledge with the help of mental reasoning.

Some teaching models were developed for the effective use of analogies in teaching Science Education such as General Model of Analogy Teaching (GMAT) model. Teaching with Analogies (TWA) model (Glynn, 1991 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, 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, performer and action analogy. Curtis and Reigeluth (1984) categorised analogies based on the following five criteria: presentational format (verbal – analogy is presented in verbal format only, pictorial – analogy is presented in pictures only and pictorial + verbal – 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 text (advanced organiser – 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 of a concrete nature. Abstract to abstract Analogy - both the analogies and the target are of an abstract nature. Concrete to abstract Analogy - the analogy is of a concrete nature but the target is of an abstract nature. One of the most difficult concepts in biology is genetics because it has terms that are not commonly used outside genetics classroom and this makes it look like a foreign language. Genetics is the study of genes, genetic variation, and heredity in living organisms (Griffiths, Miller, Suzuki, Lewontin & Gelbart, 2000). 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 structure and function of the cell and its organelles (Chattopadhyay, 2017).

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 (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 which cannot be ignored in 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 nonconcrete 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.

Statement of the Problem

Science uses technical languages that are different in some cases from 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 a number of ways language can make understanding of genetics more difficult, such as alternative meanings of words, students' lack of appropriate vocabulary, the specialised vocabulary used by teachers, and the English as a second language. Mastropieri and Scruggs (1991) are even of the opinion that there are many researches that 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.

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:

1. identify the analogies used in the presentational format in illustrating genetics in selected biology textbooks;
2. describe the analogical level of enrichment in presenting genetics in selected biology textbooks; and
3. compare the analogical position in presenting genetics in selected biology textbooks.

Research Questions

The following research questions were raised for the study:

1. What are the presentational formats of analogies used in presenting genetics in senior secondary school biology textbooks?
2. What are the levels of enrichment of analogies used in presenting genetics in senior secondary school biology textbooks?
3. What are the analogical positions of presenting genetics in senior secondary school biology textbooks?

Methodology

The study adopted descriptive survey research design. This was with the aim of assessing the analogies used in presenting genetics in senior secondary school biology textbooks in Osun State. The population for this study comprised all nine recommended biology textbooks by Osun State Ministry of Education for the implementation of 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 simple random sampling technique. 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. Eight 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).

TEXTBOOK F- College Biology by Idodoi-Umeh, Cambridge Univ. Press. Fourth Edition, 2015. 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 by 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' correction and advice

Method of Data Analysis

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

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

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

The following "Decision Rule" was adopted for the study:

- 50% and above is tagged as Adequate
- 50% and below is tagged Not Adequate

Results

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)
Colour 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)

Source: Field Survey (2018)

Using frequency count and percentages, Table 1 presents the overview of the total number of analogies in each of the textbooks were 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

Source: Field Survey (2018)

From the result, textbook A had the highest analogies 21(28.8%), seconded by Textbook F with 15(20.5%) and not otherwise. It was revealed that textbook E and B has the least analogy with 12.3% and 8.2% respectively.

Preamble: To analyze this research question one, there are three presentation formats that 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)

Source: Field Survey (2018)

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%, 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%.

Preamble: To analyse this research question two, the verbal and pictorial + verbal analogies were

categories into: simple, enriched, extended analogies. The analysis was presented in the table 4

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)

Source: Field Survey (2018)

Table 4 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% while 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%, 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 level of enrichment, the study revealed that textbook A, B, C, D, E and F have 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 level of analogical enrichment used by the selected textbooks in the study area.

Preamble: To analyse this research question three, the verbal and pictorial +verbal analogies were categories into: advanced organizer, embedded activator, post synthesizer analogies. The analysis was presented in the table 5

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)

Source: Field Survey (2018)

Table 5 showed the analogical positions of identified textbooks. It was indicted that for textbook A, the advanced organizers which were used before the statements were seen to be 14.3% while embedded activator which were added in the middle of the sentences for textbook A was 52.4% while post synthesizers was 33.3%. The advanced organizer format of textbook B was 0.0%, the embedded activator format of textbook B was 66.7%, 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%, 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%, 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%, 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 embedded activator was the predominant analogical position by the textbooks in the study area. For the analogical position, 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.

Discussion

The result of the study showed 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. The findings also agreed with 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 analogy which could improve student's retention through images are not well utilized by the textbooks in the



study area. Bean, Searles, Singer and Cowen (2015) stated that pictorial verbal format of analogy is more effective in understanding concepts as opposed to just 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 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 simple format followed by enriched and then extended enrichment. Researches have 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 towards various topics. In 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 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 activator. This was also in agreement with the work of Newton (2003) whose work revealed that embedded activator had a percentage of 92.4%. This also agreed with Curtis and Reigeluth (1984) whose analogical position had 76.0% and 100% respectively which was more than all other analogical position. Dikmenli (2010) and Curtis and Reigeluth (1984) believed that analogical terms such as Embedded activator (EA) Advance organizer (AO) are the best forms of analogies that can be used by textbooks in the study area. Researches have shown that embedded activator is more convenient for students as other types require experience and preliminary knowledge.

Conclusion

The study then concluded that verbal analogies, simple analogies and advance organizer analogies are the predominant analogies used in the 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 number of pictorial analogies 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.

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 school curriculum.
- iv) Advanced organizer and pictorial analogies should be used more as they are more effective in teaching and learning.

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