

# **BIOLOGY TEACHING METHODS**



*Edited by*

**Isaac Olakanmi Abimbola**

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Department of Science Education, Unilorin, Nigeria**

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## PREFACE

The purpose of this book, "Biology Teaching Methods," is to provide adequate guidance for students undergoing the initial teacher education programmes in universities and colleges of education, and all other biology teachers in secondary schools in Nigeria. We believe that it is important for Biology teachers to know why they are teaching biology, what biology to teach, how to teach the biology content, and how to assess students' learning outcomes from instruction, and to be up to speed concerning events in the world relating to biology and biology teaching.

There has been a strong need for this book for a long time. I, therefore, have great pleasure in introducing to you the successful outcome of an initiative commenced on 6 July 2015, by the Biology Education Group of the Department of Science Education, University of Ilorin, Ilorin, Nigeria.

Abimbola's treatment of Philosophy of Science, the treatment of History of Science, and Biology by Bello, Educational Psychology by Abimbola, and the National Policy on Education, as represented by Aims, Goals and Objectives of Education by Imam, situated properly the theoretical bases of the book.

Mulkah Ahmed surveyed secondary school biology curricula worldwide to zero in on what biology contents to teach senior secondary school biology students in Nigeria.

A major part of the book was devoted to the methods and strategies for teaching biology (Chapters 6-12), while paying particular attention to students' construction of their knowledge and the need for student-centred instructional strategies to achieve this. Bello treated "Methods of Teaching Biology," while Mulkah Ahmed treated, "Lesson Planning for Biology Teaching," and "Materials and Resources for Teaching Biology." Bello followed with the treatment of "Biology Laboratory Design, Management, and Safety."

Mulkah Ahmed then treated, "Improvisation in Biology Teaching," to make biology teachers in training very versatile and creative. In addition, this section includes trending, innovative instructional strategies such as, "The Role of Study Technology in Biology Learning Outcomes," by Rihanat Ahmed, and "The Use of Analogies and Metaphors in Teaching Biology," by Sulaiman.

Hafsat Imam carried out a critical bird's eye view of the status of biology education in Nigeria, under, "Problems and Prospects of Teaching Biology in Nigeria," to point up the way forward that may ameliorate problems faced by biology education in Nigeria.

Abimbola concluded the book with an important take-away for biology student teachers, concerning how they can grow and develop professionally, including entrepreneurship opportunities, while enjoying teaching biology. The Chapter provided information to student teachers on the 21<sup>st</sup> Century Skills they need to acquire, and knowledge of the Sustainable Development Goals they need to possess to be millennium compliant. The Chapter also included an innovative section that describes the career prospects in other sectors of the economy, for trained biology teachers who do not really want to teach.

This textbook contains many study aids, such as a good system of headings and subheadings, tables, figures, and pictures, revision questions, and copious references, for further reading. It contains five appendices, namely, "Characteristics of An Outstanding Biology Teacher," "Biology Literacy Scale for Teachers," "Faculty Teaching Practice Assessment Format," "List of Secondary School Biology Textbooks," and "List of Journals in Biology Education and Science Education Worldwide."

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## CHAPTER 12

# THE USE OF ANALOGIES AND METAPHORS IN BIOLOGY TEACHING

Musa Mohammed Sulaiman

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### Introduction

Analogies and metaphors are relational thinking tools that involve learners' personal construction of knowledge. They have been widely used by scientists in explaining their research findings to members of the scientific world and non-scientists alike. However, because of the closeness in meaning of the two concepts, researchers in the field of education have used them interchangeably. This chapter therefore intends to make a distinction between the two concepts and give an illustration of how both concepts are used in scientific discourses, in general, and biology teaching, in particular.

### Analogy

Analogy is a method of describing things that are not too familiar with things that are quite familiar. Abimbola (2006) described analogy as a method of describing things that are not known in terms of things that are known. Students and teachers of biology often use analogies as a means of representation and a source of knowledge when trying to explain abstract biological terms such as looks like, mimics, and so forth. Biological concepts, such as those related to genetics are filled with terminologies that have their origins in either Latin or Greek words, or are also rich in terms whose meanings are quite different from the everyday usage of such terms.

An analogy has two major components: the analogue component, which is used as the basis for structural comparison, and the target, which is the component or domain to be explained. They are tools used by textbook writers to explain abstract concepts. Biology teachers and textbook authors often make use of analogies when trying to explain abstract biology concepts. Analogies come in different forms when used in the textbooks. However, there are laid down criteria put in place by Thiele and Treagust for use in classifying analogies in textbooks (please see Table 1).

*Revised Version of Criteria for Classifying Analogies*

| Classification scheme       | Criteria              | Description                                                                                                                                                                                |
|-----------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nature of shared attributes | Functional            | Target shares only functional attributes like behavior, e.g., The thalamus is regarded as the gatekeeper of the cerebrum                                                                   |
|                             | Structural            | Shares only structural attributes like shapes, sizes and so forth, e.g., diagram showing how sympathetic nervous system arises from the nervous system                                     |
|                             | Structural/functional | Shares both structural and functional attributes, e.g., the cell component can be explained by comparing it to a pasta factory in terms of structure and function.                         |
| Representations             | Verbal                | Uses verbal context only in the representation of both analogue and target e.g., The beak of the pelican (target) looks like pouch but is used as a dip net (analogue) for catching fishes |
|                             | Pictorial             | Uses pictorial context only in the analog domain, e.g., diagram showing the structure of the plant cell                                                                                    |
|                             | Pictorial/Verbal      | Uses both the verbal and pictorial context in the analog domain                                                                                                                            |
|                             | Simple                | Uses statements such as "like", "mimics," and so forth, with no further explanation                                                                                                        |

|                           |                      |                                                                                                                                                                                                                                                                                         |
|---------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                           |                      | between the analog and the target, e.g.: Well known examples include certain caterpillars and insects that look like leaves and twigs of plants on which they feed                                                                                                                      |
|                           | Enriched             | Indicates some statements of shared attributes between the analog and the target, e.g., Evolution is likened to a tree in which the trunk represents the ancestral forms, while the tips of the branches represent the present day forms. The branches represent the lines of evolution |
|                           | Extended             | Analogy is made up of a combination of simple and enriched analogies and used over time in the text                                                                                                                                                                                     |
| Level of abstraction      | Concrete<br>Concrete | Both analog and target are represented using concrete objects                                                                                                                                                                                                                           |
|                           | Abstract-Abstract    | Both analog and target are represented using abstract concepts                                                                                                                                                                                                                          |
|                           | Abstract-Concrete    | Analog is abstract while the target is concrete in nature                                                                                                                                                                                                                               |
| Use of the term analogy   | Used                 | The statement is preceded with terms like "Analogue", 'Analog,' etc. to show that the authors made use of analogies                                                                                                                                                                     |
|                           | Not Used             | Statement is not preceded by any statement to illustrate that the authors made use of analogies                                                                                                                                                                                         |
| Description of limitation | Described            | Include some statements highlighting the unshared attributes, because analogies                                                                                                                                                                                                         |

|          |                    |                                                                                                          |
|----------|--------------------|----------------------------------------------------------------------------------------------------------|
|          |                    | are expected to breakdown at a point                                                                     |
|          | Not Described      | Does not include any statement of the unshared attributes or discuss areas where the analogy breaks down |
| Position | Advance organizer  | Analogy is used at the beginning of instruction                                                          |
|          | Embedded activator | Analogy is used during instruction                                                                       |
|          | Post-synthesizer   | Analogy is used at the end of instruction                                                                |

Source: Dikmenli (2015); Hulshof and Verloop (2002)

Pictorial analogy can come in two different forms as illustrated by Dikmenli (2015)

1).

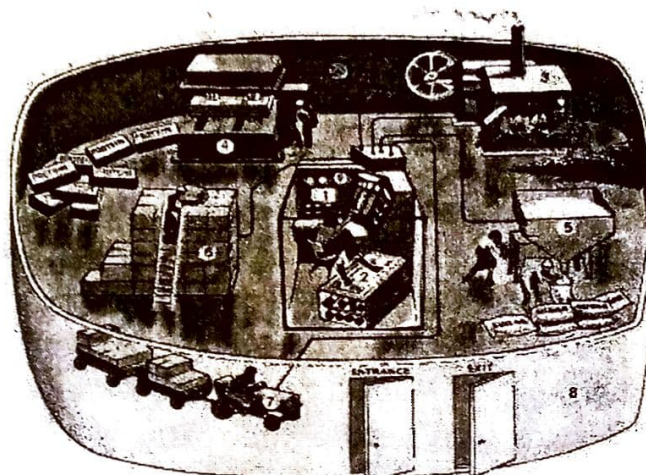


Figure 1. A picture of source domain (factory) in pictorial analogy.

Sometimes, there are both a picture of source domain (factory) and a picture of target domain (cell) (Figure 2) in a pictorial analogy. In brief, there should be at least a picture of source domain (factory) in a pictorial analogy as in Figure 1.



Figure 2. A picture of the target domain (cell) in a pictorial analogy.

Biology is filled with terms such as whip-like flagella, pouch-like beak, look like leaves and so forth. These phrases represent simple analogy since they are not used in an elaborate manner and as such could lead to misconceptions among learners. It is more advisable to make use of enriched or extended analogies when using verbal analogies, since it will provide the relationship that exists between the analog and target. A typical example of an enriched analogy used in some of the textbooks used by Nigerian senior secondary school students is "Evolution is likened to a tree in which the trunk represents the ancestral forms, while the tips of the branches represent the present day forms and the branches representing the lines of evolution." From this analogy, the "tree" is the analog, while "evolution" is the target. A student who is privileged to have seen a tree before and know the various parts will be able to visualize the concept of evolution.

Abimbola and Mustapha (2001) in their study highlighted some examples of analogies that have been widely used in teaching biology concepts to include:

1. Lock and key model as an analogy for explaining the replication and function of the DNA, and in explaining the mechanism of enzyme-substrate interaction
2. Dice throwing as an analogy to teach probability in genetics
3. The brain as a computer
4. The expression that the heart acts as a pump to illustrate the pumping action of the heart

## 5. The analogy of the embryo as a ball

### Principles for Selecting Analogies

Teachers must follow some basic principles when trying to make use of analogies with the hope of bringing about better understanding of scientific concepts and remediation of misconceptions. The principles include the need to

1. conduct goal and content analysis, by critically examining what is aimed to be learnt by making use of the right category of analogy when trying to explain scientific concepts. Thus, when trying to make use of an analogy it must be somewhat concrete to add mass to what is being explained. If the concept to be taught is not abstract or difficult to understand, it is advisable not to make use of analogies, as it will amount to mere redundancy and waste of time.
2. use familiar analog for unfamiliar new content. It is recommended that when trying to make use of analogies, the analog domain must be the ones students are familiar with, since the main goal of using analogy is to make learners get familiar with unfamiliar, complex, or abstract scientific phenomena.
3. use concrete analog for new abstract concept. Teaching abstract concept is problematic, because of its ambiguity and has been a burden to many biology teachers. Therefore, there is the need for the teachers to look for concrete analogs to present concepts to students.
4. use analogy that is mostly related to the new content. It is essential to develop and make use of analogies that have as much similar characteristics between the analog and the target to reduce the rate of misconceptions students might have in relating the analog to the target. This is also important because no matter how good the analogy is, it definitely breaks down at a point.
5. select the type of relationship regarding the nature of the new content. Analogy can be classified as either being structural, functional, or structural-functional, based on the type of relationship that is present between the analog and the target. The best of this three seems to be the structural-functional analogies, since this type of analogy is going to be more elaborate than those that are represented by either structural features or functional features alone.

6. use unrelated domain analogies rather than using related domain analogies. Unrelated analogies have both the analog and target in different fields, while related domains are one with the analog and target in the same field. Using unrelated domains ensures that students have better understanding of biological concepts, while related domains can easily bring about misconceptions.
7. consider learners' characteristics since students' experiences play a vital role in determining the right choice of analogy to be used and the mode of presentation, since students prior knowledge serves as the background that supports the kind of analogies to be used by the teacher. (Can, 2004)

Three essential features that should be catered for in using analogies, according to Guerra-Ramos (2011), include the students' background knowledge or level of familiarity with the analogy, precision in identifying the shared attributes by the teachers, and the students identifying where the analog and the target breaks down.

Aubusson, Harrison and Ritchie (2006) stated that some numbers of teaching approaches for effective use of analogies in instruction had been in use over the years, but the most common ones are the Teaching-With-Analogies (TWA model) developed by Glynn (1991) and the Focus-Action-Reflection (FAR) Guide, which was developed by Treagust, Harrison and Venville (1998) as a result of interruptions in the implementation of the Teaching-With-analogy model. TWA model and FAR guides have six and three stages, respectively.

The stages of the TWA model include:

1. Introducing the target concept to be learned
2. Cueing the students' memory of the analog situation
3. Identifying the relevant features of the analog
4. Map the similarities between the analog and the target concepts
5. Draw conclusions about the target concepts
6. Identify the comparisons for which the analogy breaks down (Harrison & Treagust, 1993; pp. 1293)

The Focus-Action-Reflection (FAR) guide is an improvement over the TWA model developed by Treagust et al. (1998), because of their research finding, which shows that teachers do not follow the steps of the TWA holistically. The FAR guide, unlike the TWA, has three stages for the effective presentation of analogies. The FAR guide is illustrated in Table 2.

Table 2

*The FAR Guide for Teaching with Analogies and Models*

| Pre-Lesson FOCUS       |                                                                                                            |
|------------------------|------------------------------------------------------------------------------------------------------------|
| Concept                | Is the concept difficult, unfamiliar or abstract?                                                          |
| Students               | What ideas do the students already have about the concept?                                                 |
| Experience             | What familiar experiences do students have that I can use?                                                 |
| In-Lesson ACTION       |                                                                                                            |
| Likes (mapping)        | Check students' familiarity with the analog<br>Discuss ways in which the analog is like the target         |
| Unlikes (mapping)      | Are the ideas surface features or deep relations?<br>Discuss ways in which the analog is unlike the target |
| Post-Lesson REFLECTION |                                                                                                            |
| Conclusion             | Was the analogy clear and useful, or confusing?                                                            |
| Improvements           | What changes are needed for the following lesson?<br>What changes are needed next time I use this analogy? |

**Source:** Harrison and Treagust (2006)

The following steps are recommended for using the FAR guide:

1. **Focus:** the teacher should initially consider the difficult aspects of the concept to be taught, whether or not the students already know something about the concept or not. It allows the teacher to get prepared for students' unfamiliarity by accessing their alternative conceptions.
2. **Action:** the teacher needs to pay careful attention to the students' familiarity with the analog, and the like and unlike of the analog and the target. This stage involves three cognitive steps: (a) familiarity with the analogy; (b) mapping of the shared attribute, and; (c) showing the students where the analogy breaks down

3. **Reflection:** the teacher needs to reflect on the clarity and usefulness of, and conclusions drawn from the analogy. The teacher needs to consider ways in which the analogy mappings or analogy position in the lesson may be improved. This phase, can take place either during the lesson or after the lesson. (Treagust, Harrison & Venville, 1998)

## Metaphors

The term "metaphor" originates from the Greek word *metaphora*, which means that something is moved from one place to another. Examples of types of metaphors are antithesis, hyperbole, metonymy, and simile. Metaphor is fundamentally conceptual in nature and goes far beyond being regarded as being linguistic in nature. It is a tool that has been used virtually every day in our communication. We can easily comprehend abstract concepts and perform abstract reasoning through the main mechanism. Metaphors allow us to understand relatively abstract or unstructured subject matter in terms of a more concrete or more highly structured subject matter.

Metaphors are figures of speech, which employ the name or characteristic of an object to explain another one with the intent of suggesting likeness between the two. A metaphor has two parts--tenor (or target) and vehicle (or source). They tend to deepen students' understanding by providing insight into the learners' experiences. They also provide a context from which students can ask questions and on which to build other concepts. Scientists, in bringing their ideas to fore, since it plays an essential role in both the formulation and communication, employ them. For instance, Charles Darwin employs the use of metaphor a "tree of descent" when trying to explain his theories of evolution and variation. Aristotle made use of a number of metaphors, similes, analogies, and models in his biological treatises. For instance, the blood vessels and the heart were compared to vases, and the flow of blood is like water in an irrigational channel. Others are, the belly resembles a manger from which the body takes its nourishment, male and females in generation are compared to the sun and earth, the back legs of the grasshopper are like the rudder of a boat, the lobster's tail is like an oars, the elephant trunk likened to a diver's breathing tube, and so forth. It is worth noting that all of them refer to the functions of organs or tissues they seek to explain.

The main essence of using metaphors in the teaching and learning process implies a flow of meaning from the familiar to the new and strange. Examples of metaphorical terms used in explaining some scientific components are highlighted in Table 1

Table 1

*Examples of Metaphorical Terms Used in Representing Scientific Terms*

| Metaphors             | Scientific Component  |
|-----------------------|-----------------------|
| Flowing water         | Electricity           |
| Wave                  | Sound/Light/Radio     |
| Wall                  | Cell wall             |
| High way              | Blood vessels         |
| Blue print            | DNA                   |
| Police force          | Immune system         |
| A Peach               | Layers of Earth       |
| Camera                | Eye                   |
| Computer              | Brain                 |
| Construction site     | Ribosome              |
| Transport company     | Endoplasmic reticulum |
| Power plant           | Mitochondria          |
| Food processing plant | Chloroplast           |
| Waste disposal plant  | Lysosome              |
| City hall             | Nucleus               |
| Storage               | Vacuole               |
| Gate                  | Cell wall             |

Metaphors, like analogies, could be either verbal, or visual. In biology-related disciplines, some specific examples of verbal metaphors used in teaching and learning, include "Water is life;" "Glucose is decomposed into smaller building stones by means of a serial enzyme;" and "Forests are the lungs of our world," while examples of visual metaphors are:

In anatomy and physiology--various living bodies pictured as the transparent ones to show their internal organs and/or their functions ("metaphor" of water or glass); in many intra-organismic topics--the bodies with their microstructures shown at the same pictures as their extracted and amplified parts ("metaphor" of lenses and microscopes);

Rick (2009) gave some examples of how some students made use of metaphors in explaining biological concepts, like mitosis and photosynthesis. They explained photosynthesis using our solar panel as, Photosynthesis is to plant energy as solar panels are to electricity. They explained chloroplast as miniature farms for plants; since chloroplast produces, great amount of energy that the leaves use in producing food while the farm would be able to sustain the local community in producing food that the community will consume.

Benefits of using metaphors in educational setting include:

1. Helping to relate new information with previously learned ones
2. Helping students to be focused and create new understanding
3. Help students to construct concepts efficiently by making use of previously learned information, by relating them to other information
4. Making issues easier, understandable, and simplify
5. Help in illustrating less known subjects with well-known subjects
6. Help individuals who create the metaphors to evaluate educational programs with the hope of improving it
7. Help the teachers to reflect their beliefs against educational processes
8. Help individual to express them more freely, and construct their own thoughts in a more detailed manner (Karadag & Gultekin, 2012, pp. 69-70)

### **Differences between Analogy and Metaphor**

The two terms are usually used interchangeably in most literature, because of the notion that they are both seeking out relationship between two things. Analogy has its origin from the Greek word *analogia*, meaning proportion, while metaphor originated from the Greek word *metaphora*, which means to transfer. Thus, analogy gives a parallel relationship with two words. A comparison points out or gives proportional relationship between two things or words. Metaphor, on the other hand, is a figure of speech that actually transfers the meaning of one thing directly to another unit. An implicit comparison inventively points something with another thing. An analogy compares the structure of two domains (analog and target) explicitly by pointing out the identity of parts of the structures, while a metaphor compares without explicitly pointing out the identity. Metaphors compare implicitly, highlighting features or relational qualities that do not coincide in the domains. Comparisons in analogies are overt,

whereas in a metaphor, they are covert (Aubusson, Harrison & Ritchie, 2006).

### **Advantages of Using Analogies and Metaphors in Biology Teaching**

The major advantages of using both analogies and metaphors in bridging knowledge gap are in the power of both tools to add sparkle to students' writing. They enable good teachers make new and unfamiliar concepts more meaningful to students, allows good readers to make sense out of passages they are reading, and, if created by students, could provide ways to assessing their understanding of new concepts (teachervision.com, 2017). Analogies and metaphors bring together two concepts from two conceptual domains to create new links.

### **Conclusion**

Analogies and metaphors are useful to scientists in getting their ideas understood by professional colleagues. Construction of meanings in science is usually evolutionary, as the meanings of concepts become clearer with time. This is a major reason why science teachers use analogies and metaphors in their teaching. It thus makes sense for biology teachers, too, to use analogies and metaphors in describing and explaining things to their students.

In sum, biology teachers should use analogies to give similar relationship to two things while using metaphors to replace the meaning of one word with another, to facilitate students' understanding. The use of analogies and metaphors makes learning pleasant, and biology teachers should cultivate the habit of using them.

### **References**

- Abimbola, I. O. (2006). *Philosophy of science for degree students*. Osogbo: Olatunbosun Publishers.
- Abimbola, I. O., & Mustapha, M. T. (2001). The use of analogies in communicating difficult science concepts to secondary school students. *The Nigerian Teacher Today*, 9(1), 62-71.
- Aubusson, P. J., Harrison, A. G., & Ritchie, S. M. (2006). Metaphor and analogy: Serious thought in science education. In P. J. Aubusson., A. G. Harrison, & S. M. Ritchie (Eds.). *Metaphor and analogy in science education*. Dordrecht: The Netherlands: Springer
- Can, G. (2004). Instructional design principles for "analogy in instruction."

- differencebetween.net (2009). *Difference between analogy and metaphor*. Retrieved from [www.differencebetween.net](http://www.differencebetween.net)> language
- Dikmenli, M. (2015). A study of analogies used in new ninth grade biology textbook. *Asia-Pacific Forum on Science Learning and Teaching*, 16(1), 1-20.
- Glynn, S. M. (1991). Explaining science concepts: A teaching-with-analogies model. In S. Glynn, R. Yeany, & B. Briton (Eds.), *The psychology of learning science* (pp. 219-240). Hillsdale, NJ: Erlbaum.
- Guerra-Ramos, M. T. (2011). Analogies as tools for meaning making in elementary science education. How do they work in classroom settings? *Eurasia Journal of Mathematics, Science, and Technology Education*, 7(1), 29-39
- Harrison, A. G., & Treagust, D. F. (1993). Teaching with analogies: A case study in grade-10 optics. *Journal of Research in Science Teaching*, 30(10), 1291-1307
- Harrison, A. G., & Treagust, D. F. (2006). Teaching and learning with analogy and metaphor: Friends or foe? In P. J. Aubusson., A. G. Harrison, & S. M. Ritchie (Eds.). *Metaphor and analogy in science education*. Dordrecht, The Netherlands: Springer
- Hulshof, H., & Verloof, N. (2002). The use of analogies in language teaching: representing the content of teachers' practical knowledge. *Journal of Curriculum Studies*, 34(1), 77-90
- Karadag, R., & Gultekin, M. (2012). The metaphors that students use to describe the term "Teachers." *University Journal of the Faculty of Education*, 8(1), 69-83
- Rick, W. (2009). *Metaphors and analogies: Power tools for teaching any subject*. Portland, ME: Stenhouse Publishers
- Teachervision.com (n.d.). *Metaphors and analogies*. Retrieved from [www.teachervision.com/professional-development/metaphors-analogies](http://www.teachervision.com/professional-development/metaphors-analogies)
- Treagust, D. F., Harrison, A. G., & Venville, G. (1998). Teaching science effectively with analogies: An approach for pre-service and in-service teacher education. *Journal of Science Teacher Education*, 9(2), 85-101