CHAPTER 29

ENGAGING STUDENTS WITH VISUAL IMPAIRMENT IN BASIC SCIENCE AND TECHNOLOGY CLASSROOMS WITH CONCEPT MAPPING STRATEGY

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Introduction

The increased emphasis on Science, Technology, Engineering and Mathematics (STEM) education is at the fore-front of academic discourse today. Science has been defined in several ways. For instance, it is a systematic study of the environment or nature through observation and experimentation, leading to an organized body of knowledge used for solving human problems (Njoku, 2018). Science provides learners with the knowledge and understanding of day-to-day phenomena, concepts and principles. It has the potential to improve the lives of individuals in society. Science involves communication with different people in the society, such as, teachers, adult and children. It teaches important attitudes in life, such as, patience, humility, perseverance, fastidiousness, curiosity, cooperation and precision. Science teaches children about the world around them and inculcates in them important life-long skills, such as, reflection, critical thinking, logical reasoning, problem-solving skills and creativity. It helps them make informed decisions as well as pursue new interests and further studies in the field. To Njoku, when scientific knowledge and processes are applied to reduce or eliminate problems of human existence in the environment, thereby, making life easier and safer, it is known as technology.

Science and technology education is the pivot on which the socio-economic development of any nation is hinged. The product of science and technology has contributed to the development of nations of the world. With the rapid pace of scientific and technological advancement coupled with the globalization of science learning, emphasis on scientific literacy and acquisition of 21stcentury skills by the citizenry for useful living in the society, basic science and technology in Nigeria is now a compulsory component of the school curriculum at the basic level of education. The application of scientific knowledge has led to the invention of equipment and machines used in industries, homes and other facets of the economy. This may be why Imo, Habila and Ozoji (2019) posit that any country that still suffers from underutilization of scientific and technological processes and products generally experiences underdevelopment. Therefore, for any country that aspires to address the problem of underdevelopment, science and technology has to be put at the forefront of every educational programme of that country (Bala, 2018). To Imo et al., teaching basic science and technology at the foundation level of education is a powerful way of inculcating a scientific mindset in the students. Hence, the need for teachers to use effective and innovative strategies, as well as properly designed learning activities in science and technology classrooms, particularly, at the basic level of education which is the foundation of science learning, for equipping all categories of students, with or without special needs.

Meeting the needs of students with special needs, especially, those with visual impairment in science and technology instruction is of vital importance because they are part and parcel of the society. Excluding them from science and technology education means denying them the many benefits provided by such an important discipline. Again, generally, this category of people faces discrimination, exclusion and oppression by the society due to their disability which isa negation of equality of education advocated by the National Policy on Education (Federal Republic of Nigeria [FRN], 2014) and the Sustainable Development Goals (UNESCO, 2018).

Visual impairment is a terminology that generally refers to vision loss. Ozoji, Unachukwu and Kolo (2016) define visual impairment as an umbrella term that accommodates all types and degrees of vision loss. It can also be defined as a decrease in the ability of an individual to see to a certain degree that causes problems not fixable by usual means such as the use of glasses. To Ozoji, et al, persons with visual impairment are defined as either medically/legally or educationally impaired depending on the type of intervention such a person needs at the time in question. In the context of this paper, students are said to be visually impaired when they are partially sighted, have low vision or are legally or totally blind. Students with visual impairment just as their peers in basic schools have a right to qualitative education. However, for this to be achieved, particularly, in science and technology, special adaptations in form of instructional designs, instructional materials and strategies must be put in place. One of the effective strategies from literature which has been shown to engage learners in meaningful construction of knowledge in the sciences among other subjects is the concept mapping strategy.

Concept mapping strategy is an information-processing teaching/learning strategy which has to do with construction, sequencing, organization and relation of ideas or concepts from the most general or difficult, to the most concrete or simplest idea. It is an activity-based and inquiry-oriented teaching/learning strategy. Concept mapping strategy helps to teach learners higher order thinking. According to Novak (1990) concept mapping strategy makes use of two-dimensional diagrams known as concept maps which indicate relationships among concepts in a field of knowledge. The maps are metacognitive tools that encourage critical and reflective thinking about what one knows about subjects through virtual representation of images (Cassata, 2006). Concept mapping strategy is rooted in constructivism which upholds that learners construct knowledge.

Concept mapping strategy has been reported to be effective in promoting meaningful learning of concepts (Novak, 2008; Usman, 2017; Ozoji, 2020). Concept maps are important assessment tools and are used to unpack the knowledge in texts, lectures or laboratories (Novak, 1998). The use of concept mapping strategy makes the structure of knowledge explicit and more easily understood by students. It helps teachers design units of study that are meaningful, relevant and pedagogically sound and interesting to students (Martins, 1994). Concept mapping strategy aids to stimulate idea generation and creativity. It is used for brainstorming and communication of ideas, note-taking and knowledge transfer and can be used at all levels. Despite the many benefits of concept mapping strategy in enhancing teaching and learning of school subjects. Studies showed that most teachers at the basic and senior secondary school levels do not know what the strategy is all about. (Edozie, 2006). A study by Ozoji (2011) showed that 80% of teachers in selected basic and senior secondary schools had never used concept mapping strategy in instructional delivery.

There are different categories of concept maps, such as, spider concept map, hierarchical concept map, flow chart concept map and systems concept map. A spider map is characterized by a unifying theme at the center with radiating themes surrounding the center of the map. According to Leary (2010), spider concept maps are useful in brainstorming and facilitating understanding of defined concepts. Different types of spider maps can be used to illustrate defined concepts. One type of spider map shows the relationship between a single concept and its characteristics. Another type shows an all-embracing concept and other related concepts. A third type of spider map which is the most detailed, shows an all-embracing concept, its related concepts and their characteristics. An example of a spider map is illustrated in Figure 1.

A hierarchical concept map shows the hierarchical relationship between an all-embracing, general, or most difficult concept and simple or least difficult concepts using linking words/phrases otherwise referred to as propositions. The most general or key concept is placed at the top of the hierarchy and the most specific concepts are arranged below. Hierarchical concepts maps are therefore, read from the top progressively down to the bottom. Hierarchical concept maps rely on three fundamental qualities, namely, hierarchical structure, progressive differentiation and integrative reconciliation (Novak, 1990). Progressive differentiation is the process of learning in which the learner differentiates between concepts as he learns. Integrative reconciliation refers to the relationship that exists among concepts from one side of the map to the other. The hierarchical concept map therefore, shows interrelationships from top to bottom and from one side of the map to the other.

The hierarchical concept map also consists of nodes and links. According to Novak (1990), the nodes (often circles) represent concepts while the links represent relationships between concepts. Words are used to more clearly show how concepts are related to one another (Anderson- Inman & Zeitz, 1994) whereas links between concepts are shown by the hierarchical structure in which the lower concepts are subsumed under the concepts that appear in the higher levels. A hierarchical concept map therefore, begins with the most general, main topic or key concept, at the top and proceeds downward to the least general, specific examples. An arrow is used to indicate the direction of a proposition (relationship) and where a cross-link connects branches. Figure 2 is a hierarchical concept map on Heredity.

A flowchart concept map refers to a drawing that uses symbols connected to each other with lines, to illustrate the flow of information in a process. It is also seen as a process flow diagram that shows the successive steps in a process, procedure, system or model. A flowchart concept map can be used to define and analyze a process, as well as, communicate complex ideas. It can also be used to produce a step-by-step picture of a process for analysis, discussion or communication. Again, a flowchart concept map enables the mapper to identify difficulties or inefficiencies where the process can be improved upon. Flowchart concept maps are characterized by symbols, namely elongated circles, rectangles and diamonds. Elongated circles indicate the starting point or end of a process; rectangles show instructions or actions while diamonds indicate decisions that must be made. Lines and arrows in a flowchart concept map show the sequence of the steps and the relationships among them. An example of a flowchart concept map on Photosynthesis is presented in Figure 3.

A systems concept map is a type of concept map that focuses on the illustration of key parts of a system and how the key parts affect, or are related to one another. Systems concept maps are used as an alternative way of teaching younger students, or when more structure is needed in the teaching or learning of a concept. In a systems concept map, information is organized in a format which is similar to a flowchart. A systems concept map on Human skeleton is shown in Figure 4.

In this chapter, the thesis statement includes the following: Engaging students with visual impairment in basic science and technology classrooms with concept mapping strategy, relevance of teaching basic science and technology to students with visual impairment with concept mapping strategy, implications of engaging students with visual impairment in basic science and technology using concept mapping strategy, conclusion and suggestions.

Engaging Students with Visual Impairment in Basic Science and Technology Classrooms with Concept Mapping Strategy

Students with visual impairment can be taught basic science and technology by engaging them in the organization of defined concepts and their defined characteristics through the use of different types of concept maps. To carry out this exercise effectively, the teacher first and foremost states the topic to be discussed and explains the purpose of the concept mapping activity. For instance, the concept of forms of energy can be effectively taught using a spider concept map. The teacher can emboss the spider concept map on a braille paper. The use of the spider concept map here engages both the teacher and student in brainstorming as they identify the unifying theme in the map at the center with the radiating concepts surrounding the center as shown in Figure 1.

To use hierarchical concept maps to teach basic science and technology effectively to students with visual impairment, the following steps have to be followed by the teacher:

1. Identify the domain of knowledge to be taught from the syllabus or scheme of work,
2. Identify the subject matter to be taught from a text, laboratory/hands-on activity,
3. State the key or general concept to be taught, for instance, Heredity,
4. List as many relevant subordinate concepts as possible (15 to about 20 concepts or "parking lot" of concepts) that apply to the specified domain or area of knowledge may suffice.
5. Rank order the list of relevant concepts, placing the most general and most inclusive concept for the particular problem of study or situation at the top of the list, and the least general, most specific concept at the bottom of the list.
6. Determine the hierarchies.
7. Construct a preliminary concept map on post-its (or on flash cards) and move the concepts around in a hierarchical manner on a raised diagram. Place the most inclusive concept at the top of the preliminary concept map and the least inclusive concept at the bottom during the exercise.
8. Use precise and appropriate linking words to join concepts on the preliminary concept map in such a way as to show how the concepts are related vertically.
9. Use cross-links to connect different domains of knowledge on the preliminary concept map (to show how the concepts are related horizontally).
10. Place concepts in ellipses or boxes and avoid having sentences and specific examples of concepts in ellipses/boxes.
11. Use arrows in a branching manner to indicate direction of relationship between concepts.
12. Revise the preliminary concept map several times until a good hierarchical concept map is produced, as there is nothing like a final concept map.

Partially completed hierarchical concept maps (or expert's skeletal concept maps) can be used to teach basic science and technology to students with visual impairment. The teacher can have the students individually, or in pairs, or small groups. The students are provided with copies of the expert's skeletal concept map on embossed braille papers. The skeletal concept maps can also be made on cardboard papers and students asked to complete them on the cardboard papers using small beads or pebbles with adhesives. They are also given a list of relevant concepts, linking words, and cross-links typed on braille papers. They are then asked to use the list provided to complete the skeletal concept maps. The purpose of the activity is to enable students with visual impairment who are not familiar with concept mapping learning strategy to organize key concepts, lower concepts and their relationships. The process also enables the teacher to find out how much prior knowledge the students have in their cognitive structures with regard to the major concept under study. Next, the teacher presents the model version of the concept map and leads the students in a discussion of the similarities and differences between the model version of the concept map and the students' own. Finally, the teacher evaluates the lesson and provides feedback to the students.

Another method of using concept mapping strategy for teaching students with visual impairment in basic science and technology instruction is involving the students in concept map construction/generation. The method is effective when students with visual impairment are already familiar with concept maps. In this method, students are made to practice how to organize key concepts, related concepts and their characteristics by producing concept maps. Here the teacher does the following as a facilitator:

1. Reads out clearly the major concept to be discussed,
2. Explains the purpose of the concept mapping activity,
3. Divides the students in pairs or small groups, with sighted students in each group,
4. Encourages the students to think of, and list all possible concepts that are related to the major concept, their characteristics and linking words/phrases on brail papers,
5. Asks students to construct their concept maps using the major concept, the identified lower concepts, characteristics, linking words/phrases and cross-links using a variety of resources from the local environment, such as beads of different sizes, grains, straws, adhesive and other relevant materials on cardboard paper, as raised diagrams
6. Evaluates students' concept maps and provides feedback to the students,
7. Provides the model version of the concept map using available relevant instructional materials,
8. Discusses the similarities and differences between students' versions of the concept map and the model version,
9. Summarizes the lesson and the concept mapping activity.

   Figure 5 shows a "parking lot of concepts" for constructing the hierarchical concept map on heredity.

Concept mapping technique can also be used in science and basic technology classrooms to enable students with visual impairment practice and test their comprehension of defined science concepts by answering essay questions. The practice also enables students to interpret concept maps.

Students can be made to work individually and can also be paired up or be divided into small groups. Completed concept maps on braille papers and teacher-constructed essay questions can be read out to them to braille. Next, students are directed to write answers to the questions using the information presented in the concept map. At the end of the exercise, students are made to present their questions and answers aloud to the members of the class. The presentations could be made individually or by group leaders as the case may be. The teacher encourages class discussion and criticisms of the presentations, scores the answers to students' questions from the discussion/criticisms and provides feedback to them. Finally, the teacher summarizes the lesson and the concept mapping activity.

Students with visual impairment can equally be taught how to take down notes with their sighted peers in many ways. A student who uses braille may use a slate and stylus, a braille writer or an electronic assistive device to take down notes. In this approach, the teacher explains that the purpose of the activity is to record key concepts, other related concepts and their characteristics. Teachers can verbalize what is in graphics or make a tactile diagram by raising the lines of the diagram to enable the students to see the image with their fingers. Students with low vision can use felt pens and bold-lined papers. Students are divided in pairs or small groups and provided with copies of blank concept maps. The teacher draws the blank concept maps, that is, a concept map with only the shell outlined. Students are then asked to fill in the concepts maps as the lesson progresses. Worksheets can made in large prints or braille, such as 18-point size using Arial. If students have access to assistive devices, worksheets and handouts can be emailed to them by the teacher for mapping activities ahead of a scheduled lesson

At the end of the lesson, the teacher evaluates the students' concept maps with emphasis on the areas of hierarchical organization, differentiation of concepts progressively from the top of the concept maps to the bottom, use of appropriate linking words/phrases, horizontal relationships using appropriate cross-links and use of specific examples. The teacher provides feedback to the students and finally summarizes the lesson and the concept mapping activity.

Power points and overhead projectors can also be employed to enhance concept mapping activity for students with partial low vision in basic science and technology classrooms. The approach facilitates meaningful learning of science concepts and reflective thinking. It captivates students' attention and makes them think of the next step in the mapping process. Key concepts, other related lower concepts, linking words/phrases and cross-links are prepared on slides or transparencies. They are then projected on a screen using powerpoint from a computer or overheads to construct concept maps. The key concept, other lower concepts, propositions and cross-links are presented one at a time on the screen. The text or domain from which the concept map was created is also presented.

When teaching with powerpoint or overheads, students can construct concept maps and take down notes with blank or partially completed (or expert's skeletal) concept maps. Students with visual impairment can be given clear verbal explanation by the teacher or sighted peer, then allowed to do mapping activities prior to class. They can also use copies of concept maps printed out from the computer to review the lesson or test their comprehension of the concepts taught by the teacher. A flowchart and systems concept maps can be used to teach the concepts of photosynthesis and human skeletal system respectively.

Relevance of teaching Basic Science and Technology to Students with Visual Impairment with concept mapping strategy

Individuals, whether visually impaired or not, have a right to education in all its ramifications. This is stipulated in the Right to Education Act of 2009 and the National Policy of Education (Federal Republic of Nigeria, 2014) that children should have access to education irrespective of their special abilities and disabilities. The philosophy of special education also points to the fact that every child deserves to be educated as a right no matter what. This is further reiterated by Ozoji (2003) referring to the philosophical basis of special education, that universal and basic education for every exceptional child irrespective of the severity of organ dysfunction or level of development or the precocity of intellectual performance. Visual impairment does not directly affect the cognitive capacity and functionality of an individual. However, restrictions which emanate from visual impairment may hinder the full growth and development of the cognitive capacity of an individual (Ozoji & Ozoji, 2015).This means that for visually impaired students, the issue of ineducability has no place, implying that, they should be taught all school subjects including science and technology. This is of vital importance, with the current emphasis globally on scientific literacy to enable individuals live effectively in today's knowledge-based and technologically driven society. A world that is controlled by the processes and products of science. Teaching basic science and technology to students with visual impairment is also a way of fulfilling their fundamental human rights (Eni-Olorunda & Oyudoyin, 2007). In other words, not teaching these students science and technology subjects amounts to denying them their fundamental human rights. The Nigerian Government also accorded a compulsory status to basic science and technology at the basic level of education. This means that all students without exception at the basic level of education must study this subject, as well as, pass it at the Basic Certificate Examination before proceeding to the senior secondary level of education. When students with visual impairment are taught science and technology, they learn basic science processes, integrated science processes and 21st century skills. They also acquire scientific attitudes which prepare them for effective living in the society. For effective teaching and learning of basic science and technology, the curriculum stipulates the use of activity-based and inquiry-oriented strategies. One of such strategies of teaching science that is both activity-based inquiry oriented as well as learner-centered is the concept mapping strategy.

Challenges of Teaching Basic Science and Technology to Children with Visual Impairment using Concept Mapping Strategy

Teaching basic science and technology to children with visual impairment is fraught with a lot of challenges. One of which is the nature of the subject, being practically-oriented and activity-based. This means that the students have to interact with, and manipulate concrete science materials, braille texts, drawing materials, note-taking devices among other objects in the course of instruction, for effective teaching, meaningful learning and in-depth understanding of science and technology concepts and principles. Teaching basic science and technology to this category of students, therefore, requires specific adaptations in teaching approaches, such as concept mapping strategy in addition to the use of specialized devices.

Despite the numerous benefits of concept mapping strategy in learning, many junior secondary school teachers do not know what the strategy is about (Edozie, 2006; Ozoji, 2011) and as such, cannot engage students with it as they cannot give what they do not have. It therefore becomes imperative for this category of teachers to undergo training and retraining through conferences and workshops on the use of innovative and effective strategies of teaching science and technology subjects. Such as concept mapping strategy.

There is the challenge of use of inappropriate linking words in constructing concept maps in science and technology which if not closely monitored, and, adequately supervised by the teacher could lead to ambiguity and misconceptions on the part of students with visual impairment. Another challenge is dealing with the erroneous opinion held by some individuals that students with visual impairment cannot study science and related subjects owing to their difficult nature and that the subjects are meant for bright students (Ozoji, Ozoji & Jurmang, 2017). This is a challenge and myth teachers have to correct in the cause of mapping, because experience has shown that visually impaired students have the capacity to learn school subjects as their peers that are not visually impaired when conducive and enabling environments for learning are provided. In other words, when the learning environment is conducive and enabling, excluding other impediments, students with visual impairment can achieve as well in science and technology as their peers elsewhere. This assertion agrees with the observation of (Kumar, Rasmussen and Stefanish, 2001) that students with visual impairment reflect the same spectrum of cognitive abilities as their peers without visual impairment.

Dearth of adequate braille texts, braille machines, calibrated glasses, raised diagrams, tactile calibrated laboratory equipment, talking textbooks, computers and transcription devices, scarcity and prohibitive costs of other relevant materials and assistive technologies. There is also the challenge of basic science and technology teachers who cannot read braille science books and science notations because of lack of training and experience in special needs education and the use of braille. Most of the students with visual impairment have unfavourable attitudes toward the study of science and its related subjects. They are either not motivated to study the subjects (Nanche & Ozoji, 2010) or have a negative self-concept of themselves (Ozoji, Ozoji & Jurmang, 2017).

There is also the challenge of dearth of personnel that have prerequisite knowledge and experience in the use of assistive technologies and science notations as observed by Ozoji and Babudoh (2012). Teachers can make science and technology more accessible and relevant to students with visual impairment through evidence-based adapted instruction if they can provide conducive learning environments and appropriate teaching equipment; engaging students in collaboration and specific adaptations in science classrooms and laboratories. Collaboration can be in the area of special needs teacher adapting textbooks, instructional materials, teaching strategies as well as modification of the science laboratories and technology workshops with the regular teacher. One of the activity-based and collaborative strategies is the concept mapping strategy.

Implications of Engaging Students with Visual Impairment in Basic Science and Technology using concept mapping strategy

Engaging students with visual impairment with concept mapping activities in basic science and technology will give them the opportunity to use this activity-based and learner-centered strategy of learning. If this is properly done, it will enkindle the interest of students in the study of science and technology subjects and if such interest is sustained, many students with visual impairment may go all out to study science and technology courses at higher levels of education. This therefore means the common objective of the sustainable development goals, the national policy on education and Education For All, centered on equality of education, and, the right to Education ACT of 2009 which stipulates that a child of the age six to 14 years shall have a right to free and compulsory education would be achieved.

Conclusion

Cutting edge strategies capable of improving teaching and learning of basic science and technology are barely employed in basic schools in Nigeria. In the light of the fore-going discussion, concept mapping strategy can be used for effective teaching of basic science and technology concepts, particularly, difficult ones to students with visual impairment. However, it is only when conducive and enabling learning environments are provided, with qualified and competent teachers, adequate accommodation and appropriate instructional materials among other prerequisites, that the concept mapping strategy can be effectively and meaningfully used to engage/ teach basic science and technology to students with visual impairment.

Suggestions

For meaningful and effective science and technology instruction to students with visual impairment, the following suggestions are provided:

1. Teachers should use cutting age tools and strategies such, as, concept mapping, activity-based strategies and assistive technologies to make understanding of basic science and technology concepts easier.

2. Teachers should supervise students with visual impairment closely during mapping activities to ensure that appropriate linking words are used to avoid ambiguity and misconceptions of science and technology
3. There should be provision of relevant interventions, including universal designs, accommodation and modifications in instructional materials in the resource room for effective teaching and learning of basic science and technology. Braille machines and braille papers, locally available materials, such as beads, grains, straws, etc. This therefore implies that the government at all levels should provide adequate funds for equipping schools with all it takes to have an effective and functional science and technology instruction for students with visual impairment.
4. Faculties of education in universities and colleges of education that train special educators should incorporate innovative teaching strategies, such as concept mapping strategy in their curricula to adequately prepare prospective teachers for effective teaching and learning of school subjects. The practice of having pre-service science teachers in such institutions register for courses in special education should be sustained. Concept mapping strategy should be used by teachers as an attitude change tool to change their unfavourable attitudes towards the study of science-related subjects.

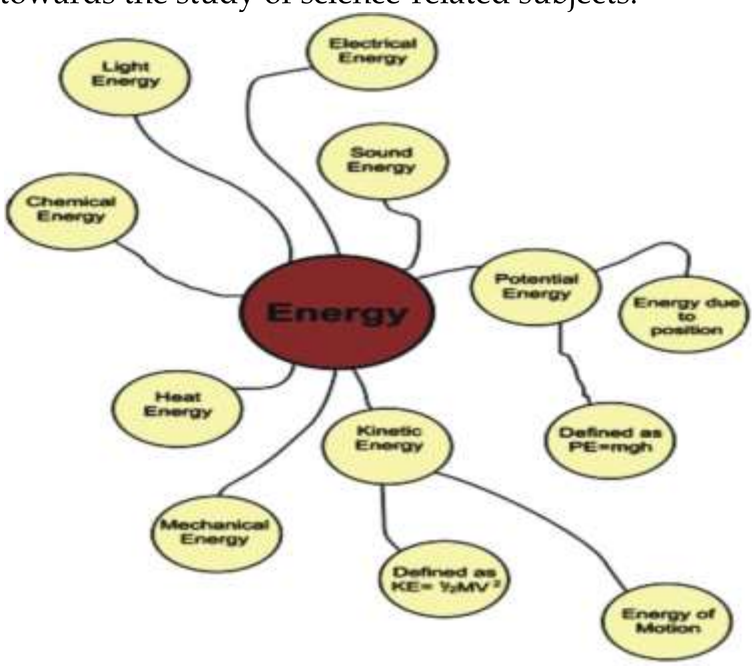

Fig. 1: An Example of a Spider Concept Map on Forms of Energy Produced by Ozoji Bernadette Ebele in 2010.

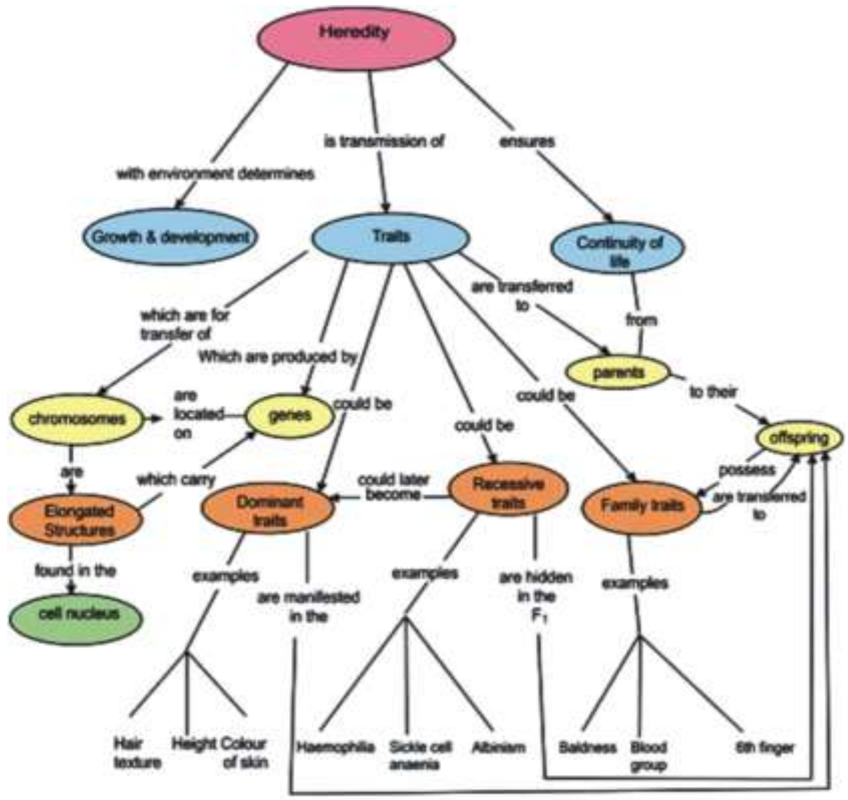

Fig 2: Example of a Hierarchical Concept Map on Heredity Constructed by Ozoji Bernadette Ebele in 2010.

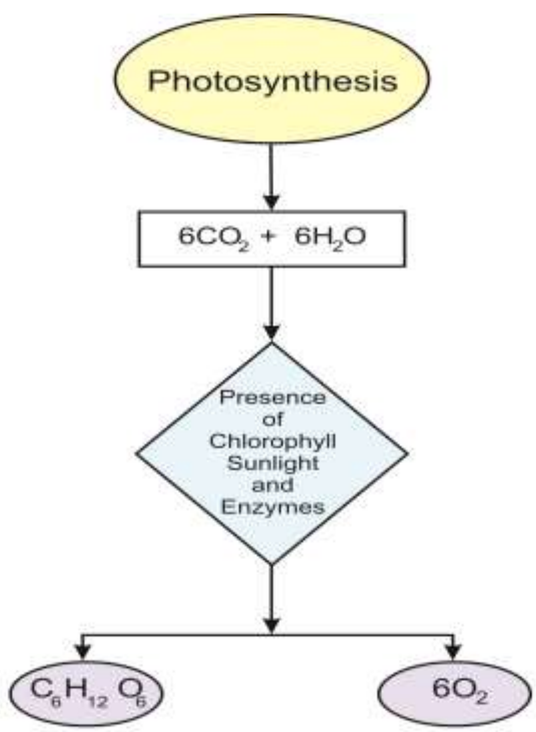

Fig. 3: An Example of a Flowchart Concept Map showing the Process of Photosynthesis. Produced by Ozoji Bernadette Ebele in 2010.

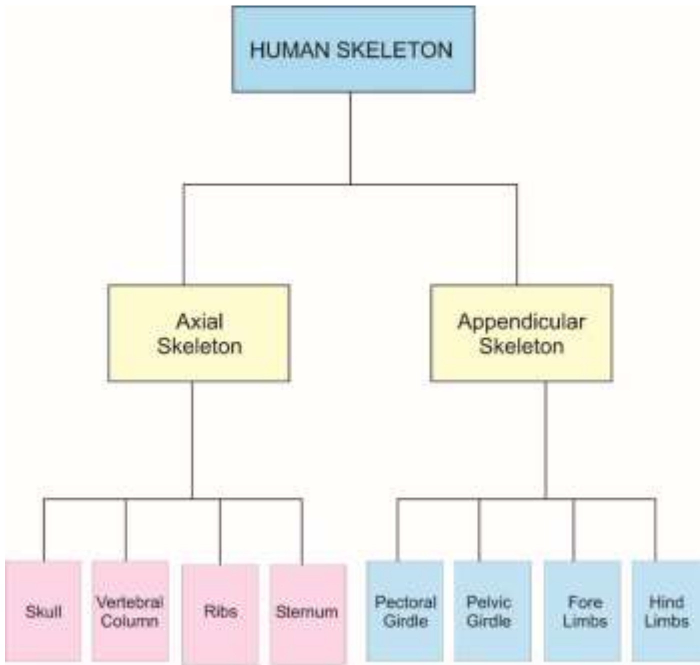

FIG. 4: An Example of a Systems Concept Map on Human Skeleton. Produced by Ozoji Bernadette Ebele in 2010

Heredity

Growth and development

Traits

Continuity of life

Chromosomes

Genes

Parents

Offspring

Elongated structures

Dominant traits

Recessive traits

Family traits

Cell nucleus

Hair texture

Height

Haemophilia

Sickle cell anaemia

Albinism

Baldness

Blood Group

Sixth Finger

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