



Design and Development of 3-Dimensional Model of Human Circulatory System to Teach a Concept of Biology in Senior Secondary Schools

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ABSTRACT

Instructional resources guarantee maximum value and effectiveness in the teaching and learning process. The instrument of instruction is communication which must be skillfully designed and developed if the objective of the instruction is to be accomplished. Models are a direct replica of real objects or figures. They are made in place of the original figure or object and used as such in place of the original. Inability to have access to mammalian internal organs is one of the challenges in teaching some concepts in Biology. Hence, we need to develop a 3-dimensional model of the human circulatory system to teach a concept in Biology. The findings revealed that the 3-dimensional automated model of the human circulatory system was successfully developed with materials sourced from the environment. Such materials include Plaster of Paris (POP), Top gum, White Cement, Car Paint (white), Acrylic Paint (Blue and Red), Tissue Paper, Binding Wire, Painting Brush, Silicon Gum, Sandpaper. This study recommended among others that management of secondary schools should make provision for the local 3-D model to be used as teaching aids for effective instructional delivery in their respective schools.

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1. INTRODUCTION

Instructional resources guarantee maximum value and effectiveness in the teaching and learning process. The instrument of instruction is communication which must be skillfully designed and developed if the objective of the instruction is to be accomplished. This requires the utilization of explicitly produced material used to make the process of instruction to be more pleasant and enjoyable. Materials that are utilized during the process of instruction to make instruction more meaningful and pleasurable are called instructional materials. Instructional Materials in its most straightforward term are those materials that help the Teachers to teach easily and the students to learn without pressure. Instructional Materials incorporate projected, non-projected, printed, and others, such as object/relic, 3-dimensional objects that are created through nearby source materials, program instruction, instructional package, and so on (Olumorin *et al.*, 2010).

Instructional materials are resources for transmitting information, ideas, and notes that can help in facilitating learning. They help in making students comprehend, retain, and recall concepts, principles or theories and acquire professional skills (Ogunlade & Amosa, 2015). The role of instructional materials if thoroughly considered cannot be completely detached from the teaching and learning process. For any meaningful educational program to be accomplished in terms of its implementation, the part of instructional materials must be given genuine need. Instructional materials perform such work as the expansion of the range of experience accessible to students, enhancement and complement the instructor's verbal explanations, therefore, making the learning experience richer and giving the teacher enthusiasm into a wide collection of learning exercises. To help the attainment of objectives of teaching a subject matter, it acts on the teacher to help his teaching with suitable instructional material that will empower him to accomplish his objectives and this improves the academic achievement of the students taught (Awolaju, 2016). Instructional materials are those materials that are purposely used to attain improvement in instruction. They are those materials and equipment utilized by the teacher during teaching to improve student's learning, capacity, and skills, to monitor their assimilation of information, and to add to their general advancement and upbringing.

A key component of successful teaching is the choice of instructional materials that address the issues of students and fit the limitations of the teaching and learning condition. A common statement that is true in teaching is that, if you have not learned, I have not instructed. A sensible end at that point is that the significance of instructional materials in educating and learning science is most successfully outlined through student accomplishment results. The teacher and student interactions in numerous scientific studies are not beneficial on account of adequate resources. The inquiry-focused science teaching showing requests a ton of exercises concerning the student that requires scientific materials and equipment (Omorogbe & Ewansiha, 2013). Availability of textbooks, laboratory apparatus, and other learning resources contribute significantly to the performance of students in science subjects.

Science education, which has a distinct place in the educational system with its content, consists of three main disciplines named biology, chemistry, and Physics. Being one of these three main disciplines, the science of Biology contains lots of abstract concepts that cause frequent problems in conceptual instruction in Biology lessons. Many students have difficulties in embodying abstract concepts therefore they also have difficulties in chemistry lessons that contain so many abstract concepts. Poor academic performance has been linked to several factors which include high teacher-student ratio, shortage of good teaching staff, poor quality of education leadership, political instability and politicization of educational

programs, automatic promotion, age of the learners, and inadequate essential physical facilities and equipment (Ewetan & Ewetan, 2015). Students' achievement in Biology in Senior Secondary Certificates Examination (SSCE) has been unsatisfactory over many years.

Various factors can influence students in academic performance whether negative or positive. The total of the problems arising from conducive environment, teacher qualification, adequacy, and professional development, remuneration and working conditions of teachers, inequality in the provision of teachers, monitoring and evaluation, the politicization of education, diversion of funds, and inadequate funds for equipment and materials for fruitful practical work; especially in view of large class size in most schools.

The circulatory system is an organ system that permits blood to circulate and transport nutrients (such as amino acids and electrolytes), oxygen, carbon dioxide, hormones, and blood cells to and from the cells in the body to provide nourishment and help in fighting diseases, stabilize temperature and pH, and maintain homeostasis. The circulatory system is one of the most important systems in the human body. It acts as a highway or delivery system that transports oxygen, water, and nutrients to all of your body cells. On the way back, it carries the wastes such as carbon dioxide. The delivery man, or carrier, of these substances, is blood. Blood vessels are the roads that circulate your entire body all leading back to the heart. The heart is a muscle that pumps blood throughout the body. The circulatory system aids in the ability of a human to carry out many life functions. First, it aids in the process of nutrition. Blood is the carrier of nutrients and brings them to the body cells providing the necessary energy for them to carry out life functions themselves. It also helps in the process of excretion by removing wastes from the cells to the blood and carrying them to tissues that can rid of them properly. This research was carried out with the aim of designing and developing a 3-dimensional model of the human circulatory system to teach biology concepts in high schools.

2. STATEMENT OF THE PROBLEM

Biology is a fundamental subject in sciences offered in senior secondary schools, it is an integral science subject that centers on the understanding of living things. It is a primary requirement that needs to be passed by students who want to study Biology related courses such as science, medicine, anatomy, agricultural science, microbiology, medicine, nursing, pharmacy, forestry, and fisheries in higher institutions of learning. Observed the factor that could be responsible for the failure of students in Biology as inadequate instructional materials which definitely must have a significant role to play in teaching and learning processes.

As classroom teachers, we must become conversant with the type of instructional materials, which can be used in any teaching/ learning situation. Instructional materials as it is said are synonymous with what we call 'teaching aids' here in Nigeria. Instructional materials constitute alternative channels of communication, which a teacher can use to convey more vividly instructional information to learners. They represent a range of materials that can be used to 'extend the range of vicarious experience' of learners in a teaching-learning situation (Amadioha, 2019).

Opined that lack of practical experience in the teaching and learning of science leading to poor mastery of important scientific skills and concepts. Other problems are the inability of teachers to diversify by using modern technology for teaching and learning (Muyoyeta *et al.*, 2017). To solve this problem, this study is a concern with the integration of technology for instruction in the classroom which would motivate students to learn and thereby making learning to real and concrete.

3. METHODOLOGY

This study, design, and production of a 3-dimensional model of the human circulatory system to teach a concept of biology in senior secondary schools was a production-oriented type of research. It involves the design and production of a model of the human circulatory system. This type is appropriate because it allows researchers to express themselves in terms of design and construction in the teaching and learning process.

The 3-dimensional model of the human circulatory system was designed and produced by us. Materials sourced from the environment were used to produce the model. Such materials include Plaster of Paris (POP), Top gum, White Cement, Car Paint (white), Acrylic Paint (Blue and Red), Tissue Paper, Binding Wire, Painting Brush, Silicon Gum, Sandpaper.

4. RESULTS

Production of the 3-dimensional model of human circulatory system centered on a material called "Papercrete". Papercrete is a medium most commonly utilized in the creation of Earthships. This is an alternative construction material constituted of Paper Pulp, Cement, Hardener, Top Bond, and Pop. The biggest advantage of papercrete is that it's lightweight but strong enough. It also has excellent insulating properties with an R-value of R2 per inch.

Design is a plan or drawing produced to show the look and function or workings of a project or other object before it is made (Shahid *et al.*, 2019; Husain *et al.*, 2023). The activity began with coming up with the idea and later proceeded to scriptwriting with a draft and sketch of the task and content coverage of the model. This gave definite directions to the researchers on how to effectively carry out those activities in the production stage. An armature was made as a framework around which the human circulatory system was built. The armature is made of iron, chicken net, and aluminum wire (which is stiff but was bent and twisted into the shape of the human circulatory system). The wire is affixed to a base that was also made of iron. Tissue Paper was soaked in water and then pulverized to a pulp using a bowl. Plaster of Paris (Pop), Hardener, Top bond was proportionally mixed using trowel and spatula. Together with the pulp, white cement was used as a binder in a smaller proportion than the paper pulp. At this stage, those actions in the designing stage were transmitted to concrete. Papercrete was used to mold the figure of the human circulatory system which require reinforcement materials that included an iron rod, banding wire, and chicken net to make the model stand solid on the base. Since the armature already forms the desired shape, papercrete was applied respectively. With the help of a spatula, researchers were able to plaster the armature with papercrete and shape it to the desired shape. The first layer lasted for about 20 minutes before we added another layer and also the final layer after which the model was left to dry for a period of two weeks. After which sandpaper was used as a smoother to smooth the surface of the model. This prepares the model for the painting stage.

This stage is known as the painting stage, the finished work was coated with white car paint. This was done to modify the surface property of the model such as abrasion, wear or corrosion resistance, and aesthetic quality. Acrylic paints (Red and Blue) were used for the finishing of the model. Acrylic paints are water-resistant when dry. Acrylic paint is one of the most versatile mediums, and one of the least toxic. It is water-soluble when wet and yet because it is a plastic polymer, dries into a flexible, water-resistant, and durable surface to which subsequent layers of paint can be added without disturbing the underlying layers. This was applied on the surface of the model to aid the actual resemblance of the human circulatory system. The labeling of the model was done on a flex banner after which stickers

were printed and pasted on the model according to the number on the flex banner. Detailed photograph images are shown in **Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11.**



Figure 1. Materials and tools for the production of the 3-dimensional model of human Circulatory system.



Figure 2. Materials and tools.

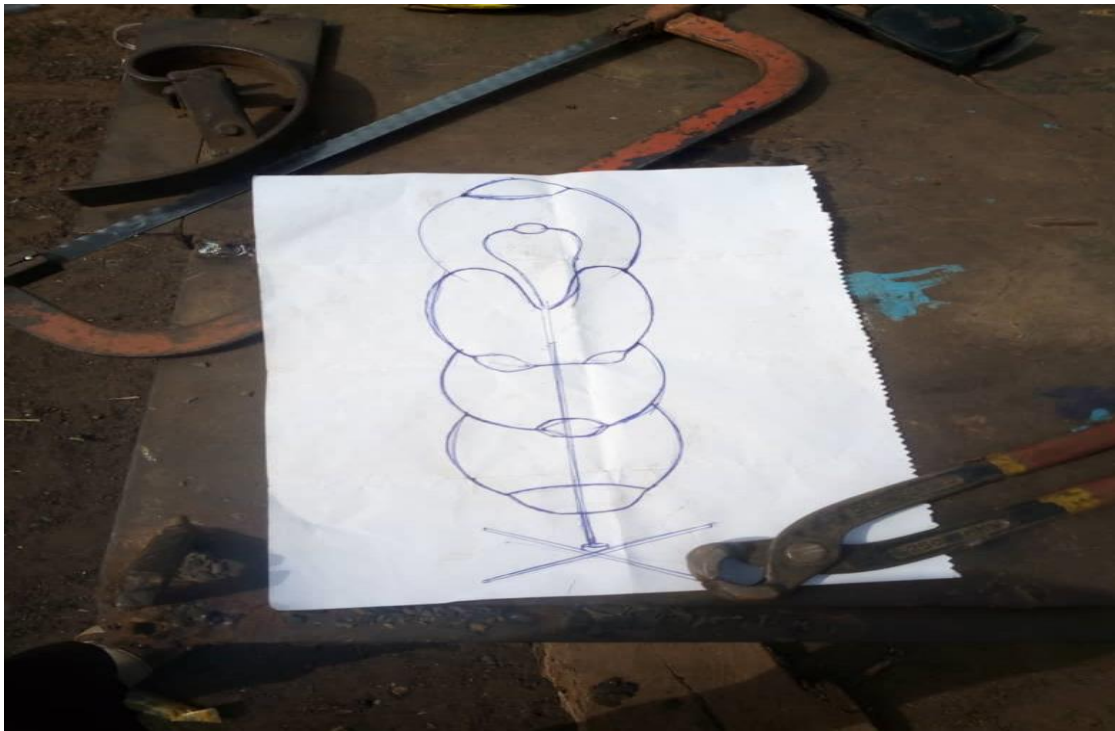


Figure 3. Sketch of human circulatory system.



Figure 4. Welding of the armature.



Figure 5. Armature (reinforcement).



Figure 6. Addictive stage.



Figure 7. Complete formwork before painting.



Figure 8. Coating with car paint.



Figure 9. Painting with acrylic in progress.



Figure 10. Complete painting with acrylic colour.



Figure 11. Finishing stage.

5. DISCUSSION

This study design and produce a 3-dimensional model of the human circulatory system to teach a concept of Biology. The 3-dimensional model of the human circulatory system is a direct replica image of the human circulatory system. The production was successfully done with materials sourced from the environment. Such materials include Plaster of Paris (POP), Top gum, White Cement, Car Paint (white), Acrylic Paint (Blue and Red), Tissue Paper, Binding Wire, Painting Brush, Silicon Gum, Sandpaper. The most important attribute of the 3-

dimensional model is making learning real, immediate, and permanent (Yoo *et al.*, 2017). The increase of students' participation in the learning activities that allow students to learn by observation and demonstration would have accounted for the better performance of students. Generally, the position of biology in the education of secondary school students is to allow the students to manipulate and experiment with suitable equipment and materials. This will prepare them for acquiring adequate laboratory and field skills in biology.

6. CONCLUSION

The instructional value of the 3-dimensional model has been established in this research. This is because students will perform better when been taught using 3-dimensional instructional materials. Teaching and learning could be enhanced when the teacher exposes learners through innovations in addition to conventional approaches of teacher-dominated classes. The use of a 3-dimensional model in teaching the human circulatory system is a step in this direction in which the students would be actively engaged in the instructional activity when taught using the developed 3-dimensional model of the human circulatory system. This study concluded that the developed 3-D model would improve students' performance on the topic Human Circulatory System.

7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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