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Full Length Review Paper

Dealing with biology students' fear of genetics: computer assisted instruction (CAI) to the rescue

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Abstract

The study reviewed students' fear for Genetics in Biology in Nigeria based. Personal observation of the reviewer and evidence from literature showed the traditional teaching strategies have low positive effect on students' understanding of Genetics. Also, the review showed that poor performance on questions bothering on Genetics has been severally attributed to Biology teachers' use of traditional lecture method which fails in communicating Genetics concepts effectively. This formed the basis of review. It was concluded that the Information and Communication Technology (ICT) packages could be used by teachers to assist in distilling students'' fear of Genetics and make teaching and learning more realistic and effective. It was recommended that Biology teachers should be trained and regularly retrained by the government on the utilization of ICT packages for instructional delivery in Biology.

Keywords: Biology, Genetics, CAI, Teaching methods.

INTRODUCTION

Genetics is the study of heredity and variation. It is the science which seeks to account for the resemblances and differences exhibited among organisms related by descent. Children inherit their biological parents' genes that express specific traits, such as some physical characteristics, natural talents and genetic disorders. Parents pass traits to their young ones through gene transmission and these genes are located on chromosomes and consist of DNA. Chromosomes contain specific instruction for protein synthesis (Tamarin, 2007). Genetics is one of the fields of Biology which basically deals with the study of genes, genetic variation, and heredity in living organisms. Genetics generally intersects frequently with many other life sciences and is strongly linked with the study of information systems. Historically, geneticists have worked in three different areas, each with its own particular problems, terminology, tools and organisms. These areas are classical genetics, molecular genetics and evolutionary genetics. Classical genetics concerned with the chromosomal theory of inheritance; that is, the concept that genes are located in linear fashion on chromosomes and the relative positions of genes can be determined by their frequency in offspring. Molecular genetics on the other hand is the study of the genetic materials: its structure replication and expression, as well as information emanating from the discoveries of recombinant DNA techniques. Evolutionary genetics deals with the mechanisms of evolutionary changes in gene frequencies in populations. Darwin's concept of evolution by natural selection finds a firm genetics footing in this area of the study of inheritance as in Table 1 (Tamarin, 2007).

Table 1: Features of Genetics classifications

Classical Genetics	Molecular Genetics	Evolutionary Genetics
Mendelian principles	Structure of DNA	Quantitative genetics
Meiosis and mitosis	Chemistry of DNA	Hardy-Weinberg equilibrium
Sex determination	Transcription	Assumption of equilibrium
Sex linkage	Translation	Evaluation
Chromosomal mapping	DNA cloning and Genomics	Speciation
Cytogenetic (chromosomal change)	Control of gene expression	
	DNA Mutation and Repair	
	Extra Chromosomal inheritance	

In Genetics, students learn about genes and their mode of transmission from generation to generation. Such knowledge helps students to understand problems of genetic nature rather than relying on superstition and other mystical explanations. Also, students learn accurate scientific ways of explaining the genetic defects that may be found in their families and communities. The teaching of Science in general and Biology in particular in schools enable students to acquire broad knowledge, skills and attitudes that would equip them to solve their personal and societal problems as they develop into adults. Thus, schools are meant to guide students to develop competencies for problem solving in the environment. Genetics is an important topic in Nigerian Secondary School Biology (SS III) curriculum. Global collaboration on Human Genome Project is evidence that international community has place importance on Genetics. The primary objective of Human Genome Project is the analysis of human genes in which mutation will lead to disease. The recommendations from Human Genome Project could promote advances in prevention, diagnosis, and provision of therapy of genetic disorders (Ishaku, 2015).

LANGUAGE AND COMMON MISCONCEPTIONS IN GENETICS: HISTORICAL PERSPECTIVE

Several investigators including Ramorogo and Wood-Robinson (1995) have shown that young people use their own intuitive ideas to explain some aspects of inheritance, even before they receive tuition on these subjects. And by the time a child receives formal science education, his/her preconceptions are already well established working theories, and problems arise when these 'naive' theories disagree with the presented science concepts in the classroom. These preconceptions then interfere with new learning and lead to the establishment of misconceptions or alternative conceptions and these can be very stable and highly resistant to change (Arnaudin and Mintzes, 1985; Fisher, 1985; Driver and Oldham, 1986; Driver and Bell, 1986). Obviously, these ideas, according to Wood-Robinson (1994), should be taken into account by teachers when planning and teaching; if they are not, and if they are erroneous, they can easily interfere with the acquisition of scientifically acceptable knowledge about Genetics. On the other hand, many misconceptions are formed in the way unscientific everyday language is used. Confusion is caused between the everyday uses and scientific meanings of words, for example: alive and animal, leading to the idea that inanimate objects which 'move' are alive and that animals are large land mammals or pets (Tamir et al., 1980). Other misconceptions can arise if the topic is completely new to the child because there are no prerequisite ideas to build upon, or if the cognitive demand of the topic is greater than the conceptual development of the child while it should be noted that many scientific concepts require abstract thinking (Lawson and Renner, 1975). Examples are photosynthesis, respiration, enzyme, mitosis and meiosis, gametes, alleles, and genes and genetic engineering (Yu-Chien, 2008). Inhelder and Piaget (1958) claim that students' ability to deal with abstract concepts in meaningful learning is correlated with their level of cognitive development. In relation to this view, Lawson and Renner (1975) reported that unless the students have reached the Piagetian level of formal operational thinking, they will not be able to cope adequately with these ideas. In view of this, Shayer and Adey (1981) posit that only some of fourteen-year-old students have reached this level, yet they need to be able to understand the concepts of mitosis and meiosis in order to comprehend topics such as Mendelian Genetics. Therefore, one can assume that students' difficulties in dealing with scientific ideas may originate in the abstract level of the

concepts as well as the students' cognitive developmental stages (Yu-Chien, 2008). In Genetics, many researchers have shown that students have serious misunderstandings, even after instruction concerning the basic scientific content related to biological inheritance. For instance, research has shown that students do not fully understand;

- Chromosomes, genes, or alleles (Collins and Stewart, 1989);
- They cannot adequately interpret some concepts such as homozygous or heterozygous (Slack and Stewart, 1990);
- They have alternative views of some processes such as mitosis and meiosis (Kindfield, 1994); and
- They do not understand the meanings of probability in relation to genotype and phenotype frequencies in offspring (Browning and Lehman, 1988).

According to Bahar et al., (1999), the complex nature of Genetics is another reason why Genetics is difficult to learn and teach. The structure of the knowledge of Genetics is complex and students have to use this complex knowledge in solving complex Genetics tasks (Collins and Stewart, 1989). In science education studies, many researchers have noted that, when concepts and processes in a subject belong simultaneously to several levels of organization, considerable difficulty is encountered when learning the subject (Bronsan, 1990). Genetics concepts refer to different levels of biological organization and students have difficulties with linking these different Genetics concepts and processes with these different levels. However, the levels of organization are mentioned differently by researchers in the different science disciplines (Marbach-Ad and Stavy, 2000). Analysis of the nature of Genetics leads to a realization that the complexity lies in the fact that the ideas and concepts inherent in them exist on four levels:

1. The macroscopic (organismal) level

This is the first level at which students can see, touch, smell and describes their properties. In other words, it is a tangible and visible level (Johnstone, 1991). Students can obtain a useful and long lasting learning experience when they deal with macroscopic phenomena at the organismal level. By manipulating an entire plant or animal, all their senses can be used in observation (Kapteijn, 1990).

2. **The microscopic (cellular) level**

This is the second level at which no direct experience is possible through touching objects and an attempt is made to give mental pictures explaining or describing what are observed or mentioned at the macroscopic level. The microscope is positioned between the object and the observer which make even visual observation considerably restricted (Marbach-Ad and Stavy, 2000).

3. The molecular (biochemical) level

This is the third level. Biochemical structures are not directly visible at all in living organisms. In Biology, students get a glimpse of organic molecules only by using indicators. If a substance is present, it will show itself through a colour, nothing more (Kapteijn, 1990). In fact, most molecular objects cannot be observed even indirectly, and must be imagined by students (Marbach-Ad and Stavy, 2000).

4. **Symbolic (representational) level**

This is the fourth level of thought in which the students try to represent observations by symbols, formulae, mathematical manipulations and drawing graphs (Johnstone, 1991).

According to Kapteijn (1990), the macro/micro perspective can be useful in Biology education and that concept formation at the cellular and biochemical level is important if we want students to learn and understand macroscopic phenomena. However, researchers who deal with the perception of concepts relating to different of organization generally note that the micro-levels (cellular and molecular) are more difficult to understand than the macroscopic level. It is reasonable to assume that the reason for this is, at least in part, that the micro-levels are generally taught in a theoretical manner. The processes and objects at these levels cannot be touched or directly observed and, in many cases, they cannot be easily extrapolated from observations at the macroscopic level. Nonetheless, students attempt to make such erroneous extrapolations and they make errors as a result. Genetics is connected with the occurrence of ideas and concepts on these different levels of thought. Observations of morphological characteristics of living things, such as colors of flowers or the height of humans takes place at the macroscopic level and are accessible to the senses. The appeal to cells, gametes, and nucleus, and chromosomes, DNA, genes and alleles to explain the macroscopic level takes students into the microscopic and molecular level, which is not directly accessible to the senses. These are then represented

and manipulated by mathematics (ratios and probabilities) which are symbolic (e.g. Aa represents an allele; a pair of gene) of what is happening at the microscopic and molecular level, and giving rise to the macroscopic level (Bahar et al., 1999). Some researchers think one of the reasons why Genetics is so difficult is because several levels of organization must be integrated in order to understand the processes underlying genetic phenomena and to grasp the overall picture of inheritance and Genetics. It means that to understand Genetics fully, it is necessary to experience all the above four levels. Thus, according to the information processing model, this may pose problems because the working memory has a limited capacity. Using several levels simultaneously is likely to bring about an information overload. Bahar *et al*. (1999a) suggested that, in teaching practice, teachers should confine themselves to one level at a time. Students have to develop this thinking on the different levels of thought gradually. Marbach-Ad and Stavy (2000) suggested starting on the macroscopic level and then microscopic level, molecular level and symbolic level, step by step. When dealing with the micro-levels and trying to link the macroscopic with the micro- levels, micro- levels with symbolic level, and even symbolic level with macroscopic level, it would help students for learning Genetics/Biology. Another reason for the difficulties encountered, both in understanding the micro- and symbolic levels and in connecting between levels, is either because sometimes one level (e.g. the macroscopic level) 'belongs' to one discipline (e.g. Biology), and the other level (e.g. the molecular level) 'belongs' to a different discipline (e.g. chemistry) or concepts from these different levels of Biology are dealt with in different chapters of textbooks (Yu-Chien, 2008). At one level, the importance of language in science education has always been recognized. In order to understand science topics especially in Biology in which Latin and Greek words are heavily used, students need to become familiar with a wide range of specialist vocabulary (Bahar, 1996). Language development and conceptual development are inextricably linked. Thought requires language, language requires thought. Viewed from a negative angle, difficulty with language causes difficulty with reasoning. However, though obviously important, this aspect of language is only part of the story. Understanding science is more than just 'knowing the meaning' of particular words and terms, it is about 'making meaning' through exploring how these words and terms relate to each other (Sutton, 1996). One of the biggest problems of language in science is the vast technical vocabulary with which students need to become familiar in order to be able to make sense of what they hear, read and have to use when writing in their lessons.

CONTRIBUTING FACTORS TO LEARNING DIFFICULTIES IN GENETICS

A study by Haambokoma (2007) and Adelana (2018) reported the followings as factors contributing to learning difficulties in Genetics:

1. **Inadequate explanation**

   Most students attributed their having difficulties in learning Genetics to teachers' inability to explain adequately during lessons. They further reported that the topic was not well presented to get the concepts. This is so because the teacher was not explaining well. Therefore, students do not get adequate and effective explanations necessary to enhance understanding.

2. **Topic not taught**

   Another reason given by students was that the topic was not taught to them at all. They also indicated that instead of being taught, they were required to read on their own from the given notes without any explanation. One teacher explained that some teachers themselves do not know the subject matter because in colleges the topic is either not taught or not properly taught to trainee teachers hence teachers tend to shun the topic when they go into schools for fear of embarrassing themselves in front of students.

3. **Speed of lesson presentation**

   The fast rate, at which some teachers presented lessons on Genetics was given by students as a reason for their finding it difficult to learn it. For example, students reported that the teacher was too fast while teaching the topic which made students not to grasp something reasonable from the lesson. In addition, the time allocated to the teaching and learning of Genetics was too short and this made it difficult to learn the topic well.

4. **Unfriendly teachers**

   In this respect, students stated that some teachers never liked to be asked questions by learners on issues students did not understand during the lesson. Hence, the unfriendly nature of the teacher made students not to ask questions.

5. **Scheduling of the topic**
   Teaching of Genetics, few weeks before writing the final year examination was given by most students as a factor which made it difficult for them to master the topic. Students reported that the topic was taught nearly at the end of the year when the examinations were around the corner and by that time most students had lost concentration to learn. Hence, the late introduction of the topic made them to lose concentration in it because they were busy preparing for their examinations. Some teachers also reported that Genetics is taught towards the end of the term when students are about to write their final examinations and do not have enough time to read and understand the concepts presented to them in Genetics.
6. **Negative attitude:** Students indicated that they had a belief that Genetics is a difficult topic and that this made them not to put any effort in learning the topic. Some students also have negative attitude towards Genetics because senior students commented that it was difficult. Some teachers also indicated that students had a perception that Genetics was a difficult topic to learn even before they were taught and therefore, never concentrated when they were being taught.
7. **Discouragement from teachers**
   Some students reported that some teachers were not encouraging when it comes to learning Genetics. Instead they were told that the topic was difficult.
8. **Poor mathematical knowledge**
   Another factor given by teachers for learners having difficulties in Genetics was their inability to carry out mathematical calculations involving probability. For example, one teacher who had been teaching Biology for 24 years reported that poor mathematical background of some students makes it difficult for them to change the four possible combinations to percentages.
9. **Lack of learning resources**
   Students cited lack of appropriate reading and learning materials as factors which contribute to learning difficulties in Genetics. Teachers observed that lack of teaching and learning aids such as video tapes, computer programmes, charts etc. to illustrate what was being taught was a hindrance to learning of Genetics.
10. **Lack of practical activities**
    Teachers cited the lack of practical activities as one of the factors students have difficulties understanding Genetics in that they were not actively involved in the learning process.
11. **Too many terms**
    Some students indicated that there were too many new and similar terms in the topic which confused them. They cited terms such as phenotype, genotype, heterozygous, homozygous, allele, alleles etc.

TEACHING AND LEARNING OF GENETICS

Genetics is considered to be one of the most difficult topics to teach and learn in Biology by teachers and students in many parts of the world (Chifwa, 2015). Students have a lot of misconceptions about Genetics which act as barriers to understanding the topic. Concepts in Genetics include many interrelated ideas and facts. To achieve meaningful understanding of Genetics, learners must actually relate the ideas and facts that make up the concept. And teachers must use relevant teaching methods. In expository lessons, the teacher connected ideas for the learners. The learning cycle is an inquiry based teaching strategy that divides the instruction into three phases: exploration, concept introduction and concept application. During exploration, the teacher provides learners with concrete experiences related to the content to be learned. The learners mentally examine ideas by brainstorming to identify what they already know. The teacher then introduces the concepts to the learners more explicitly. The teacher promotes a discussion period in which learners share their observations with peers. The teacher then links learner experiences with relevant scientific concepts. Then the learners engage in additional activities in which they apply their newly developed knowledge to new situations (Atay and Tekkaya, 2008).

Conventional Science Teaching Methods

Chifwa (2015) posits that in order for teachers to decide what teaching method to use, the teacher must know what teaching methods are available, what strengths and weaknesses these methods have, what purpose each method serves and how to use the methods. Teaching methods are chosen on the basis of fitness for a particular purpose. A number of factors determine what strategies a teacher should use to accomplish a given learning outcome. These factors may include age and academic level of students, amount of time available, physical environment, availability of teaching and learning resources as well as the topic being presented. Danjuma (2015) posits that for any meaningful learning and teaching to take place, there should be suitable means of presenting the content to the learners at all levels of education. The means or strategies of presenting the content to the learners depend on the familiarity with the basic principle of effective teaching method in science. Bichi (2009) states that the basic principles of effective pedagogy in science teaching include mastery of science contents, wise use of instructional methods, knowing the psychology of the students, teacher's knowledge about himself and conducive environment for learning. He further stated that basic principles to note are: the more child-centered a method is, the better is the learning outcome; the more teacher-centered a method is the less effective learning outcome is. A variety of teaching methods increase students' attention and interests and also help the teacher to manage the class well (Petty, 2009). Teaching methods on a continuum are lecture method, demonstration method, discussion method, project method, laboratory activity method, inquiry method, discovery method, process method, and problem solving.

1. **Demonstration method:** Muzumara (2008) defined a demonstration as a repetition of a series of planned activities which are designed to illustrate a certain phenomenon or event. Petty (2009) defined a demonstration as 'showing how'. Mohan (2010) agree that a demonstration method has several advantages that make it very useful in teaching biology as it allows learners to observe real objects and events, it helps in economizing resources, minimize risks and hazards associated with certain experiments among others advantages although a major disadvantage is limited learner participation and students do not develop manipulative skills.
2. **Project method**: The Project Method is a teaching approach which allows students to identify and choose a piece of work, topic or a problem to investigate. Here, students are allowed to go out to obtain relevant information for the purpose of the project. The Project method is entirely student-centred and students could either work individually or in groups. The teacher's role is to monitor how the project is being executed, give encouragement and offer assistance when necessary. At the end of the project, students are expected to write their report. It is important that students' reports are discussed in class. Since this method enables them to carry out an investigation on their own, it leads students to develop science process skills, stimulate the development of scientific attitude and of course facilitate meaningful learning of science (Danjuma, 2015).
3. **Inquiry method**: The Inquiry Method is seen by Author and Robert (1975), who identified three types of inquiry methods of teaching science. They are the teacher guided inquiry, the modified inquiry and the free inquiry. The teacher guided inquiry is a method of inquiry in which instruction is carried out through the teacher's guide. Some of the advantages of inquiry-orientated approach to teaching are, according to Author and Robert (1975), student-centred instruction because students carry out investigation themselves; students developing more interest in the lesson because they are actively involved; inquiry learning builds in students' self-concept, meaning that students are willing to take explore, tolerate minor failures and learn science.
4. **Guided discovery method**: The Guided Discovery Method is an approach in science teaching which was postulated by Brunner (1961). The approach enables students to get firsthand experience in getting facts, concepts, principles and processes by using mental process and manipulating scientific equipment and materials. Brunner believed that a child who is exposed to the guided discovery gets four benefits: a shift from extrinsic to intrinsic motivation, an increase in intellectual attainment, valuable to students' investigation processes and, serves as a memory aid. The Guided Discovery Method is applicable to virtually all areas of teaching and the types of activities in which the students are involved, vary from topic to topic and with the age and ability of the student. The amount of guidance the students receive from the

teacher also varies but is never excessive. The method encourages mental skills development of students as well as their observing, measuring, classifying ability among others (James, 2000).

5. **Problem-solving method**: The Problem-solving Method is an instructional strategy in which problems (scientific in nature or related to the real world) are carefully formulated and presented to students (Bichi, 2002). In the process of solving problems, students interact with one another using instructional materials and ultimately construct knowledge and acquire the process of science. The Problem-solving method is a way of helping students to see the personal relevance and the applicability of the science they learn. Problem-solving provides opportunities for students to work as scientists, investigating phenomena in a systematic way and finding solutions to scientific problems. Problem-solving promotes investigative thinking in children and it enables the learner to experience new ideas. Problem-solving process is interesting, challenging and therefore motivating (Oyedokun, 1998).
6. **Laboratory activity method**: The Laboratory Activity Method is an activity performed by an individual or group of students for the purpose of making personal observations or processes, products or events. It has been used in teaching science as a means of verifying principles, laws or theories; practicing one or more cognitive skills such as ability to observe, classify, measure, interpret data, etc. and, to determine the relationship between causes and effects, (Abdullahi, 1982).
7. **Discussion method**: Chifwa (2015) states that discussion method is one of the teaching methods used to teach science subjects. During classroom discussions, students learn how to express themselves clearly, to justify opinions and to tolerate different views. During discussions, learners also get a chance to ask for clarifications, examine their own thinking, evaluate ideas and put together personal viewpoints. This method enables learners to collaboratively construct their knowledge (Mohan, 2010; Davar, 2012). Discussion method is a two-way interaction method. To a large extent, it is student-centred since students participate actively. It increases curiosity about the subject, enhances a more positive perception of students about the value of the subject. To get information on what to contribute during discussion, students need to spend more time reading. Although the discussion method is effective, it could be time consuming and the classroom could appear noisy if not well moderated by the teacher (Bichi, 2009).
8. **Lecture method**: A lecture is oral presentations intended to present information or teach people about a particular subject. Lectures are used to convey critical information, history, background, theories and equations. According to Danjuma (2015), the lecture method is a teacher-centred method, which is seen as the traditional talk – chalk method of teaching. Here, teacher does the talking while students serve as receiver only by listening and taking down notes. In relation to Genetics, lecture method is only useful in introducing the topic to the students since they have little prior knowledge. This method promotes initial understanding of concepts and principles. However, for this method to be very effective it should be used together with other methods such as group work, pairing, practical work and role play (Chifwa, 2015). Lecture method is not suitable for slow learners and for students with language problems, it can be boring, the students are not actively involved in the lesson, the concentration span for students is short (Petty, 2009; Davar, 2012).

Non-conventional instructional design

Instructional Design (ID) also known as instructional system design (ISD) is the art and science of creating an instructional environment and materials that will bring the learner from the state of not being able to accomplish certain tasks to the state of being able to accomplish those tasks. The approach to instructional design is effective because it forces attention to what is going to be learned (learning objectives) and what must already be known prior to the learning transactions. Once the learning objectives have been identified, they are progressively sequenced from lower order to higher order learning (Lujara, 2008). Instructional systems design combines knowledge of educational theory and practice with appropriate technologies to enable learning. It involves choosing appropriate technologies and designing interactions that promote effective and efficient knowledge transfer. The effectiveness of any instructional material depends also upon an appropriate planning, hence the instruction has to be planned if it is to be effective and designed in some systematic way. The development of contents for e-Learning can well benefit from the instructional design approach. However, there is need to revisit the traditional instructional design in order to incorporate the Learning Object (LO) paradigm (Lujara, 2008). Various approaches can be used to make learning objects available over the web. The simplest

approach is to generate web pages containing these resources and make the web pages available through a web site for the course. The other approach is to use a full-fledged course management system such as a Learning Content Management System (LCMS).

1. Asynchronous mode: Asynchronous or self-study learning consists of content that is available online at any time that the student wants to access it. It is where communication, collaboration and learning can occur in different time and different place, and users can select when they wish to communicate. Based on the developed techniques of networking, asynchronous learning is split up into on-line and off-line status (Fang and Huang, 2006).

1.1 Off-line Learning: Computer-Aided Instruction (CAI) is a typical method of off-line learning. In general, the content of CAI — text, graphs, pictures, audio and video are stored in a CD-ROM. Recent product, a Digital Versatile Disk (DVD) is capable to store seven times more capacities than a CD-ROM. Therefore, these two kinds of disks are basic storage for off-line learning. In general, interactive response on off-line state is faster than on-line state. Once the contents have been stored, editing is not allowable. Hence, it is suitable to construct the core courses that are well developed fundamental curriculum.

1.2 On-line Learning: The content of on-line learning is built by the hypermedia technique, which is stored in the network computer server. Students can study or review the contents from the web site at any time. There are two types of data sources, the static type based on text, graphs and pictures combined as the auxiliary parts of the resources to provide the leaner a complete concept. The second is dynamic involve motion pictures, associated texts, matched sounds etc. The static resources require less bandwidth than the dynamic content; however, it lacks sense of reality that enables the learners get a whole picture of the subject. On the other hand, the latter type enables the learners to feel the sense of reality. Students would pay more attention on the subjects due to the colourful and diversified environment; hence the outcome is better than the former one. But, huge amount of data and slow transmission speed of the net are its weaknesses. Contents are allowed to renew at any time, therefore, it always remains up-to-date (Fang and Huang, 2006).

2. Synchronous mode: Synchronous learning is generally occurring in real-time with highly interactive and structurally dynamically characteristics, is led by the instructor. It allows people to interact with each other at the same time in different places, synchronous e- Learning imitates a classroom, which means classes take place in real-time and connect instructors and students via streaming audio or video or through a conference room. Synchronous learning requires the presence of both parties at the same time for the learning to take place. Therefore, it is also referred to as live or real-time interaction (Harriman, 2005). Discussion between students and instructor is ongoing in real time via the system equipment. Instructor and students may not meet each other face-to-face. Moreover, the common source of content is distributed to learners at the same time in different places, that avoiding repetition work of the lecture. The environment is named Videoconference Classroom. Although it has several advantages, steady and wide bandwidth network configuration is absolutely needed. The most important advantages of synchronous learning are immediate feedbacks and more motivation and obligation to be present and participate (Harriman, 2005).

3. Blended Learning: Blended learning also called hybrid learning. It is the mixing and integration of different learning delivery approaches including classroom and e-Learning to create a single learning programme. To complement traditional methods of delivery, e-Learning is often being used in a blended manner. With blended learning, technology-delivered learning and the classroom come together to generate the best possible offering. Past patterns suggest that the likely future will be neither solely depend on online learning nor solely depend on instructor-led classroom learning. It appears that the hybrid or blended models most frequently emerge as the most effective learning strategies. Determining the right blend of technology-delivered and classroom-based learning is almost like perfecting a recipe (Lukaja, 2008).

COMPUTER ASSISTED INSTRUCTION (CAI) AND BIOLOGY EDUCATION

The use of information and communication technology (ICT) is becoming an integral part of Education in many parts of the globe and Nigeria is not left behind as ICT gradually finds its way into the Educational systems despite chronic limitations brought about by economic disadvantages. Globally, solutions to existing problems have been a trend in instructional activities. Efforts are therefore necessary to find solutions to the numerous problems encountered in teaching and learning processes (Anunobi et al., 2017). In the quest of seeking for

systemic solutions to students learning problems, the use of ICT tools has been of help, hence, new educational technologies such as game-based learning, mobile learning, web-based instruction, among others could shift the teacher-centered and learning environment to a student-centered environment that is more beneficial (Association for Educational Communications and Technology, AECT, 2007). Generally, several researchers admitted that ICT have an impact in learning and teaching of science (Adeyemo, 2010). Fakomogbon, Shittu, Omiola and Morakinyo (2012) conducted a study on design, development and validation of a web-based instructional package for teaching concepts in basic technology for junior secondary school students in Nigeria. The results revealed that comments received from experts and student representatives confirmed that the content, navigation mode, interactivity, structure, colour used and authoring tools used were relevant and it was of good quality for the intended users. Also, Özkök (2013) conducted a study designed to test the validity and reliability of the Web-based Learning Environment Instrument (WEBLEI). The findings revealed that the WEBLEI is valid and also a reliable measure of students' perceived web-based learning environments traits. Similarly, Thongmee, Ruangsuwan, and Terdtoon (2015) conducted a study on development of web-based learning environment model to enhance cognitive skills for undergraduate students in the field of electrical engineering. The results of model implementation efficiency revealed that students who studied by using the developed web-based learning environment model received pre-and post-points of – achievement (52.37 and 92.40%). It was assumed that the web-based learning environment model had its quality at the highest level and could be used as a pedagogical tool for undergraduate students. Laleye (2016) carried out a study on development and validation of a computer-assisted instructional package for learning Basic Science in Nigeria. The overall reaction from the validating team revealed that the developed package (CAIP) is valuable for learning physics concept in Basic science. Specifically, it has been shown that the introduction of ICT in Biology lessons can raise not only level of knowledge but students' attitudes toward Biology as well (Kubiatko and Halakova, 2009). Hence, many science teachers, educators, and researchers have proposed to employ CAI in Biology teaching. For instance, during the implementation of the teaching unit *Eye sight and sense* to students, Katircioglu and Kazanci (2003) monitored the effectiveness of the group performing individual work with a programmed multimedia presentation and the group with teacher's help in addition to slide show compared to the control group. The results of this study showed that students in the experimental groups achieved significantly greater success than the students from the control group. Çepni (2006) investigated the effects of the Computer-Assisted Instruction Material (CAIM) related to the topic *Photosynthesis* on students' cognitive domain levels (knowledge, comprehension and application). The results of the research showed that the overall success of students in the CAI group in the overall achievement test was significantly higher in comparison to the success of students from the traditional group. Analyzing the success of students on individual cognitive domains, it was found that both groups gained about the same number of points at the level of knowing the facts, while in the domains of understanding and application of knowledge, students from the CAI group achieved significantly better results compared to the students from the control group. Yusuf and Afolabi (2010) investigated the effects of Individualized Computer Assisted Instruction (ICAI) and Cooperative Computer Assisted Instruction (CCAI) on secondary school students' performance in Biology compared to Conventional Instruction (CI) in the topics *Food chain, food web, energy flow, nutrient, movement, and pyramid of numbers*. It was found that the performance of students exposed to ICAI either individually or cooperatively was significantly better than the performance of their counterparts exposed to other CI. Comparing the efficiency of ICAI and CCAI, significantly higher achievement of students was accomplished with CCAI method. Furthermore, Efe and Efe (2011) examined the effectiveness of CAI compared to the traditional teaching in the implementation of *A Cell* teaching topic in the first grade of secondary school. The students who were taught by CAI software which contained a large number of simulations were more successful in solving problems in six cognitive domains. The authors emphasized that students should be enabled to learn the contents by using this type of software given they use visualization in order to easier understand the structure of cells, the function of various cell organelles, cell division, transport of oxygen, food and water through the cell membrane, active and passive transport, membrane potential. In addition, Hancer and Tüzeman (2008), also found that CAI is more efficient than the traditional methods concerning the increase of academic achievement of students in the realization of lessons. Terzić and Miljanović (2009) examined the effectiveness of computer-assisted learning in Biology teaching and the effectiveness of cooperatively applied

multimedia application in Biology teaching. The results of their research showed that the use of computers in Biology teaching was much more efficient than traditional teaching in terms of quality, durability and applicability of knowledge. However, as pointed out by Vera, Tomka and Tijana (2013), citing Hancer and Tüzeman (2008), not all biological contents are appropriate for implementing the CAI application. This has been confirmed by many studies that examine the effectiveness of CAI over the traditional teaching models in the implementation of various biological contents. In addition, CAI application in Biology teaching is little known in most countries. Possible reasons for that include the lack of computer equipment on Biology in most schools, a small amount of published educational software, and insufficient training of Biology teachers for using computers in teaching (Drakulić, Miljanović and Ševkušić, 2011; Terzić and Miljanović, 2009). Many studies have indicated that there is a strong relationship between the use of computers and students' academic achievements in teaching and learning processes (Danjuma, 2015). Computer Assisted Instruction (CAI) was found to be as effective as classroom instruction for fact-based learning, but not as effective for topics requiring critical thinking or mathematical problem-solving. In addition, the time required by learners to use CAI was overall higher than conventional classroom instruction. Similarly, Owusu (2009) reported that comparisons between low-achieving and high-achieving students show that CAI was more effective with lower-achieving students than with higher-achieving ones. She indicated that the greater benefits experienced by lower-achieving students were largely due to the need these groups had for elements common to the majority of CAI programme-extensive drill and practice, privacy, and immediate feedback and reinforcement.

CONCLUSION AND RECOMMENDATIONS

The review has shown that the use of computer Assisted Instruction (CAI) is effective for aiding students' learning of Genetics while the teacher acts as a facilitator. This goes to confirm the effectiveness of some other computer assisted packages which are designed to assist instructional delivery or for individualized study of Genetics in Biology. The followings are suggested that Biology teachers should be trained and regularly retrained by the government or concerned agencies in Nigeria on the usage of computer assisted instructional packages (CAI) for supporting instructional delivery in Genetics. Also, since the utilization of CAI by students need teachers as facilitators in and outside the classroom, hence, Biology teachers should be trained on becoming effective and efficient facilitators of CAI products for better students' coordination.

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