COMPUTER SIMULATION AND DIGITAL PUZZLE PACKAGES AS DETERMINANTS OF STUDENTS' LEARNING OUTCOMES IN ECOLOGY AND GENETICS IN SENIOR SECONDARY SCHOOLS IN OYO STATE

BY

OLUBUKOLA JOYCE, OLUMIDE
NCE (ACE, Ondo); B.Sc. (Ed) (ACE, Ondo), M.sc (U.I)
MATRIC NO.: 161340

A Thesis in the Department of Science and Technology Education, Submitted to the Faculty of Education In partial fulfillment of the requirements for the award of the Degree of

DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN.

February, 2019

ABSTRACT

Ecology and genetics are taught in Senior Secondary Schools (SSS) Biology to equip students with the knowledge for addressing environmental and hereditary health challenges. Reports on SSS students' achievement in external examinations in biology revealed that students exhibited poor outcomes in these areas. These have been attributed to the method of instruction used by biology teachers. Previous studies largely focused on factors influencing students' achievement in ecology and genetics with little consideration for computer-assisted eclectic approach that promote students' active participation. This study, therefore, was carried out to determine the effects of computer simulation and digital puzzle packages on students' learning outcomes (achievement, problem solving skills and attitude) in ecology and genetics in SSS in Oyo State, Nigeria. The moderating effects of self efficacy and mental ability were also examined.

The study was anchored on Kolb's Experiential and Lev Vygotsky's socio-cognitive learning theories, while the pretest-posttest control group quasi-experimental design with a 4x3x2 factorial matrix was adopted. Four Local Government Areas (LGAs) were randomly selected and eight schools (two per LGA) were purposively selected based on the presence of a functional computer laboratory. Eight intact Biology classes were randomly selected from SSS II. The schools were randomly assigned to conventional method (92), computer simulation (92), digital puzzle (93) and computer simulation and digital puzzle (94) packages. Treatment lasted eight weeks. Instruments used were Students' Achievement in Ecology and Genetics (r=0.80), Students Problem Solving (r=0.83) and Mental Ability (r =0.85) tests, Students' Attitude to Ecology and Genetics (r=0.79) and Students' Self-efficacy (r=0.80) scales and instructional guides. Data was analysed using Analysis of covariance and Scheffe post-hoc test at 0.05 level of significance.

There were significant main effects of treatment on students' achievement ($F_{(3, 346)}=447.59$; partial $\eta^2=0.80$), problem solving skills ($F_{3,346)}=836.57$; partial $\eta^2=0.88$) and attitude to ecology and genetics concepts ($F_{(3,346)}=327.26$; partial $\eta^2=0.74$). Participants in computer simulation had the highest adjusted post achievement mean score (27.77), followed by computer simulation and digital puzzle (27.41) and digital puzzle (26.72), while the conventional method group had the least adjusted post achievement mean scores (10.69). Participants in computer simulation and digital puzzle had the highest adjusted post problem solving skills mean score (26.62) followed by the digital puzzle (25.80) and computer simulation (25.66), while the conventional method group had the least adjusted post problem solving skills mean score (9.85). Participants in the digital puzzle group had the highest adjusted post attitude mean score (58.07), followed by the computer simulation (55.69) and computer simulation and digital puzzle (54.36), while the conventional method group had the least adjusted post attitude mean score (26.77). There were no significant main effects of mental ability and self-efficacy on students' learning outcomes in ecology and genetics concepts. The two- way and three- way interaction effects were not significant.

Computer simulation and digital puzzle instructional packages are viable aids, the combination of these packages enhanced students' learning outcomes in ecology and genetics in senior secondary schools in Oyo State, Nigeria. Therefore, these packages should be adopted more in teaching biology.

Keywords: Computer simulation and digital puzzle instructional packages, Ecology and genetics concepts, Problem solving skills, Students' attitude to ecology and genetics.

Words count: 499

CERTIFICATION

I certify that this work was carried out by **Olumide Olubukola Joyce**, with **Matric. No. 161340,** under my supervision in the Department of Science and Technology, Faculty of Education, University of Ibadan.

..

Supervisor

Prof. A. M. Olagunju

B.Sc (Ife), M.Ed, Ph.D (Ibadan)

DEDICATION

To the source of my strength and inspiration,
JEHOVAH ELOHIM,
To the memory of my loving husband,
Pastor Ajibayo Olumide
To my boys,
Oluwaseunayofunmi Olumide
And
Ayobami Olumide
I love you dearly

ACKNOWLEDGEMENT

I am eternally grateful to Jehovah Elohim, my inspiration and strength, for His faithfulness. He initiated this project and oversees it to completion.

My profound gratitude goes to my Supervisor, Professor Alice Morenike Olagunju, who not only painstakingly supervised this work; she mothered me all through the period of my training. You are a rare gem.

I sincerely appreciate my amiable lecturers in the Department of Science and Technology, University of Ibadan. Dr. T. Ige, Dr. Tella, Dr. Ukoh, Dr. Akinyemi, Dr. Abimbade who were ever ready to assist in ensuring the successful completion of this work.

I deeply thank my brother, Mr. Wole Ojomo for your unflinching support all through the period of the training. Jehovah is your exceeding great reward.

I cannot but mention my foster family, the Olorunfemis. Thank you for always being there for me.

I am also indebted to my Provost, Prof. Olukoya Ogen for his timely encouragements. I am immensely grateful sir. To my sign and wonder, Oluwaseunayofunmi and Ayobami, turned my supporting club, cheering and urging me on, thank you. I love you dearly. To my Pastor, Bishop Adeniji, all my friends and colleagues at work, I say a big thank you. You mean so much to me.

God bless you all real good.

TABLE OF CONTENTS

LIST OF TABLES

Tables **Pages**

LIST OF FIGURES

Figures **Pages**

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Biology, a science of life, deals with the characteristics of living things, their forms and functions, as well as their relationship with one another and with their environment. It is a subject that engages the students in diverse process skills, such as organizing information, designing experiments, observing, interpreting, clarifying, predicting events and reporting adequately. One of the primary reasons why Biology is taught is to enable students to comprehend biological ideas, laws, principles and theories.

Federal Ministry of Education (2013) lists the following objectives of Biology in its curriculum : to aid the comprehension of the function and structure of lively things as well as to appreciate nature; acquire appropriate field and laboratory trainings: enable performance and evaluation of experiments and projects in Biology; acquire important skills in science, such as observing, classifying, analysing and explaining collected data in biology; acquire vast comprehension of biological concepts that are useful for further studies in biological science; possess scientific orientation that proffers solutions to problems in Biology; and develop ability to bring in principles in Biology to issues affecting individual, community, environmental, societal health and financial status.

Achieving these aims demand exposing the students to teaching that will enhance the understanding and mastery of all the topics. Biology is one of the basic subjects for various applied areas of studies that contribute to the growth of the nation technologically. These fields include biotechnology, nursing, pharmacy, physiology, physiotherapy and medicine. Science and technology in general determine, to a large extent, the level individual growth and advancement of nation.

Students' performance in Biology in Oyo State for May/June WASSCE for the period between 2008 and 2015, revealed a worrisome decline. This situation is particularly discouraging in view of the fact that majority of the students offer Biology. The subject may be their last formal exposure to science.

Table 1.1: Oyo State Entry and Result Statistics for May/June WASSCE for 2008-2016

Year	No of Candidate	No and % of A to B3		No and % of C4 to C6		No and % of D7 to E8		No and % of F9	
		No	%	No	%	No	%	No	%
2008	30,005	831	2.76	5,317	17.68	10,573	35.18	13,334	44.38
2009	24,904	263	1.06	2,709	10.88	4,532	26.19	17,401	61.87
2010	41,845	866	2.31	9,497	22.69	8773	24.71	21,047	50.29
2011	45,970	516	0.62	6,236	13.57	11,362	19.68	38,375	66.13
2012	43,164	588	1.35	6,586	15.25	2,711	6.28	33,867	77.12
2013	74,670	2,567	3.48	24,153	32.80	19,532	26.53	29,147	37.19
2014	24098	413	1.7	5679	23.57	7600	31.54	10406	43.19
2015	19371	519	2.7	5418	27.97	5984	30.89	7450	38.44
2016	27,426	523	1.91	5527	20.38	5,722	20.54	15654	57.17

Source: Ministry of Education Oyo State, Ibadan

From Table 1.1, it is obvious that the percentage of pass at credit level is generally too low in public senior secondary schools in Oyo State. Although the enrolment for Biology was higher than that for other science subjects, Biology recorded very poor achievement in Senior School Certificate Examination. Based on this analysis, it may be difficult for candidates to gain admission to higher institution, if they wish to study Biology-related courses.

The Biology curriculum for 2009 (NERCD 2009) has only four themes: Organisation of life, The Organism at work, The Organism and its environment and Continuity of life. Ecological concepts are infused into the theme “Organism and its Environment”, while genetics is a topic under the theme “Continuity of life”. Themes under Environmental Education Concepts (like Ecosystem, Pollution, Conservation methods and Population) and concepts in genetics (like heredity, variation, alleles, dominance, recessive genes, transmittable characters, genes, chromosomes, laws of inheritance) are in the West Africa Senior Certificate Examination (WASSCE) and National Examination Council (NECO) Senior School Certificate Examination syllabuses (Obioma, 2007). Ecology and Genetics cover two out of the four themes of the Biology curriculum. A large proportion of the questions in the examinations are grouped under these concepts.

Genetics is often considered to be at the forefront of all modern science because of the level of difficulty students and teachers experience in learning and teaching the concepts. Understanding its importance gives one an in-depth knowledge of the human nature and that of organisms surrounding human. The knowledge of genetics has been considered useful from the inception of civilization, when people applied genetic principles to work on the production of food crops used for domestic purposes (such as guinea corn, millet and sorghum) and in-kept animals. The genetic knowledge when applied to plant and animals results in the development of species that are resistant to diseases and pests, and production of healthful and nutritious harvest. Application of genetics is found to be helpful in areas such as human health and medical care. Pharmacists today consider the roles of normal genes and defective genes in manufacturing pills, intending to provide the best and safest drugs for curing sicknesses. This is achieved through considering the genetic settings of the patient. Pharmaceutical industries have recorded significant success since the discovery and application of genetics into its practices. All over the world today, people facing chronic genetic health challenges are about 5% of the population. Some of the diseases that are found to have genetic origin include asthma, forms of cardiovascular disorder, diabetes and hypertension.. At the International Congress of Genetics, Tony Griffa recommended that students should learn Biology concepts and principles and apply them creatively in novel situation. This is in view of the emphasis on acquisition of knowledge which is the lowest of Bloom's taxonomy of education objectives. Higher levels of cognitive functioning (comprehension, application, analysis e.t.c) are seldom achieved. The Chief Examiners' report (2007- 2017) showed that students perform poorly in these areas in Biology

Afforestation, pollution, conservation techniques and population are some topics under ecology in the Senior School Certificate Examinations (SSCE)/National Examinations Council (NECO) Senior School Certificate Examinations syllabuses (Obioma, 2007). The utility of ecological concepts in Biology has made it an important topic. Ecology is that branch of Biology that focuses on the study of association between plants, animals and their surroundings.. Ige (2001), cited in Ogundiwin (2014), states that the study of ecology enables students to understand the processes of change brought about as a result of the interaction of living things and the influence on the physical environment. Through the study of ecology, students are able to discover some of the most important ecological issues affecting the environment and how to prevent them. These include how human activities disrupt ecological relationship, the challenges they encounter as they discharge their daily activities and the significance of ecological concepts in scientific advancement that affects the lives of mankind. Ecology is an aspect of science that is dynamic and relatively young.

WAEC Chief Examiner's Reports (2010; 2011 and 2012) show that the senior secondary school Biology students had major problems that border on lack of metacognitive skills, which led to the poor performance of students in the areas of ecology and genetics (Umoke and Nwafor, 2014). Some of them are textbook- and laboratory-based reasons (Ivowi, 2000); inability of the secondary school students to recognize most of the laboratory apparatus relating to ecology and genetics they could not identify in what experiment each is used (Saat, 2004; Aydogdu and Kesercioglu, 2005); misconceptions of concepts identified (Olagunju and Abiona, 2004;

D'Avanzo, 2008); large class size (Olagunju, 2005); the structure of the curriculum; concentrating the examination questions on few topics different from ecology and genetics (Garba, 2009); inadequacy of teaching material/ resources, laboratory equipment /reagents/chemical, and laboratory space (Aremu and Sangodoyin,2010);and insufficient practical skills (Danmole, 2012). The reasons given in the Chief Examiner's Reports for the poor performance in the years 2003-2013 are wrong spelling of labels and technical terms in ecology and genetics, non-adherence to rubrics, shallow knowledge of the concepts, inability of the students to express themselves in correct vocabulary and inability to clearly describe the experimental steps involved in ecology and genetics (Chief Examiner's Report WASSCE, 2012).

The poor achievement in ecological concept, as observed by Oyeleke (2011), reflected in the wrong answers given to ecological questions asked in WAEC examination in 2007, for example on five importance of water to organisms in the rainforest. Chief Examiner's Report (2007) further reveals that some candidates wrote answers like "cooking, drinking and washing," instead of maintaining body temperature, essential for plant turgidity, and necessary for photosynthesis. Also students were asked to mention briefly three adaptive measures of arid animals to drought and high temperature. The report showed that the students' answers were wrong. Ayanda (2006), while citing from WAEC Chief Examiner's reports, maintains that students' knowledge of genetics concept in Biology was poor despite the fact that several crucial efforts have continually been made over the years to remedy the yearly poor performance and also improve students' performance. WAEC Chief Examiner's Report revealed that, in 2009, students did not answer question 4d, on genetics correctly. The question reads: "Explain in details these terms: Co-dominance, Sex-linked characters, Hybrid vigour

Many students were not aware that the sex-linked genes are borne on the X-chromosome. Co-dominance was an ambiguous word for the students. Some of them felt co-dominance was another term for recessive gene. Hybrid vigour was misplaced for hybridization. The WAEC Chief Examiner's Report in 2011 revealed that Question 3a on using the thermodynamics' second law to explain the energy flow level across difference trophic levels in a food chain was poorly answered by the candidates. Most of them could neither state the law nor relate it to food chain. The calculations on genetics in Question 4 of 2014 WASC Examination proved difficult for the candidates to solve, according to the Chief Examiner's Report.

In view of the foregoing, Adegbile (2002) and Oyeleke (2011) noted that teachers who wish to produce students who are versed in ecological concept knowledge and can achieve conceptual comprehension need to employ metacognitive teaching strategies.

The problem-solving ability of students is a contributary factor to the poor performance in Biology. This can be traced to their inability to manage resources sufficiently within the period earmarked for the study. A recent study conducted by Ogundiwin and Ahmed (2015) on senior secondary school students' skills in problem-solving in ecology revealed that many students face difficulties in understanding many aspects of school Biology, because of their poor problem-solving skills and the teaching strategies employed by the teachers. Raimi (2003) argues that exposure to practicals help develop competence in specific skills needed by students to perform specific roles in life task.

Furthermore, the introduction of practical in the normal setting of teaching and learning processes helps students to develop the problem-solving ability. This is because they provide the students the required opportunity to experience and build a feeling and interest in the phenomenon being studied (Abimbola, 2013).

Critical thinking skills that enhance the development of problem-solving skill, creativity and tolerance in solving difficult tasks are basic skills that will help produce a holistic learner (Ogundiwin and Ahmed, 2015). Possession of problem-solving skill will make students adept problem-solvers. This will help in demonstrating the ability to think cross-functionally across various problems. Graham (2005) claims that problem-solving ability is usually developed in the students through the introduction of practical in the normal setting of teaching and learning processes. The ability to transfer the problem-solving skills to real-life situations is a major expectation in sciences. This is because problem-solving ability will enable the students to tackle some of the prevailing biological problems being experienced today (Ige, 2001; cited in Ogundiwin, 2014). Problem-solving ability will help the students explore, manipulate the situation and reflect on their experiences. Elaboration and reflection improve learning, providing the students with the required opportunity to experience and build a feeling or interest in the phenomenon being studied (Raimi, 2003).

Problem-solving skill has a special role in the study of the sciences. According to Okurumeh (2009), proficiency in problem solving requires practice and, when the learner is given enough opportunities for practice, this results in acquisition of competence which, in most cases, could lead to invention. Problem-solving ability has been regarded as the linking tie between context and applications in a learning environment, for the development of basic skills and their uses in various dimensions. Monitoring is also a vital component in developing effective problem-solving ability. So, the teacher needs to monitor the students' progress.

As important as problem-solving skill of students is to basic life situation, it cannot be effectively developed and applied in ecology and genetics issues if the attitude of the students towards ecology and genetics is not enhanced. Another factor affecting students' performance in Biology is students' attitudes towards Biology. Ajayi (2007) states that students' bad attitudes to science make them perform poorly in science subjects. Educators in science field have noted that the acquisition of right disposition towards science ought to be a non-negotiable goal of the school curriculum.

Although there are several definitions of attitude, all of them agree that thinking, feeling, or acting positively or negatively toward objects in the environment is the most suitable definition. The components of attitude as claimed by social psychologists are three namely: affective, cognitive and behavioural. Feelings about object is referred to as affective and it is tested by using psychological indices (heart rate). The *cognitive* component is a set of views about the features of the object and it is assessed by performing the paper-and-pencil tests (questionnaire). Finally, the way people act toward the object and its assessment is done through direct observation of behaviours. This is termed the *behavioural* component.

Attitude towards science might be viewed as observed predisposition to assess in specific ways, objects, people, and actions. It is also seen as a learned, negative or positive, feeling about science that conveniently summarizes the beliefs about science. Attitude predicts behaviours that are related to science. Assertions such as "I dislike science," or "I prefer science," are seen to be displays of attitudes toward science because they connote a general right or wrong feelings toward the official training in science.

Students' attitude is also defined as students' predispositions to responding or reacting in their interpersonal relationships, particularly in interacting with teachers and the students. Krapp (2002) states that positive students' attitudes are fundamental to students' academic performance. Several research findings have also reported that, although efforts have been intensified to better the teaching-learning process in Biology, students in high schools still have negative attitudes towards science, especially Biology (Ajayi, 2005). From the learning theory perspective, students with negative attitude to science will lack the drive to persist and do better in this field (Adeoye, 2007). Attitude towards science is directly related to performance in science (Jegede, 2007). Positive attitude/favourable attitude may lead to significant higher performance in science. Attitude, like achievement, is an important outcome of science teaching. A major goal of teaching science, Biology in particular, is that it opens up students to favourable attitudes toward Biology and biosocial problems. Attitudes can be seen as an important aspect of education because they tend to influence behaviour (Nelson, 2011). People acquire attitudes through learning and can also change attitudes through persuasion, using various techniques. Attitudes steadily change; persons gradually practice new attitudes and polish old ones when they come in contact with new experiences and information (Adeoye, 2011).

Cimar (2012) found that genes, chromosomes, Mendelian genetics, and hormones are considered difficult concepts by secondary students. This has resulted in learners having negative attitude towards genetics. The deterioration in knowledge and poor attitude have been attributed to inappropriate teaching strategies (Daramola, 2010). Teachers have a critical role to play in the formation of their students' attitude and achievement (Akinsola, 2013); hence, the call for urgent attention to investigate the learning method that could better enhance students' positive attitude towards Biology

Ojo (2009) observes that various study techniques have been proposed for ecological concepts such as fieldworks or field trips. Ige (2001) used mapping concepts and problem solving teaching strategies to determine the academic performance of secondary school learners in ecology. The study revealed that concept mapping and problem solving teaching strategies emerged more efficient than the conventional instruction in the teaching of ecology in Biology. Olagunju and Ojo (2006) assert that learner-centred strategies embrace active involvement of students, which is the focus of the cognitive learner-centred theory. Students are enthusiastic with such innovation. It emphasizes the dynamic mental input of pupils by supplying occassions for students to profoundly listen to, read, talk about, as well as write and ponder on the contents, notions, matters and apprehensions of an academic subject. Ogundiwin (2013) worked on pre-theoretic intuition quiz; Oloyede (2014) investigated critical exploration; while Awolere (2016) worked on experiential.

The rapid application of computer in education has sprung changes in the teaching-learning process, courses as well as the employed instructional methods engaged by the teachers' and administrators (Loveless and Ellis, 2002). Such positive alterations in the use of techniques for instruction are brought about due to the reason that computer-aided methods boosts students' drive and fashions proper environments for learning where rote education diminishes and active acquisition of knowledge can meaningfully take place. (Renshaw and Taylor, 2000).

Akingbemisilu (2016) observes that new technologies are invented everyday and they have tremendous effects on every aspect of society. Aremu, Olaosebikan, Fakolujo and Oluleye (2013) and Aremu and Obideyi (2014) reported high acceptance and usability of modern technology for classroom instructions by students. However, AbdulRahaman (2014) and Akingbemisilu (2014) claim that the effects of these technologies have not been very obvious in the teaching-learning process in Nigeria. Students consistently look forward to being in a classroom where they are helped to develop knowledge unaided, through the experiences they are exposed to, not just passively receiving one-dimensional information. They also expect to get involved in discussion in classes and project groups; most of their assignments are done during class periods, instead of organizing tutorial classes (Tom, 2012).

There are several technology-driven strategies that have surfaced recently. These include web questing, podcast, flipped learning, cloud computing, mobile learning, and assistive technology (Gladys *et. al.* 2015; Akingbemisilu, 2016). The effects of these recent technology-driven strategies on instruction have been considered significant. However, each of these technologies has peculiar characteristics that make it unique. Web quest, for example, helps to harness social networking for business goals. Its podcast, which includes the release of series of audio files that can be downloaded on regular schedule from the Internet, is particularly useful for lessons that centre on listening skills, such as in languages, storytelling and pronunciations as well as for the visually impaired learners. Cloud computing, particularly useful for ICT lessons, helps users store information that is vital to them on a secured world wide web, which could be retrieved easily. Mobile learning is unique for distance education where lesson contents can be accessed on the mobile platform (Adedoja, Egbokhare and Oluleye, 2013). Mobile learning is also well suited for theoretical concepts and it serves mainly as support tool for learning. Assistive technology involves the use of educational technologies for the physically challenged, thereby enhancing their rate of comprehension of what the teacher teaches.

Helping students to combine pictures with words to develop models of dynamic systems is another way of enhancing learning (Schnotz and Bannert, 2003). This method led to the development of a kind of special collaborative animation: computer simulations (Nerdel and Prechtl, 2004). Simulation packages provide intermediate models that students understand more easily than detailed and complex models. Simulation was found to propel science students in the middle school to study aquatic ecosystem beyond the surface level. The aquarium represented a physical model (Efe and Efe, 2011). National Research Council (2011) observes that, through simulation, users are enabled to detect and manipulate with illustrations of phenomena that should rather be unseen. These features make simulations very useful in appreciating and determining the behaviour of a range of events.

Computer simulation packages provide field learning experiences or virtual laboratories that remove practical and unrealistic constraints to students' investigations. This way, they establish the new, inquiry-based approaches to science instruction. They allow students to observe, explore, and manipulate scientific explanations of occurrences in science that ordinarily would be difficult to notice and formulate. They can assist learners to intellectually connect scientific phenomena that are abstract with the unseen procedures underlying the events and the learners' observations (Liao, 2005). Computer simulation packages have great potential to promote and make science instruction inquiry-based, thus side tracking imminent problems to general use of these approaches. Young people who are increasingly engrossed with the use of digital media all day are attracted to computer simulations. Simulations allow users to discover the inferences of controlling or adjusting constraints within them (Pilli, 2008).

Students apply newly acquired skills and are motivated towards advanced learning while using realistic simulation (Chen, and Howard, 2010). Students' attitude towards science may have been influenced over time by the significant role played by simulation. Research on realistic simulations showed how relevant science is and springs changes in students' perception of science (Zubair and Nasir, 2011). Students' self-perception and goal orientation are changed when they are exposed to live simulation learning environment.

Very little has been done on the use of this method for imparting learning outcomes in Biology education, especially in enhancing learners' achievement, problem-solving skill, and positive attitudinal change. Problem-solving skills are acquired in learners through critical thinking, which makes them adaptive problem-solvers. One of the aims of Biology curriculum is to develop broadly applicable skills in deep thinking, communication and objective reasoning ability to train learners for competency, workplace sustainability and self-sustainability in the world economy (Federal Ministry Education, 2008). Most students perform poorly in examinations that determine capacity to identify set expectations, assess arguments, and analyse interpretations. The performance of learners on higher-order thinking measures ability revealed a major necessity for students to acquire effective thinking abilities to solve problems. Although several research work supply circumstantial proofs for methods that make better critical thinking for problem solving, many of them rely on self-report of the students, and this limits the depth of interpretation. Hence fresh research that investigates the effects of instructional factors that aid problem-solving skill is necessary.

Scott (2006) identifies various methods of using puzzles instructional packages in education. These include public events, illustrative strategies, classroom resources, introducing new ideas, arts and craft, physical manipulation, skills, posing problem and creative research. There were raw proofs that the comprehension of abstract ideas improved and the development of problem-solving aptitudes in students improved, using puzzle instructional packages in imparting knowledge in science education in Korean universities (Anany and Mary 2002). This is also supported by the findings of Lauric and Robbert (2001) in Korean universities in their experiment with utilizing puzzle to teach and learn computer science education. The students understood abstract concepts by solving puzzle.

Kendall et al. (2008) found that puzzle-based active learning equips learners with the use of resources better than the inactive type of analysis does. The use of puzzles made learning more exciting. Consequently, the expected learning outcomes were achieved. Puzzle instructional package was compared with conventional instructional method by Anany (2002) in the investigation of procedures. The result revealed that the use of puzzle package produced better results. The learning aftermath of the candidates exposed to puzzle package improved more than that of their course mates who were exposed to the conventional method in algorithms. Aremu and Olasunkanmi (2007) aver that puzzle is an educational resource that imparts critical thinking skills. The prerequisite to line up with current methods in technology and interactivity has made the computer very useful in the scholastic section. Digital puzzles could allow for interactivity, immediate knowledge of result, reinforcement and practice, which are necessary for effective learning.

The conventional method consists of the oldest method of teaching used in most Nigerian schools. It is a traditional "talk-chalk" package. The teacher "gives out" the facts to the students and the students listen and digest the knowledge (Osokoya, 2002). There are reasons why teachers stick to the conventional mode of teaching. Some of them as given by Adesoji (2004) are overloaded curriculum, lack of infrastructural facilities, lack of training programmes/workshops and lack of skill in handling difficult concepts (Olagunju, 2002). Abimbola(2013) claims that dominant in secondary schools in Nigeria is the teacher-centred methods. Ogundiwin and Ahmed (2015) contend that the adoption of conventional method is inadequate in effective impartation of scientific knowledge. Olatoye and Adekoya (2010) also opined that, in relation to the teaching of science secondary schools in Nigeria, the traditional method of teaching is not effective.

In order to have adequate knowledge, improve problem-solving skill/abilities and develop positive attitude towards ecological and genetic concepts, it becomes imperative for learners to be equipped with the ability to organize and execute prompt actions required to achieve successful level of performance in these concepts (Anderson 2007). This is self-efficacy.

Self-efficacy predicts students' academic performance both directly and indirectly across academic areas and levels (Adepitan, 2004). It is an indicator of academic performance, because it has been reported to be associated with motivation, resilience, optimum and goal orientation, which are also predictors of success in school work (Chambers, 2009). Wagner (2005) defines self-efficacy as the personal convictions in one's capacity to excel in particular situations. According to Pajarez (2006), learners that display confidence in their educational prowess are motivated intrinsically, keep close watch on their work periods more excellently, are better problem-solvers, show more persistence and are more prone to achieving their academic goals than those who are not confident of their academic abilities. Low self-efficacy propels students to feel they are not inclined to be efficacious academically and thus make little effort. They consider tasks that are challenging threats that are to be avoided. They, therefore, develop low morale, that produces poor scholastic performance.

Furthermore, Wood and Gentile (2003) asserted that high level self-efficacy learners work harder and engage in more self-efficacy strategies that promote school success. According to Fend and Scheel (2005), students' self-efficacy can be influenced by teaching strategies, either positively or negatively. Students who are exposed to particular pedagogy that increases their confidence and their capability in the subject are motivated to put more effort into attaining higher-level achievements in the subject. In other words, if a student believes that he or she has what it takes to master the concepts and principles in Biology, the belief, whether true or not, could affect his or her interest, motivation and performance in Biology. Shaugnessy (2004), therefore, advocates that teachers should seek to increase academic self-efficacy by employing strategies that would enhance the self-efficacy of students. Adeoye (2011) discovered a low level of self-efficacy in Biology students. The mental ability of the students increased with high level of self-efficacy.

Ojo (2008) discovered that students' mental ability has imparts on learning, retention and subsequent pedagogic accomplishment in Biology. According to them, mental ability expedites the interaction process which characterizes the initial learning phase by enhancing efforts and readiness to learning.

Onabanjo (2007) recognises a very high relationship between students' mental ability and performance in science-related courses and Mathematics. He defines mental ability as the enablement to display higher mental practices of remembering, thinking and solving problems. Researchers like Mayer (2000), Kasali (2000) and Sangodoyin, (2011) have established a link between mental ability and students' performance in science. To Mayer (2000), the nature of discovery in cooperative learning and interactivity provides a beneficial boost to passive learning that is monotonous. With this, both the teacher and students may control their own pace of lesson according to their individual abilities. In addition, cooperative learning can give students with low ability, prolonged learning time to progress through the help from colleagues with high mental ability who are not confined by linearity or much slower pace (Mayer and Moreno, 2003). Therefore, the interest to proceed or recede and collaborate with other learners allows learners to learn according to their individual pace that will insure that both groups of students perceive information equally. This is called self-pacing. Mental ability, to some extent, determines the resourcefulness, concepts formation, language awareness and problem-solving ability of learners.

This work, therefore, investigated the combined effects of computer simulation and puzzle-based (digital) instructional package on students' learning outcomes in Biology with respect to the self-efficacy and mental ability of senior secondary school students in Oyo State.

1.2 Statement of the problem

Efforts have been intensified towards achieving success in SSSCE and NECO in Biology. Yet, students' results have persistently been poor. The poor performance of students, as revealed by their results in external examinations, has been acrued to students' poor comprehension of ecology and genetics in Biology, which is reflected in the negative attitude towards the subject and poor problem-solving skills. This may be due to the abstract nature of some of the concepts from which the bulk of the questions are raised and students' poor problem-solving skills in answering questions on ecology and genetics. They could not apply the conceptual knowledge in an examination situation. The poor handling of the concepts by teacher-centred methods aggravates the problem. Researchers have suggested the use of meta-cognitive teaching strategies, which involve a shift in focus from teacher-centred teaching methods to learner-centred one, such as the use of video compact disc, audio cassettes, Entereducate, computer simulation and puzzles, to teach. Studies have indicated that these are persuasive in defining students' learning outcomes in some other subjects and other nations of the world but the extent to which computer simulation and digital puzzles would combine to influence students' learning outcomes in Biology has not enjoyed any research focus in Oyo State, Nigeria.

The past studies on the use of computer simulation and digital puzzle instructional packages did not focus on the moderating effects of self-efficacy and mental ability on senior secondary school Biology students' learning outcome and did not establish the combined effect of computer simulation and digital puzzle packages on the learning outcome. Therefore, this study determined the effects of computer simulation and digital puzzles packages on secondary school students' achievement, problem-solving skills, and attitude to ecology and genetics in Biology coupled with the intervening effects of students' self-efficacy and mental ability in Oyo State, Nigeria.

1.3 Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

$H0_1$: There is no significant main effect of treatment on students' (a) achievement in genetics and ecology in Biology,(b) problem-solving skills in ecology and genetics, and (c) Attitude to Ecology and Genetics

$H0_2$: There is no significant main effect of self-efficacy on students' (a) achievement in genetics and ecology in Biology,(b) problem-solving skills in ecology and genetics, And (c) attitude to ecology and genetics.

$H0_3$: There is no significant main effect of mental ability on students' (a) achievement in genetics and ecology in Biology, (b) problem-solving skills in ecology and genetics, and (c) attitude to ecology and genetics.

$H0_{4:}$ There is no significant interaction effect of treatment and self-efficacy on students' (a) achievement in genetics and ecology in Biology, (b) problem-solving skills in ecology and genetics, and (c) attitude to ecology and genetics.

$H0_5$: There is no significant interaction effect of treatment and mental ability on students' (a) achievement in genetics and ecology in Biology, (b) problem-solving skills in ecology and genetics, and (c) attitude to ecology and genetics.

$H0_6$: There is no significant interaction effect of self-efficacy and mental ability on students' (a) achievement in genetics and ecology in Biology, (b) problem-solving skills in ecology and genetics, and (c) attitude to ecology and genetics.

$H0_7$: There is no significant interaction effect of treatment, self-efficacy and mental ability on students' (a) achievement in genetics and ecology in Biology, (b) problem-solving skills in ecology and genetics, and (c) attitude to ecology and genetics.

1.4 Scope of the study

Senior secondary school II students from eight senior secondary schools in four local government areas in Oyo State, Nigeria participated in the study. The study determined the effects of computer simulation and Puzzle-based (digital) instructional package on students' achievement, problem-solving skills, and attitude in genetics and ecology in Biology. The study also examined the moderating effects of students' self-efficacy and mental ability on the dependent measures. The ecological and genetic concepts in the SSCE Biology curriculum for senior secondary school II was used to prepare the packages for the study.

1.5 Significance of the study

The study is of benefit to students, it exposes them to genetics and ecology instructions using computer simulation and puzzle-based (digital) instructional packages which improve their achievement, problem-solving skills, and attitude in genetics and ecology in Biology. Findings from this study assist teachers to detect and make use of appropriate techniques to use in teaching abstract concepts in Biology as they attend seminars, conferences and workshops organized by governments and stakeholders. Adopting the packages used in this study help improve teaching/learning process in the classroom. The techniques are easy to use and aim at encouraging active learning in a classroom setting. They help the instructor to know the comprehension levels of students as they promote immediate feedback. Finally, this study will be very useful to curriculum planners who are in constant search of appropriate teaching strategies for effective teaching-learning in secondary schools.

1.6 Operational definitions of terms

Achievement in Ecology and Genetics: This is the level of performance of students with regard to their scores in ecology and genetics, which was measured in this research by Students' Achievement Test on Ecology and Genetics.

Attitude to Ecology and Genetics: This is students' behaviour/predisposition towards concepts in Biology with respect to their scores, which was measured in this research using Students' Attitude Towards Ecology and Genetics Questionnaire.

Computer Simulation Package: This is software developed by the researcher based on the process of imitating a real phenomenon. It is a device that displays instruction in classroom to aid teachers' effectiveness in impacting skills and knowledge to students in ecology and genetics.

Digital puzzle: This is a puzzle package developed by the researcher. It is in the form of an educational toy, usually requiring students to put together pieces to form a specialised whole in ecology and genetics.

Mental ability: It is the capacity of the students to perform higher mental processes of remembering, reasoning, understanding, and problem solving which was measured using Students Mental Ability Test.

Problem-solving skills: In this study, problem solving skills refer to the skills used in application of conceptual and procedural knowledge in ecology and genetics to solve a defined problem. It was measured in this research using Students' Problem Solving Test to determine the scores, a form of phase-by-phase instructional procedure.

Self-efficacy: This is an individual's assessment of his or her capability to learn and master a task or tasks while also exhibiting confidence at carrying out such tasks with little or no supervision. It was measured in this research using Student Self-Efficacy Scale. The maximum score was 80 and the minimum was 20.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents review of the literature related to this study. The chapter is subdivided into the following:

2.1 Theoretical Framework.

2.1.1 Socio-cognitive theory

2.1.2 Socio- cognitive theory in relation to computer simulation and digital puzzle packages

2.1.3 Different models supporting simulation

2.1.4 Conceptual model for puzzle package

2.1.5 Problem-solving model

2.2 Conceptual framework

2.2.1 Students' Achievement in ecology and genetics

2.2.2 Students' Problem-solving skill

2.2.3 Students' Attitude to ecology and genetics

2.2.4 Computer simulation package

2.2.5 Puzzle-based learning package

2.2.6 Conventional instructional method

2.2.7 Self-efficacy

2.2.8 Mental ability

2.3 Empirical Review

2.3.1 Computer simulation package and students' achievement in ecology and genetics

2.3.2 Computer simulation package and problem-solving skills in ecology and genetics

2.3.3 Computer simulation package and students' attitude to ecology and genetics

2.3.4 Digital puzzle instructional package and students' achievement in ecology and genetics

2.3.5 Digital puzzle instructional package and students' problem-solving skills in ecology and genetics

2.3.6 Digital puzzle instructional package and students' attitude to ecology and genetics

2.3.7 Modified conventional package and students' learning outcomes

2.3.8 Self-efficacy and students' achievement in ecology and genetics

2.3.9 Self-efficacy and problem solving skills in ecology and genetics

2.3.10 Self-efficacy and students' attitude to ecology and genetics

2.3.11 Students' mental ability and students' achievement in ecology and genetics

2.3.12 Students' mental ability and problem-solving skills in ecology and genetics

2.3.13 Students' mental ability and students' attitude to ecology and genetics

2.4 Appraisal of the reviewed literature

2.1 Theoretical framework

2.1.1 Socio-cognitive Theory

The study was anchored in Kolb's experiential and Lev Vygotsky's socio-cognitive learning theories. Kolb's experiential learning theory is a holistic perspective that combines experience, perception, cognition and believe. Building upon works by John Dewey and Kurt Lewin, Kolb believes learning is the process whereby knowledge is created through the transformation of experience (Kolb 1984). The theory presents a cyclical model of learning, consisting of 4 stages – concrete experience. This involves the learner's active experiences. Activities such as lab sessions or field work.

- Reflective observation:

This is when the learner consciously think back on that experience

- Socio-cognitive theory discusses the process of accumulation of knowledge or learning that is directly related to observing of models. The models can be those that are from media sources or imitated interpersonally. Effective modelling teaches basic laws and useful methods for handling varying situations. This theory can be applied to solving problems today in many different areas, such as education, public health, mass media and marketing.

Socio-cognitive theory argues that human agency (that is individuals who are agents) takes the lead in human personal development and with it humans can accomplish things. The possession of individual self-belief affect disposition to issues and this permits them to work out an amount of caution about their actions, views and moods; this is the key to this sense of agency (Bandura, 1986: 25). A projection of human behaviour is provided by Bandura. He views beliefs that people have about themselves as critical tools that can be used to control them and that also serve as their personal agency. Thus, individuals are seen as the producers and products of their own surroundings and of their communal systems. Human agency is extended by Bandura includes collective agency. Shared opinions about their potential and common aspirations to make their lives better make people team up to work together. This theoretical projection makes the theory to be subjected to change in collectivist-oriented societies and human adaptation as well as individualistically-oriented ones.

Through self-system psychological mechanism, environments and social systems influence human behaviour. Hence, socio-cognitive theory contends that factors such as educational and family structures, economic conditions, and socio-economic status do not have direct effect on human behaviour. Instead, they affect it indirectly by influencing personal standards, emotional states, people's aspirations, self-efficacy beliefs and other self-regulatory influences. In sum, the theory's submission about social and mutual functioning, which indicated a diversion from the prevailing behaviourist and learning theories of the day, later had a notable effect on mental thinking and speculating in the last two decades of the twentieth century and in the new millennium.

Deeply grounded in Bandura's social mental viewpoint is the knowledge that persons are endowed with peculiar qualities and potential that makes them human. These include abilities to learn through vicarious experiences, plan alternative strategies (forethought), symbolize, self-reflect, and self-regulate. These aptitudes equip humans with the intelligence through which they shape their destinies.

Extraordinary capacity to *symbolize* is possessed by humans. With this, they can approve courses of action, acquire fresh information through reflective thought, deduce answers to issues around them, provide guides for action, solve problems intellectually, and link up with others irrespective of time and space. As argued by Bandura, thoughts are propelled by symbols; that is symbols trigger the need to think. It is by turning their experiences to symbols that they can live enriched, well-structured and meaningful lifestyles that ensure stability. Symbolizing also facilitates populace to save the evidence needed to channel their impending behaviours. This is the process through which it is made possible for them to imitate noticed behaviour.

Using symbols, individuals are able to engage in self-directedness and *forethought*, solve cognitive problems and set action plans, forestall the possible penalties of these actions, and map goals and objectives for themselves to guide, provoke, and adjust their deeds. The ability to map out alternative plans and foresee the penalties of a deed without really getting involved in it is made possible by the ability to think.

People learn based on personal experience and through keenly watching others' behaviours. This is known as *vicarious learning*. On many occasions, it prevents them from risking otherwise fatal and costly errors. Such observation guides future action. Learning by observing is achievable through the processes of attention, retention, production and motivation. If the detected behaviours are retained in memory, they can be produced. This process is made possible by the human capability to symbolize.

Self-regulatory mechanisms that are adopted by individuals provide the ability to self-directed behaviours that lead to changes. How people self-organize their own deeds and behaviour directly relates to the assessments people make concerning their actions, attributions, the precision and steadiness of their self-watchfulness and self-guide, choices, as well as the appraisal and concrete reactions they make to their own behaviour (in the form of positive changes) through the self-regulatory process. Self-judgement and noticeable self-encouragement which act as personal spurs to behave in self-directed ways are components of this.

The most "absolutely human" capability (Bandura1986: 21) is that of *self-reflection*. This makes it an outstanding feature of socio-cognitive theory. By this, people deduce meanings from their practices, manipulate their understandings and self-convictions, carry out self-asssessment, and adjust their thoughts and conducts accordingly.

2.1.2 Socio-cognitive Theory in relation to Computer Simulation and Digital Puzzle Packages

Socio-cognitive theory explains the process by which knowledge is acquired or direct learning that is related to the observation of models. Computer simulation and digital puzzle packages are models observed by students to enhance their mastery of ecology and genetics. Bandura (1986) discusses human functioning which stresses intellectual, mediated, self- control, and self-reflecting methods in human adaptation and change. People are viewed as self-organizing, self-reflecting, proactive and self-regulating. They are not conceived as reactive organisms which are driven by hidden inner impulses or controlled by environmental forces. The product from this abstract viewpoint is human functioning, that is the end result of a unique interchange of particular, social, and ecological imparts. The students create an environment which engenders self-reflection, and makes sense to their experiences, and manipulate their own cognitions and self-beliefs. It also influences the way they think and behave.

Learning Biology using computer simulation package makes learners to develop meaningful understanding of concepts in Biology. It affords them the opportunity to learn through construction of their own knowledge and ideas from the computer simulation practices, with the mentor serving as a guide. Okurumeh (2009), asserts that students permitted to participate actively in learning become more autonomous learners and good problem solvers.

2.1.3 Different models supporting simulations

The basic model supporting simulations in this research is social constructivism. This is an ethical viewpoint that observes knowledge as the result of individual understanding supported by one's former knowledge and the experiences of others.

Gibbons' (2001) model-centred-instruction (MCI)

Gibbons (2001) argues that motivating learners to generate understandings about substances and actions in their environment is central to instruction. Knowledge is symbolized by models which learners create while processing information. They then concentrate on facts or undertakings which will trigger their learning courses. If there are no real objects, environments or events, teachers create symbols, which are termed models (Gibbons, 2001). Simulated teaching activates students' learning processes in the class, serving as impetus that aids focusing attention on specific information. Instructional delivery, classroom management and materials construction, among others constitute major aspects of simulated teaching. The students determine how to solve problems, construct mental models, process information, as well as develop heuristic skills.The flow chart below shows the process students follow when engaging in simulated teaching.

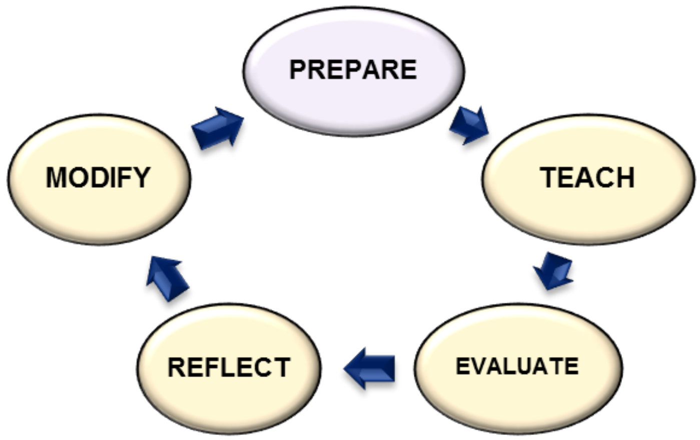


Figure 2.1: Simulated teaching

The figure illustrates the guidelines in the implementation scheme of simulated teaching. It begins with the preparation phase, followed by the carrying out of the lesson, evaluation of performance, reflection or processing of the teaching experience and the modification phase, where students make decisions to modify teaching behaviour and practices for improvement purposes.

Preparation Phase

1. The teacher finds out pupils' prior knowledge of the topic through relevant questions
2. The teacher orientates the students on the objectives and expected performance in each phase.
3. Students are allowed to put theoretical knowledge already gained into action – mount the disc (computer simulation CD) on the system already connected to the projector.

Teaching Phase

4. The teacher executes the lesson in line with the prepared plan and the assigned time. The presentation takes 10-15 minutes only, based on the length of the topic.
5. The students identify, watch and listen to the simulation.

Evaluation Phase

6. The students ask questions on their observations or part of the simulation presentation that is not clear.

Reflection Phase

7. The teacher explains, models, illustrates, clarifies, and supplies missing information.
8. The students generate important notes.

Modification Phase

9. The students give insights, feedback and comments gained during the teaching, when the teacher was answering the questions and supplying the missing information.
10. The student corrects or modifies previous information.

Simulations allow students to test suppositions and more generally "what-if" settings, enabling learners to apply cognitive understanding of their action in a situation, that is, they can be regarded as an alternative of cognitive tools (Thomas and Milligan, 2004). Simulations in this respect are compatible with a constructivists' view of education. Lock (2010) states that, since the early 1980s, there has been a growing interest in the potentialities of computers as facilitators of students' learning. Mayer (2004) claims that the use of computers as facilitators of students' learning enhances the students' performances in a wide range of school outcomes, including academic achievements, mental progressions, meta-cognitive skills, drive toward learning, self-regard and communal advancement.

Decision for simulation

Simulation is most times used inappropriately by individuals who are inexperienced and untrained. If simulation is wrongly applied to a study, the study will not produce meaningful results. Four items must be considered before deciding to apply simulation in a study:

1. **Type of problem**

   Simulation can only be used for a problem that cannot be analysed or solved using common sense or direct experimentation. It is used for a problem that is abstract in nature a phenomenon that is otherwise invisible.

2. **Availability of resources**

   The determining resources for conducting a simulation study are people and time. An experienced analyst that can determine both the details of the model and how to verify and validate it is needed or else a wrong model might be developed. Also, sufficient time should be allocated so that there will not be short cuts in designing the model.

3. **Cost**

   Sufficient fund should be allocated to take care of each step in the simulation process; that is, buying the software and the computer resources. When there is shortage of fund, simulation should not be applied in a study.

4. **Data**

   Data should be made available. If there is no existing data, it should be collected. Without data, the study will produce unreliable and incorrect results.

2.1.4 Conceptual model for puzzle package

For meaningful learning to occur teachers need to change from sage to director, and giver to collaborator; essentially, they should be instructor rather than initiator. Students learn from thinking about what they do; therefore teachers should serve as motivators.

Using puzzles that epitomise resources and items from the children's surroundings enable them to spot, validate and stock experiences for later use. This view is supported by the work of Zmaczynski (2002), who developed a puzzle apparatus for the study of Chemistry and its history based upon the equilateral triangular model of the periodic table of the chemical elements. The puzzle has a triangular shaped base and it is shaped and sized in order to accommodate rhombohedra-shaped pieces that fit into the base and form an overall triangular shape. This successfully completed puzzle has each piece reflecting a chemical element in its correct place in the periodic chart. Zmaczynski (2002) avers that the puzzle enabled students to recognize, verify and store chemical formula experiences for later use in chemical equations.

Maldonado (2005) proposed a concrete structure for developing and estimating puzzle in Science Education. The framework is based largely in part upon research, development in cognitive science and developmental theories and utilization. It is this model for development, evaluation and research that was adopted for this study. The framework could be implemented with any number of theories. The framework is based on the tasks facing any puzzle developer, evaluator or user. The components of the model are explained thus:

Model for Developing and Evaluating Puzzles

(The Basic Version)

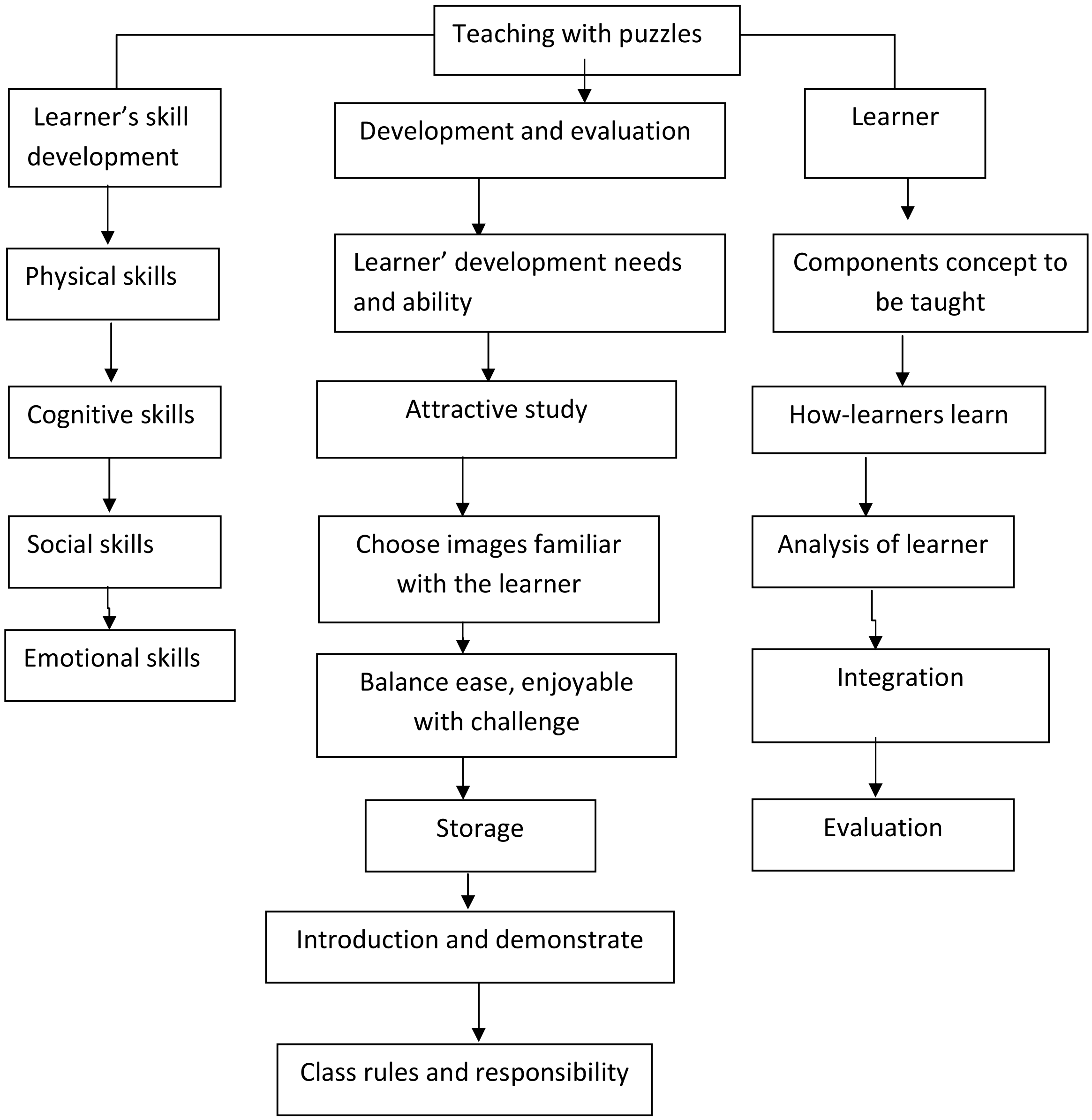


Figure 2.1: Model for Development, Using and Evaluating Puzzles for Teaching

Source: Maldonado (2005). Puzzles: A tragically abandoned, commonly accessible resource. *Young Children* 51 (4)

Learners' Skills Development

Puzzle, can expand nearly every aspect of learner's development, particularly the following:

i. Physical skills: As learners clutch, hold, and fix puzzle pieces, they develop eye-hand harmonisation and fine-motor precision.

ii. Cognitive skills: By attaching or joining words together, learners derive skills in solving issues. Puzzle-solving experiences help learners learn scientific ideas and principles, such as arranging, categorizing, matching, and setting relationships.

iii. Social skills: Learners learn how to discuss with others and get involved in thinking when solving puzzle along with friends As they watch others solving puzzles, they discover new puzzle-solving strategies. When guided, supported and motivated in the process of a puzzle's completion, learners develop management skills.

iv. Emotional skills: Puzzle solving is interesting and engrossing. When a puzzle-solving activity is executed, learners feel delighted with themselves. They become confident and prepared to attempt new puzzles or other tasking activities.

In choosing puzzles for learning the following points must be considered:

- Choose puzzles that are suitable to each learner's progressive ability and needs. This means choose puzzles that are appropriate to learners age and development, that is, from simple to complex. Observe and work with learners so as to provide puzzles that fit each person's needs. Through careful observation, you can cater for a range of progressive abilities, with puzzles of different types and themes.

- Choose puzzles that are striking.

Table puzzles have to be durable so as to withstand repeated use by learners. Puzzles also have be striking and interesting to learners. Clarity of image and simplicity are crucial in this regard. Puzzles that are familiar, attractive and aesthetically beautiful invite the learner to engage in the activity.

- Choose puzzles that are familiar to learners.

Familiarity and identification with subjects encourage learners. It is easier for learners to evaluate their success when they are able to recognize the subject of a puzzle. Their sense of genuineness is based on their dealings with their surroundings and the pieces of materials (Piaget, 1954). When puzzles that symbolize resources and items from the learner's environment are used, they are able to spot, verify and accumulate experiences for later use.

- Obtain puzzles that combine ease, joy with challenge.

Ideally, some classroom puzzles are considerably cheap for learners to arrange together, while some puzzle are challenging. Select an enjoyable puzzle. Bear in mind the fact that learners' need to experience a sense of enablement and triumph; this will make them independent in their actions and in their thinking. Guide learners in their most beneficial use of puzzle through routine and responsibilities.

- Store puzzles in one area.

A library can be set up to suit the curriculum modules, such as ecology and civic. The most important thing is that puzzles should be stored for future use.

- Maintain quality:

Painstakingly access puzzles in case of misuse. Instruct learners to report when a piece of puzzle is not found. A learner could be frustrated if he/she discovers that the last piece needed to set up a puzzle is not there. Learners need to know that the material they are using is of great value to the teacher as well. The teacher might appoint a "puzzle patrol leader" to handle this daily task. Repair and replace any missing puzzle pieces.

- Introduce and demonstrate new puzzle.

When you introduce a new puzzle to the class, make sure you endorse the materials' uniqueness. Never take puzzles for granted. Puzzle-solving is involving learners in the puzzle-solving activity and not presenting or testing concepts. The solving of a puzzle is the activity. So, little language should be used. The learner decodes the language to the puzzle-solving process and the teacher takes clues from the learner's action and speech.

- Development of class rules and responsibilities

Puzzles help learners to be responsible as they pay attention to the materials they work with. Simple and clear guidelines should be set up for selecting, using and returning puzzle thus:

A clean and clear table is needed to work. Always verify whether the picture is complete and the pieces are intact. Search for the missing pieces if there are some. Alert the teacher if the pieces cannot be found. Make sure the pieces do not mix with someone else's when working together on the same table. After the day's work, return the pieces to the rack.

Components of the concepts to be taught:

The analysis of each sub-concept to be taught and the objectives for each concept should be well stated in accordance with the guidelines given in the curriculum. Here, the concepts and objectives are in accordance with the guidelines of WASSCE syllabus.

How learners learn:

The learning theories on which these puzzles are based are Kolb's experiential and Lev Vygotsy's cognitive developmental theories of learning. These have been well discussed in theoretical framework in chapter two.

Analysis of learners:

Each sub-concept was carefully considered to find out similarities and differences that could confuse learners in concepts that seem to be abstract, confusing and mixed up. These include air, water and land pollution, conservation techniques, mutation, cell division, and laws in genetics. These misconceptions were taken into consideration in selecting the puzzle. The most misunderstood concepts were used more often in the puzzle so as to ensure practice that would lead to better learning and understanding.

Integration:

The concepts and sub-concepts were incorporated into the selected puzzle. Some were modified to suit classroom situation. The integration alien terms were practised on sub-concepts which learners found abstract and confusing.

Evaluation:

The puzzle developed was tested in order to determine its effectiveness, using different categories of learners. The outcome of the try-out study was useful in making decision on:

a. duration for learners to complete the puzzle
b. class arrangement, chairs, tables, to facilitate easy access to the puzzle.
c. how easily the learner could think critically to answer the question based on the conceptual framework.

Ecology and genetics puzzles were selected and used for the research.

2.1.5 Problem-solving models

Several problem-solving models have evolved to enhance students' problem-solving skills in science. Each of these models has stages or steps which provide series of alternative pathways to solving problems. The following problem-solving models were adopted in this research.

Ashmore, Frazer and Casey Model

Ashmore, Frazer and Casey (1979) developed a 4-stage model comprising

1. defining the problem
2. selecting appropriate information
3. combining the separate pieces of information
4. Evaluating

Ashmore, Frazer and Casey (1979) argue that the success in problem solving would be high when:

(i) there are strong background information and knowledge of the problem;
(ii) there is knowledge of problem-solving strategies and tactics;
(iii) there is confidence in the problem solver;

This model, which is presented in Figure II, can be used in solving problems in Physics, Chemistry and Biology.

1 Defining the Problem	The objective of the problem is clarified by starting in clear terms what is needed in the problem
2 Selecting Information	Choosing the appropriate and relevant information required to solve the problem. This comes from problem statement, data or memory
3 Reasoning	Re-ordering and restructuring the appropriate reasoning information by combining or piecing together several pieces of information in order to get the solution
4 Evaluating	Checking all the solution processes to confirm whether they are in line with the objective of the problem

Other models include; Polya's Four-step Model, Resnick and Glaser Model, Earpol Model, Wright and Williams Model, Heller Keith and Anderson's Model, Slack and Steward's Heuristic Model, Ikitde's Experimental Problem Solving Model, and Physics Problem-solving Model. Some of the above-mentioned models are appropriate only to numerical problems as could be found in Physics, Chemistry and Mathematics, while some can be used for both numerical and non-numerical problems. It is, therefore, the contention of the researcher that Entrepreneurship Education biology should be more applicable to models that have both numerical and non-numerical application. The model of choice for this study is that of Ashmore, Frazer and Cassey (1979), which has the following four basic steps: (i) defining (ii) selecting (iii) reasoning and (iv) evaluating. The selection of this model for this study was informed by the following reasons:

(i) Simplicity in application to pupils in secondary schools; and

(ii) applicability to both numerical and non-numerical, a characteristic features of EE concepts in Biology. It was assumed that the use of this model will facilitate students' problem-solving achievement in Biology.

2.2 Conceptual Framework

Active learning and strategies in each category

Active learning is a practice whereby students engage in higher-order thinking tasks, such as analysis, synthesis, and evaluation (Paulson and Faust, 2009). It involves students getting engaged in the class activities and not merely inactively listening to an instructor's lecture.

Learning is an active process that demands *thinking*. When one learns a new idea, one is actively erecting one's intellectual representations of such idea in a personally meaningful form. The new idea interrelates with the old ideas, in the process of combining the new and old ideas into a comprehensible system of ideas. Some of the most effective teaching methods are meant to arouse thinking, to replace passivity with activity. Strategies of active learning are those activities which an instructor incorporates into the classroom to foster active learning. The strategies in each category are shown in Table 2.3.

Table 2.3: Categories of Active Learning and Strategies in Each Category

Exercise for Individual Students							
The "One Minute Paper"	Muddiest (or clearest) Points	Affective Responses	Daily Journal	Reading Quiz	Clarification pauses		
Questions and answers the "Socratic Method"							
Wait Time	A student summarizes the answers given by another student	The fish Bowl	Quiz/Test questions				
Finger signals	Flash cards	Quotations					
Critical Thinking Motivators							
The pre-theoretical intuitions quiz	Puzzles/Paradoxes						
Share/Pair							
Discussion	Note Comparison/Sharing	Evaluation of Another Student's Work					
Class Cooperative Groups	Class Active review sessions	Work on the chalk board	Mapping of concepts	Visual Lists on board/paper	The Jigsaw Group Projects	Role Playing excercises	Panel discussion

Source: Paulson and Faust (2009)

2.2.1 Achievement in ecology and genetics

Themes under environmental education, for example environments, contamination, preservation techniques and the populace, are found in the Biology Curriculum of West African Senior School Certificate Examinations (WASSCE) /National Examinations Council (NECO) Senior School Certificate Examinations syllabuses (Obioma, 2007). According to Ige (2001), ecology provides awareness and comprehension of the processes of change made possible by the link between plants and animals and the effects on their physical surroundings. In the secondary school Biology modules, ecological concepts are crucial to scientific projections. Despite its importance to society, available statistics from Oyo State Statistics and Entries on West African Examination Council (WAEC 1999; 2003; 2004, 2006; 2007; 2008) in senior secondary school students' performance in Biology revealed that, although Biology had the highest enrolment among the other science subjects, the result was very poor, as the questions on ecology were answered incorrectly owing to the students' poor knowledge of ecological concepts.

Chief Examiner's Report (2003) and Oyeleke (2011) reveal that the ecological questions asked in WAEC 2007, for example, the question on five important uses of water to organism in the rainforest, was wrongly answered. Chief Examiner's Report (2007) further reveals that some candidates wrote the uses of water to man to be "drinking, cooking and washing," rather than maintaining body temperature, essential for plant turgidity, necessary for photosynthesis, and many others. Also in the 2007 WAEC question, students were asked to describe briefly three ways each by which animals in arid habitat are adapted to drought and high temperature. Chief Examiner's Report (2007) reveals that the students' performance on the question was very poor.

It is tasking to assess many environmental assumptions because it is practically unmanageable to control all the variables in nature and duplicate nature in organized settings. Invasive species concept forms the basis of ecological thought and has considerable consequence to diversity of global species. So it is tangled in disput.

Genetics is in the forefront of science in the modern era. Discovering its significance gives an in-depth knowledge of the human nature and that of organisms surrounding human. The portion of science that concentrates on scientific examination of genes, heredities and variation in organisms is called genetics.

2.2.2 Problem-solving skills

Problem-solving skill is relevant in the sense that information about the problem is first given during lesson before problems are presented to the students to lead them to the solution. These pieces of information have to be recalled and combined before the solution is arrived at. The solution leads to the acquisition of higher-order rule or more complex information which could be used to solve other future problems.

Moemeke (2003) carried out a study using 161 SS II Biology students to determine the importance of problem-solving skills in ecology. Two groups of 75 and 83 students were taught ecology using the problem-solving approach and conventional lecture method, respectively. After the treatment, Ecology Problem-Solving Test (EPST) was administered to generate pre- and post-test data. The results revealed a major difference in achievement, with the problem-solving experimental group showing superiority over the conventional lecture method group. Problem-solving processes were found to be the platform through which meaningful learning can be acquired.

The focus of Andren's (1997) study was effectiveness of problem-solving skills in aiding students' understanding and solving of environmental problems. Community students served as the study sample. The problem-solving model was employed to assess the students' environmental problem-solving abilities before and after the treatment. The experimental group performed better than the control group. This model was adjudged valuable in systematically focusing students' attention on components of environmental problem-solving abilities.

A similar study was carried out by Chen (2004) in teaching "National Estate Management" using 119 final-year students in the BSc (Real Estate) programme who had previously completed three years of core modules and electives. In the past, the module's conventional mode of instruction was by way of lectures, tutorials and assignments. The class was organised into 22 groups of 5 to 6 members. At the end of the exercise, students were asked to give feedback and comments on the problem-solving approach. A total of 91.1% of the students indicated that the problem-solving approach gave them free hand to identify the problem with the teacher as a guide. Only 8.9% preferred the conventional lecture method which they were used to. The study concluded that students were generally receptive to the problem-solving approach. Also the majority of the students agreed that the approach promoted collaborative and active learning; students were able to learn by experience and sought information on their own. They were also allowed to focus on real-life problems instead of syllabus content. The study cautioned that, in using the problem-solving approach, teachers should learn to facilitate rather than direct students' learning (AACU, 2005).

More recent studies emphasise the need for improved biological literacy and international competitiveness (Klymkowsky, 2006; Bybee and Fuchs, 2006). However, there is lack of evidence for methods that empirically improve critical thinking skills that facilitates problem solving (Tsui, 1998, 2002).

Students' problem-solving skill is determined by their ability to think critically. Previous work on critical thinking specifies that students' do not change their behavioural pattern in the short term (Giancarlo and Facione, 2001). However, it is possible to develop cognitive skills over a comparatively short period of time. Giancarlo and Facione (2001) found that the critical thinking disposition of undergraduate was significantly altered after two years. Existing research claims that changes in undergraduate's problem-solving character cannot be discovered in weeks; rather they are measured in years.

2.2.3 Attitude to ecology and genetics

The display of positive or negative feelings about someone or something, whether negative or positive is termed attitude (Seifert, 2007). Research has indicated that attitudes are learned, not inherited. Adesoji (2008) identifies teaching pedagogy, teacher's disposition, gender, parental input, age, interest in career, the community opinion of science and scientist, cognitive styles of pupils, social effects of science and success as influencing students' attitude to science. The impact of a student's attitude toward science is important (Farahnas, 2012). Attitude is a person's disposition towards ideas, institution and object, Kerlinger (1977), cited in Ayorinde (2008), defined it as a structured inclination to act, think, feel, recognize and behave toward a particular object. It could be learnt or developed and emulated (Daramola, 2010).

The learner acquires so much from the disposition of a teacher to form attitude towards learning. As teachers act, students emulate and perfect such act or behaviour.

Most teachers do not realize this; so, they do not handle the teaching of Biology as a subject or some concept in Biology well. The negative disposition of teachers to some subjects and topics may be responsible for negative attitudes displayed towards the learning of such.

Duyilemi (2006) argues that some science teachers exhibit negative attitude towards the teaching of science subjects, while some display positive attitude. Ali and Aigbomian (2009) observe that the extent of a student's interest in a subject determines the extent to which the student works hard to be successful in it. This implies that students' disposition to teaching and learning determines academic achievement.

Attitude is a variable that influences the achievement of students (Iroegbu, 2002). Sjoberg (2006) avers that there is no noticeable major difference between attitude towards Biology and students' Biology achievement. The concept of attitude is not indispensable to only social psychology, but also to the psychology of personality and that of learning in general. Often attitudes held by others cannot be observed directly; they must be inferred from behaviours (Idowu 2010).

Attitude is predispositions to classified groups of events or objects and reacting to them with some level of evaluating constancy. Attitudes are logically hypothetical constructs that are manifested in conjoint practice, oral reports, uncultured behaviour and psychological system. It is an intellectual inclination to act and it is conveyed by gaging a particular entity with some measure of favour or disfavour. Students generally have attitude that focus on objects, people or instruction. Attitudes consist of four components namely, cognition, affective, behavioural and evaluation (Idowu, 2010).

Osborne, Simon and Collins (2003) identify many factors that influence one's attitude: sex, essential variables (for example socio-economic class), teacher/classroom, and curriculum. Zacharia and Barton (2004) recognise school variables (particularly classroom variable) like how affectionate students are to their teachers, the science curriculum, or the science classroom climate. Zingaro, (2008) posits that students' and the learning environment do relate together. Being a young and dynamic aspect of science, some ecological concepts are based on conceptualizing rather than experimentation and the statistical concept in probability may be difficult for students to understand. Genes, chromosomes, Mendelian laws, homones in genetics have been considered difficult concepts for secondary school students. This has resulted in learners having negative attitude towards these concepts (Cimer, 2012).

2.2.4 Computer simulation package

The type of teaching method adopted by a teacher greatly impacts students' interest in a subject. Interest can guarantee a student's attention, and encourage the learning style. Therefore, teachers should facilitate experiential learning environment. This will make them experience learning with enjoyment (Muhammad and Fadzlliyati, 2010). The teaching method introduces reality into teaching environment and stimulates the interest of the student through provision of more information about the environment. This can be made possible through the use computer simulation.

A simulation is a form of experiential learning scenario; it exposes the learner to real-world experience as defined by the teacher. Simulation can be likened to a laboratory experiment that has students as the test subjects. The use of computer simulation in teaching makes science accessible and thinking visible. Essentially, it will facilitate student-student interaction instead of teacher-student interaction.

2.2.5 Puzzle-instructional package

Puzzles are problems that are fun to solve (Scott, 2002). They are problems or games that propel creativity (Shapiro, 2005). *Cambridge Advanced Learner's Dictionary* (2008) views puzzles as a game or toy involving fitting separate pieces together or a problem or question which one has to answer by using some knowledge. The use of puzzles in teaching and learning improves understanding of abstract concepts in addition to developing problem-solving abilities and critical thinking in students (Anany and Mary, 2002; Gardner, 2006).

Powell and Wells (2002) state that there are several materials that provide for both construction and diversity of activities and skills. Project Learning Tree, Project Wild Class, Science-Technology-Society are examples of materials with many activities: Preparing for Tomorrow's World, Super Saver Investigator and Aquatic Project Wild. These activities are found in United States of America. An activity manual produced by ERIC/SMEAC is described by Howe and Disinger (2000). It has examples of activities that one can design in relation to diverse environmental topics and hereditary issues. There are other wide ranges of innovative tools that can be effectively used and applied in the teaching/learning of environmental and hereditary concepts in Biology in our schools which will improve teaching/learning, motivate and make the contents relevant to students. One of such is using puzzle instructional package.

According to Kendall et al. (2008), puzzle is a problem or enigma that challenges ingenuity and a problem that seeks solution. Puzzles as resources for teaching and learning are of different types. They include assembly puzzles, interlocking puzzles, disassembly puzzles, disentanglement puzzles, construction puzzles, 3-dimensional puzzles, 2-dimensional puzzles, crossword puzzles and puzzle-based learning. These different categories of puzzles can be adopted and adapted for the teaching and learning of selected topics in secondary school science subjects. Bora (2003), Idowu and Ige (2007) and Kendall et al. (2008) identify some essential features of educational puzzles:

1. Generality: Educational puzzles have to explain some universal problem-solving principles. Problem solving may be supported by the strategies provided by an instructor.
2. Simplicity: Puzzles used in education should be easy to state and easy to remember. Such puzzles increase the chances of getting the solution to the problem.
3. Eureka Factors: A puzzle should be interesting. The Eureka moment is eventually attained as soon as the correct path to solving the puzzle is recognized. A sense of relief then ensues. The initial frustration also disappears.
4. Entertainment: Educational puzzle entertains; otherwise the user may lose interest easily

Computer simulation – digital puzzle packages

This is a package set up as an active learning experience in which the learner is exposed to the real world of the phenomena being studied in the form of pictures combined with words and digital puzzle clues on the concepts so that learning can be made more meaningful. These are coupled with evaluation-based pictorial and crossword puzzle focused on the development of the problem-solving skills of the students.

The computer simulation-digital puzzle package allows for interactivity, immediate knowledge of result, reinforcement and practice which are necessities for higher learning outcomes needed by students to solve problems and create higher-order thinking in other related endeavours.

2.2.6 Conventional instructional method

National Teachers Institute (2011) states that the approach to teaching in Nigeria is teacher- centred, which implies that the teacher does all the talking, and the learners do all the listening. Resources and pedagogy used are supposed to be easily introduced to the real world. The traditional or conventional instructional method is characterized by:

i. Unspecified or unclear objectives,
ii. Too much attention on instructor behaviour other than students' behaviour,
iii. Making use of lecture methods to supply cogent ideas,
iv. A fixed set of rules apply to all students,
v. No steady method of assessing a large proportion of resources for remedy purpose other than evaluative grounds.
vi. Deferred response to students about his performance,
vii. Ministerial reactions of students to the instructional materials, and
viii. Few faculty or students or teacher-to-student interaction.

2.2.7 Self-efficacy

Self-efficacy as a psychological term has been variously conceptualized. According to Pajare and Urdan (2006), self-efficacy is the belief that one is capable of performing in a certain manner or attaining certain goals. Self-efficacy is the belief (whether or not accurate) that one has the power to produce an effect. For example, a person with high self-efficacy may engage in a more health related activity than when an illness occurs, whereas a person with low self-efficacy would habour feelings of hopelessness (Omroid, 2006).

The definition of self-efficacy was further simplified by Bandura (1998). Perceived self-efficacy was defined as a person's belief about their capability to produce designated levels of performance that exercises influence over events that affect their lives. Self-efficacy determines how people feel, think, motivate themselves and behave. A strong sense of efficacy enhances human accomplishment and personal well being in many ways. People with high assurance in their capabilities approach difficult task as challenges to be mastered rather than as a threat to be avoided. Such an efficacious outlook fosters intrinsic interest, and deep engrossment in activities. It helps students set themselves challenging goals and maintain strong commitment to them. Students also heighten and sustain their efforts in the face of failure and quickly recover their sense of efficacy after failure or setback. Such students also attribute failure to insufficient effort or deficient knowledge and skills which are acquirable. Students also approach threatening situations with assurance that they can exercise control over them. Such an efficacy outlook produces personal accomplishments; reduces stress and vulnerability to depression (Zimmerman 2008).

Individual's belief in their ability to exert control over their and feelings of competence constitute self-efficacy (Elliot, Kratochwill, Littlefield and Travers, 2000). Furthermore, Joanne and Shui-fong (2008) are of the views that self-efficacy is the judgment of personal capacity to perform a specific and prospective task. It affects an individual's level of motivation, affective states and action (Bandura, 1997). In general, individuals with high efficacy not only out-perform those with low efficacy (Banduara 1997; 2001 Baron; 2004) but they also invest greater effort and persistence when facing setbacks (Bandura as cited in Joanne and Shui-fong, 2008).

Students' self-efficacy is reported to be linked to students' problem-solving skills, attitude and achievement in most academic areas, including the sciences. Self-efficacy is a person's self-appraisal of his/her capabilities (Adeoye, 2007). Adeoye (2007), on investigating the effects of self-efficacy on students' performance submit that self-efficacy influences students' academic performance in science.

From the foregoing discussion, it can be seem that self-efficacy is the belief that one can master situation in a given task and produce positive outcome. Ngwoke (2005), explained interest as something in which one identifies ones personal well being. In this sense interests are source of motivation. Deci, and Ryan (1991) argued that since intrinsically motivated behaviours are behaviour an individual undertakes out of interest, then clarifying the effect of interest would add to educators understanding of the impact of intrinsic motivation in learning.

In a similar development Hurlock as cited in Ngwoke (2005) maintained that interest drive people to do what they are free to choose. When people see that something will benefit them, they become interested in it. Every interest satisfies a need. In activities like counting, subtraction, addition and multiplication in mathematics, interest leads one to want to know or learn more from the task. Interest adds enjoyment; makes the performance of activity tasking and more economical in terms of demands on limited cognitive awareness (Ngwoke, 2005). Omroid (2006) described the concept of interest as the feeling that a topic is intriguing and enticing. That is, interest adds pleasure, excitement and liking in an academic endeavour thereby making students to remember the subject matter in the long run.

One dominant factor in science learning is interest. Interest has been seen as a psychological construct, which has the potential to increase or reduces students active participation in science. According to Nworgu and Ezeh (1999) interest can be defined as a feeling of like or dislike towards an activity. This shows that interest is that inert tendency which propels an individual towards engaging in a particular activity. Interest plays a very significant role in any learning process. It can mar a good and competent science teacher’s effort to achieve desired learning outcome.

2.2.8 Mental ability

Mental ability explains the level at which an individual assimilates, comprehends instructions, and resolves issues. It also refers to the capacity to reason, remember, understand and solve problems. An individual’s overall score is rated the most important factor in individual factors. Orukootan (2006) and Abimbade (2007) are of the view that mental ability can be used to determine high- and low-ability participants.

There have been controversies over the relationship between mental ability and students’ academic performance (Raimi, 2003). Studies have shown that the performance of students vary in subject to the types of materials and methods employed in instructing them (Okafor, 2006). Mental ability was found to influence students’ learning in Biology; it was only the pairs of low mental ability and high mental ability groups that were significantly different (Olagunju and Abiona, .2004). Against this background, mental ability was included as a variable in this study.

2.3 Empirical review

2.3.1 Computer simulation package and students' achievement in ecology and genetics

Some studies have indicated that using computer simulations instructional packages have positive influence on the achievement or performance of students in science. Kiboss, Wekesa and Ndirangu (2006), for instance, assessed a computer-based instruction simulation (CBIS) programme impart on learners' understanding and opinion of cell theory in school Biology. The CBIS programme was developed to teach Biology in schools, in form of a classroom invention to teach science. It affects positively enhances students' comprehension in cell division lessons.

Okoro and Etukudo (2001) affirmed that learners introduced to the CAI achieved significantly well than those subjected to the extrinsic motivation based traditional method. Akour (2006) found that students exposed to traditional instruction aided by the use of computer performed expressively better than their counterparts who were taught using traditional instruction.

Pektas, Türkmen and Solak (2006) in their research study examined that the success of students taught digestion and excretion in a computer-aided instructional process was profound than those that taught using the lecture method. Akcay, Aydoğdu, Yıldırım and Şensoy (2005) examined the efficiency of computer-aided method in science education in influencing the achievement of students than the traditional teaching method. Karamustafaoglu, Aydın and Özmen (2005) did a study on pre-service science-and-technology teachers. The dynamic-system simulation-based instruction used for the experimental group enhance achievement than the traditional instruction employed for the control group. In addition, Ozdener (2005) avers that computer generated laboratories support traditional laboratories. Students handled with this approach excelled in solving problems related to force and motion when taught "Force" in lessons aided by simulations prepared in collaborative Physics programmes (Uzun, 2004). Students who used computer-simulated experiments were also found to be statistically better at understanding speed and velocity.

Bayrak (2008) compared computer-assisted instruction and face-to-face instruction among Physics students. He used seventy-eight fresh students from the Divisions of Biology Education and Chemistry Education; there was also a pretest/post-test control group. The data were analysed with t-test with SPSS. The experimental group was found to be more successful than the control group.

Elangovan (2014) carried out a quasi-experimental study for six weeks. This was to determine the effectiveness of two different 3D computer simulation-based teaching methods, namely realistic simulation and non-realistic simulation. The participants were 136 Form Four Biology students in Perak, Malaysia. Paired samples t-test and one way ANCOVA were employed for analysis. The realistic simulation was more effective 3D computer simulation-based teaching method than the non-realistic simulation; the Biology students improved in achievement and memory retention.

Teke, Dogan and Duran (2015) compared the analysis of seventh-grade (the second level of the primary education) students' achievement in "The Human Body System". The unit in Science and Technology lesson examined the simulation method and the traditional method to determine the influence of these methods on students' learning. Seventy students that enrolled in the seventh grade in Konya in the 2009-2010 academic years took part in the study, which lasted five weeks. A statistically significant difference was found between the learning of the simulation-method group and the traditional-method group ($p<0.05$).

Olanekan and Oludipe (2016) carried out a study on the effects of computer simulation instructional strategy on the academic achievement of Biology students in DNA replication and transcription. The pretest-posttest quasi-experimental control group design was used for the study. DNA Replication and Transcription Achievement Test (DRTAT) was developed and administered to fifty undergraduate 300-level Biology Education students selected as the participants. The result showed a significant main effect of computer simulation on students' mean achievement score.

2.3.2 Computer simulation package and problem-solving skills in ecology and genetics

Computer simulation enhances learning through provision of opportunities to develop skills in problem identification, seeking, organizing, analysing, as well as evaluating, and communicating information (Akpan, 2001). It is also useful in developing the skills of problem-solving as well as decision-making in Biology issues (Lee, Hairston, Thames, Lawrence and Herron 2002). Furthermore, a well-designed simulation allows learners to deploy their mode of informational representation and develop hypotheses about events which are problematic as they solve problems (Windschitl and Andre, 1998). Genetics construction kits helped students to develop rich mental models of knowledge of genetics (Collins and Morrison, 1992; Liao and Chen 2007).

Huppert, Lomask and Lazarowitz (2002) investigated computer simulations in relation to how higher-level inquiry skills are developed. It was found that the students who used a simulated yeast cell lab performed better than those completing a hands-on lab. Similarly, Akpan and Andre (2000) determined the effectiveness of computer simulations and hands-on frog dissection used separately and together. Students who received simulations-before-dissection (SBD) and simulations-only (SO) significantly learned more anatomy than students who received dissections-before-simulations (DBS) or dissection-only (DO).

Barlis and Fajardo (2013) examined the effectiveness of simulation and computer-assisted instructions (CAI) among students under regimental training. They employed multiple choice and problem-solving questions on some topics in Physics II. The participants were in ten (10) intact sections; there were 113 for the traditional group and one hundred and 126 for the experimental group, who offered Engineering Physics during the second semester. Both groups had better performance at pretest to the posttest, irrespective of the methods adopted. Hence, both methods, individually, were effective in teaching the students.

2.3.3 Computer simulation package and students' attitude to ecology and genetics

Sahin (2006) asserts that one type of computer application is simulations. With simulations, teachers can make students focus better on learning objectives (De Jong and Van Joolingen, 1998). Simulations enable them to observe a real-world experience and interact with it (Sahin, 2006). Therefore, science education needs to develop suitable simulation pedagogies (Lindgren and Schwartz, 2009).

Kocakulah and Kocakulah (2006a) investigated the attitudes of students before and after the simulated instructions and experimental apparatus. A statistically significant difference was found in the two scores. Aşçı and Demircioğlu (2003), however, did not find any significant difference in the attitude of students exposed to computer simulation and those instructed through the traditional teaching strategy.

Aslan-Efe, Oral, Efe, Sünkür (2009) investigated students' achievement in and attitude to Biology. This was done through comparing computer simulation-supported Student Teams Achievement Divisions (STAD) of co-operative learning with traditional learning. A total of 81 students in 10^{th} grade participated in the study. An achievement test with 31 questions on photosynthesis and an attitude scale was employed to collect data. The teaching method that was supported by computer simulations had greater effects on students' achievement; there was also no statistically significant difference between the attitudes of the two groups.

2.3.4 Digital puzzle-based instructional package and students' achievement in ecology and genetics

Digital games have been found to be very useful different disciplines in the past decades (Koether, 2003; Franklin, Peat and Lewis, 2003; Lauer, 2003). Instructional digital games are constructed to enhance learners' performance in Mathematics (Kebritchi, Hirumi, and Bai, 2010; Pilli and Aksu, 2012). Ann (2006) and Nelson (2011) advocate the use of puzzle instructional package all through stages in education and all ages.

The various formats for students to demonstrate their learning could improve students' interest and interaction, and extend classroom learning (Orlich, et al., 2010). Digital puzzles create a powerful learning environment. Harris (2001) found no distinct fundamental link between academic prowess and usage of digital games. Hays' (2005) exploration on forty-eight experimental had varied results. However, a criticism of 32 numerical studies found immersive digital games to be more impactful on the cognitive gains of learners than the traditional approach (Vogel et al., 2006).

Pange (2003) claims that playing digital games improves the cognitive functioning of the brain. Yip and Kwan (2006) discovered that the attention and knowledge transfer of students improved when digital games were employed (Shaffer et al., 2005). The games also created collaborative learning environments.

In spite of the seeming effectiveness of puzzle instructional package, some studies have shown limitations of this package. Ross and Huang (2001) and Hill (2003) confirmed that it is not always effective in teaching operating system concept in computer studies. Obstfeld, Maurice and Kenneth (2001) identified some of these limitations to include: lack of required skills or creative imagination by teachers for adapting, adopting and creating puzzles; financial constraint; time constraint and scarcity of relevant textbooks. This inconsistency indicates that studies on the effectiveness of digital puzzle in the classroom are inconclusive.

The studies conducted by Coulter (2003), Kaka (2008), Falkner, Saoriamarthi and Michalewicz (2009), Adedoja, Abidoye and Afolabi (2013) revealed the effectiveness of puzzle in promoting academic achievement in different subjects. However the aforementioned scholars' investigations were not self-learning or computer-based.

Experts have identified the importance and usefulness of puzzles in teaching and learning processes. Puzzle instructional packages in science education in Korean universities improved comprehension of abstract concepts; they also develop problem-solving abilities in students (Anany and Mary 2002). Puzzle-solving engages students with materials (Kendall et al, 2008).

2.3.5 Digital puzzle instructional package and problem-solving skills in ecology and genetics

Digital puzzle package is a new instructional package that is focused on the development of problem-solving skills (ACM, 2006). A paradox or puzzle involving the concept is one of the most useful means of sorting out students' intuition on a giving topic. It helps them struggle towards a solution. A classroom that employs different experiences could aid students' success (Orlich, Harder, Callahan, Trevisan and Brown, 2010). Studies involving eclectic teaching experiences showed that students achieve more with this kind of approach (Maal, 2004).

Digital puzzle instructional package gives a multi-sensory instruction which combines the use of intuition and puzzle to create the optimal setting identified by Maal (2004). The digital puzzle instructional package aims to encourage science students in problem solving (Nicholas, 2009). According to Fisher (2001) and ACM (2006), most of the students never learn how to think about solving problems throughout their education period.

Scotts (2006) emphasizes that teaching with puzzle that are produced from wood or very heavy cardboard helps young children aged 1-8 years learn motor skills and hand-eye coordination as they fix the pieces of puzzles together. Logical puzzles can be used to teach logical thinking skills, spatial concepts, and motor coordination. Physical puzzles are particularly good for tactile learners who in most cases cannot absorb traditional educational methods.

Research, as observed by Idowu and Ige (2007), shows that the use of puzzles in teaching and learning in Nigerian schools has been scored very low. This is because puzzles are usually used as entertainment and relaxation rather than puzzles, particularly in teaching abstract concepts. Serj (2002) notes that puzzle instructional package is significantly better when compared with the conventional method in developing problem-solving skills in junior secondary school mathematics. Idowu and Ige (2007) are of the opinion that puzzle-based learning build problem-solving skills in students by experience, imitation and reflection.

2.3.6 Digital puzzle instructional package and students' attitude to ecology and genetics

Pilar (2013) investigated the effects of digital games on the mathematical achievement, attitude and motivation of middle school students. One hundred and sixty-eight students of a private transnational school in Africa were involved in the study. They were randomly stratified into treatment and control groups. Scholarship was assessed using internal school examinations based on standards affliated to that of the National Council of Teachers of Mathematics (NCTM) principles and benchmarks. The Course Interest Survey (CIS) based on Keller's ARCS model of motivation was employed to measure motivation to learn Mathematics. Fennema-Sherman Mathematical Attitude Scales (FSMAS) was deployed to measure mathematical attitude. A Multivariate Analysis of Covariance performed. A significant increase was found in all the independent variables. Using the digital game boosted the interest of the students, thereby producing a positive attitude in them.

2.3.7 Modified conventional package and students' learning outcomes

This is the oldest method of teaching used in most Nigerian schools. It is a traditional talk-chalk strategy. The teacher "gives out" the facts to the students and the students listen and digest the knowledge (Osokoya, 2002).

There are reasons listed by Adesoji (2004) which make teachers refuse to change their conventional teaching style:

(a) Lack of infrastructural facilities
(b) Overloaded curriculum
(c) Lack of training programmes/workshops, and
(d) Lack of skill in handling difficult concepts identified..

Olagunju, (2002) observes that the conventional lecture method commonly used by science teachers is monotonous, students are passive and no meaningful learning takes place. This contributes to the negative attitude toward science, which results in underachievement. Ajayi (2005) asserts that instructional strategies should be varied, as there is no perfect strategy for teaching and learning outcomes. Robert (2003) argues that the conventional lecture method cannot be totally ignored; any innovation of instructional strategy is to complement the conventional lecture method.

2.3.8 Self-efficacy and students' achievement in ecology and genetics

Pajares (2006) avers that students who have a strong sense of efficacy are more likely to challenge themselves with difficult tasks and be motivated intrinsically. They will put up a high degree of effort so as to meet their commitment; they also attribute failure to things in their control instead of blaming external factors. They equally quickly recover from setbacks; so they are likely to get their personal goals. They blame failure on insufficient input or poor knowledge and skills, which are acquirable. Conversely, low self-efficacy students are convinced that they cannot perform well; therefore, they may not make any serious effort.

Elsevier (2009) inspected the basic relations among self-efficacy, academic ambitions and delinquency on the academic achievements of selected Austrian students. They were 935 from ten schools and they were aged 11-18 years. Academic and self-regulatory efficacy was discovered to have effect on academic achievement. Academic efficacy had positive relationship with aspirations; while social self-efficacy had negative relationship with academic achievement. Tella (2015) found no significant main effect of self-efficacy on students' achievement in Chemistry.

Aremu and Tella (2009) investigated the relationship between gender, age, general mental ability, anxiety, Mathematics self-efficacy and achievement in Mathematics among students in secondary schools in Oyo State, Nigeria. Multiple regression was employed to analyse the data collected from 1,099 SS2 students. Mathematics self-efficacy, anxiety and gender had significant correlations with students' achievement in Mathematics. Therefore, Mathematics self-efficacy was considered the best predictor of Mathematics achievement, and then gender and anxiety.

Shahrzad, Kourosh, Mohammad, Haitham and Hossein (2011) investigated the relationship that exists between self-efficacy and academic achievement in high school students. A total of 250 students in the academic year 2010/2011 were picked by the use of multistage cluster sampling and completed self-efficacy scale. Average in classes was used to measure achievement score grade point. The data collected were subjected to correlation coefficient and regression analysis. Self-evaluation, self-directing and self-regulation had relationship with academic achievement. The researchers concluded that self-efficacy is a reckoning factor in academic achievement.

2.3.9 Self-efficacy and problem solving skills in ecology and genetics

Bandura (1994) claims that self-efficacy beliefs determine how people feel, think, motivate themselves and behave. Cognitive, motivation, affective and selection processes are important in this regard. A strong sense of self-efficacy boosts accomplishments and personal well-being.

Aurah, Cassady and McConnell (2014) investigated the influence of metacognition and self-efficacy beliefs on genetics problem-solving ability among Kenyan high school students using a quasi-experimental research design. A total of 2,138 purposively selected high school students in Western Province, Kenya served as participants. Biology ability test, a self-efficacy questionnaire, a genetics problem-solving test, and metacognitive prompting questionnaire were the instruments employed for data collection. The analysis was through descriptive statistics, correlations, and multiple regressions. Genetic problem-solving ability was predicted by metacognition and self-efficacy. The relationship between metacognition and genetics problem-solving ability was also moderated by self-efficacy.

2.3.10 Self-efficacy and students' attitude to ecology and genetics

The relationship between the self-efficacy belief of students and their achievement has been analysed in many studies. Woolfolk, Hoy, and Davis (2005) established that the self-efficacy of the teachers positively affected the achievement and attitude of the students. Tschannen-Moran and Hoy (2001) found self-efficacy to be directly related to the classroom behaviours of the teacher. Self-efficacy, according to Ukoh (2012), is an individual's own capacity and positive or negative judgements about himself/herself. This means that self-efficacy is not a function of an individual's skills but his/her belief about having the skill and ability to put them into use.

Ukoh (2012) avers that self-efficacy belief of a teacher is the judgement that his abilities would be effective for the achievement and learning of students. Self-efficacy belief has an important effect for providing a quality education. Tella (2015) found that there was significant main effect of self-efficacy on students' attitude to Chemistry. High self-efficacy had the highest adjusted mean score, followed by medium and lastly followed by low self-efficacy.

Ward (2001) and Popoola (2012) found that students of high self-efficacy were found to have better attitudes to Chemistry than those of low self-efficacy and students with medium self-efficacy performed better than those of low self- efficacy.

2.3.11 Students' mental ability and students' achievement in ecology and genetics

The ability of a learner is a construct that researchers have found to affect the achievement of students especially in science and Mathematics (Sangodoyin, 2011; Dada, 2014). Students of different mental ability levels often perform in different ways, depending on the types of methods and materials used for instruction. Sangodoyin (2011) emphasizes that students with low mental ability need special attention in their work. This is because, usually, their level of motivation towards learning is very low and their attitude to learning is usually negative. Based on this, there is need to develop strategies and materials that can increase the motivation and improve attitude of such learners.

Kuncel, Crede and Thomas (2005) conducted a study on general mental ability predicting achievement in Mathematics. A total of 969 adolescents (60% females, 40% males) attending grades 7 to 12, with ages ranging from 13 to 18 and a mean age of 16.4 years (SD = 1.62) served as the sample. General intelligence was measured through the Mental Abilities Scale for Students (ÕP-VVS) developed by Tripod. The mean levels of total scores differed statistically significantly ($p < .001$) between high and low academic achievement groups in all ages, $F(2,626) = 23.2$, $p < .001$. Besides, successful students in Mathematics performed above average in mental abilities test. However, the students that had low academic achievement in Mathematics had below-average intelligence scores.

Vocka, Preckelb and Hollingc (2011) investigated mental abilities and school achievement. They analysed the interplay of reasoning, divergent thinking, mental speed, and short-term memory, in relation to academic achievement. Adolescents in grades 7 to 10 (N = 1135) constituted the sample. The data were analysed through structural equation modelling. Mental speed and short-term memory were found to reflect basic cognitive processes.

Akinlana (2013) investigated the contributions of academic optimism, academic motivation and mental ability to academic performance of senior secondary students. The study was conducted in Ogun State, Nigeria. Five hundred and eighty-eight students participated in the study. General Achievement Goal Orientation Scale, Almost Perfect Scale-Revised, and Mental Ability Test tested the independent variables; Junior School Certificate Examination results in Mathematics, English and Integrated Science tested the dependent variable. Analysis was done using Multiple Regression Analysis. Mental ability was the most potent predictor variable ($B = .052$; $t = 6.729$; $p<.05$).

Babayemi and Akinsola (2014) investigated the effects of crossword-picture puzzle (CPP) and mental ability on students' achievement in Basic Science. A pretest-posttest quasi- experimental design was employed. The sample consisted of 389 JSS II Basic Science Students from nine schools randomly selected in three states in Southwestern Nigeria. Four instruments were used–Teachers' Instructional Guides for: Crossword-Picture Puzzle Teaching Strategy, Conventional Lecture Method;

Basic Science Students' Achievement Test ($r=0.70$) and Australian Council for Educational Research Test ($r=0.86$). The data were analysed using ANCOVA and mean scores. The results showed that mental ability significantly affected achievement (F (2, 389) =5.04; $p<0.05$; $\eta^2=.03$).

Castro, Prenda, Laguador and Pesigan (2015) did a a survey of mental ability, work behaviour and trait of high- and low-performing first-year Computer Engineering students. The results showed that high- performing students had significantly higher persistence in doing their work and they had significantly higher expectations of positive effect from achievement-oriented activity than the low-performing students.

2.3.12 Students' mental ability and problem solving skills in ecology and genetics

Yoloye (2004) defines mental ability as a genetic, cognitive, physiological, nutritional and social factor as well as acquisition of skills all taken together to decide ability. The global objective guiding the consideration of mental ability is that the test has the capacity to differentiate between high- and low-ability participants (Adekunle, 2005; Orukootan, 2006; and Abimbade, 2007).

To Mayer (2000), the nature of interactivity and discovery in cooperative learning bears a beneficial boost to the monotony of passive learning. With this, both the teacher and students may control their own pace of lesson according to their individual ability. In addition, cooperative learning can give low-ability students extensive learning time before moving forward through the help from high- mental ability colleagues which are not confined by linearity on much slower pace (Mayer and Moreno, 2003). Therefore, the liberty to proceed or recede and collaboration with other learners allow self-pacing, which ensures that both group of students perceive information equally. Mental ability, to some extent, determines the imagination, language perception, concepts formation, and problem-solving ability of the learners.

Pajares and Kranzler (1995) examined self-efficacy beliefs and general mental ability in relation to mathematical problem solving. They sampled 329 high school students. The results revealed that mental ability had strong direct effects on problem-solving performance.

2.3.13 Students' mental ability and students' attitude to ecology and genetics

Mental ability has also been found to influence students in science. Raimi (2003), Olagunju and Chukwuka (2008), Dada (2015) found that mental ability had effects on the students' attitude. Morribend (2004) concluded from his study that mental ability had significant effect on students' attitude. Students with high level of mental ability display confidence in handling issues and in understanding concepts. These improve their academic performance and enhance their attitude to the concepts. They are encouraged to seek in-depth knowledge of the concepts. Low mental ability is associated with timidity, incompetence, negative attitude to concepts and generally to life situations.

2.4 Appraisal of the reviewed literature

From the reviewed literature, it is clear that there have been past studies (both within and outside Nigeria) which investigated the effect of the instructional strategies on learning outcomes, the interaction effect of self-efficacy and mental ability with instructional strategies and their ultimate effects on learning outcomes in Biology. Some have shown significant effect of mental ability and self-efficacy on learning outcomes, while some could not establish this.

The review of literature on computer simulation and digital puzzle instructional packages showed that the majority of the studies were on Chemistry and Physics and Mathematics and none on Biology. From studies on computer simulation and digital puzzle packages that were examined, it has been observed that most of the studies were conducted on acquisition of science vocabulary, Mathematics, Physics, Chemistry, Accounting, Economics and Foreign Language. The review could not establish empirical bases for using computer simulation and digital puzzle in teaching and learning Biology.

The existing literature also publicised that the mental ability of the learners is very important in learning; it plays a major role in determining an individual's performance. Low mental ability in Biology can mar students' problem-solving skills, attitude and achievement in ecology and genetics in Biology. Furthermore, the review of literature showed that students' self-efficacy associated with Biology appears to affect students' problem-solving skills, attitude and achievement in Ecology and Genetics.

Therefore, there is the need for further studies to establish the appropriate instructional method for both high-and low-mental ability students with different self-efficacy levels in ecology and genetics. The past studies on the use of computer simulation and digital puzzle instructions did not focus on the moderating effects of mental ability and self-efficacy and did not establish the combining effect of computer simulations and digital puzzle on senior secondary schools Biology students' learning outcomes in ecology and genetics. This is the gap which this study filled.

CHAPTER THREE

METHODOLOGY

3.1 Research design

The study adopted the pretest-posttest control group quasi-experimental design using a 4x3x2 factorial matrix. It examined possible effects of computer simulation and digital puzzle instructions, mental ability and self-efficacy on students' achievement, problem-solving skill, attitude to ecology and genetics in Biology. The design is shown structurally below:

0_1 X_1 0_2 E_1 (Experimental group 1, Computer Simulation Package)

0_3 X_2 0_4 E_2 (Experimental group 2, Digital Puzzle Package)

0_5 X_3 0_6 E_3 (Experimental group 3, Computer Simulation-Digital Puzzle Package)

0_7 X_4 0_8 C (Control group)

Where O1 and O_3 $0_5$and 0_7 are pretest scores of the experimental and control groups, respectively.

0_2, 04, 0_6 and 0_8 are posttest scores of the experimental and control groups, respectively.

X_1 is for the experimental treatment of computer simulation package.

X_2 is for the experimental treatment of digital puzzle package

X_3 is for the experimental treatment of computer simulation- digital puzzle package

X_4 is for the conventional package.

The analytically designed 4x3x2 factorial matrix of the study is presented in the table 3.1.

Table 3.1: Schematic Representation of the Matrix

Treatment/strategies	**MENTAL ABILITY**	**Self efficacy**		
		High	Medium	Low
Computer Simulation	High			
	Low			
Digital Puzzle Learning	High			
	Low			
Computer Simulation – Digital Puzzle	High			
	Low			
Conventional Package	High			
	Low			

3.2 Variables of the study

The following were the variables of the study include:

Independent variable: This was the instructional package at four levels

i. Computer simulation instruction
ii. Digital puzzle instruction
iii. Computer simulation – digital puzzle instruction
iv. Conventional-based instruction

Moderator variables:

i. Self-efficacy (at three levels: high, medium and low)
ii. Mental ability(at two levels: high and low)

Dependent variables:

i. Students' achievement in ecology and genetics
ii. Students' problem solving skills in ecology and genetics
iii. Students' attitude to ecology and genetics in Biology

3.3 Selection of participants

Four randomly selected local government areas of Oyo State were used for the study. Two schools were purposively selected from each local government area under study, six schools for the three experimental groups and two for the control groups. Eight purposively selected schools were used for the study and eight intact classes were used altogether. The criteria for the selection of the schools for experimental groups were

i. must be co-educational schools
ii. availability of computers
iii. presence of an experience Biology teacher
iv. Evidence that the topics ecology and genetics have not been taught

The criteria for the selection of schools for control groups were

(i) Unavailability of computers
(ii) Presence of a Biology teacher
(iii) Evidence that the topics ecology and genetics have not been taught.

Selection of concepts

Some of the topics identified in the Biology syllabus that are related to ecology and genetics sub-concepts are biomes, ecosystem, measurement, pollution, Gregor Mendel's work, terminologies used in genetics, basic laws in genetics, transmittable character, transmission and separation of character in organisms.

3.4 Research instruments

(1) Students' Achievement Test in Ecology and Genetics (SATEG)

(2) Students Problem-Solving Test in Ecology and Genetics (SPSTEG)

(3) Students'' Attitude to Ecology and Genetics Biology Scale (SAEGBS)

(4) Students' Self-Efficacy Scale (SSES)

(5) Students' Mental Ability Test (SMAT)

(6) Instructional Guides for Computer Simulation Package on Ecology and Genetics in Biology (IGCSPEGB)

(7) Instructional Guides for Digital Puzzle Package on Ecology and Genetics in Biology (IGDPPEGB)

(8) Instructional Guides for Computer-Simulation and Digital Puzzle Package on Ecology and Genetics in Biology

(9) Instructional Guides for Conventional Instructional Package on Ecology and Genetics in Biology (MCIPEGB)

(10) Evaluation Sheet for Assessing Teachers' Performance on the Use of the Packages (ESAPT)

3.4.1 Students' Achievement Test in Ecology and Genetics (SATEG)

The test was self-constructed. The instrument was used to measure students' achievement in ecology and genetics. It consisted of forty (40) multiple choice items with 4 options labelled A-D. After giving it to 4 biology experts to read, only twenty-five (25) multiple choice items survived scrutiny. The twenty-five (25) multiple choice questions were given to twenty (20) SS II students in a pilot school, and only twenty (20) items survived scrutiny using discrimination indices of 0.4-0.6. The 20 items were administered in another school which was not part of the schools for study and the items were found to be content- and face-valid. The reliability coefficient was established using Kuder-Richardson formular (KR20). The reliability index of 0.80 was obtained. The instrument was used for both the pretest and the posttest.

Table 3.2: Table of Specification for Students' Achievement Test in Ecology and Genetics (SATEG)

Topic	Level of cognitive development						Total
	Knowledge	Comprehension	Appli cation	Analysis	Synthesis	Evalu ation	
Biomes	2	7	-	10	-	-	3
Ecosystem	1,	4	6	9	13	3	6
Measurement	18	-	20	-	-	-	2
Pollution	8	-	-	-	-	-	1
Gregor Mendel's work	-	11	-	-	-	-	1
Terminologies used in Genetics	-	-	-	-	15	5	2
Basic laws in genetics	-	19	-	17	-	-	2
Transmittable character	16	-	-	-			1
Transmission and separation of character in organisms	14	-	12	-			2
Total	6	4	3	3	2	2	20

3.4.2 Students' Problem-Solving Test on Ecology and Genetics in Biology (SPSTEG)

The test was designed by the researcher to measure students' problem solving in ecology and genetics. The instrument was made up of two sections – A and B. Section A contained personal data of the subjects. Section B had eight structured problems testing the students' problem-solving ability in ecology and genetics problems. The model of choice was that of Ashmore, Frazer and Casey (1979). The students defined the problem, selected appropriate information, combined the separate pieces of information and evaluated them. The reliability coefficients of the eight test items were determined using test-retest method, which gave 0.83.

3.4.3 Students Attitude to Ecology and Genetics Scale (SAEGS)

The instrument was developed by the researcher to measure the affective learning outcomes, referred to as the students' attitude to the use of computer simulation and puzzle-based packages in the teaching of ecology and genetics concepts in Biology. The instrument consisted of two sections. Section A focused on the personal data of the students: name, sex, age bracket, name of school, school type. Section B had 20

Likert-type scale responses: Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). Cronbach alpha co-efficient of 0.79 was obtained. Therefore, the instrument was considered high enough to be used for the study.

Scoring of Attitude to Ecology and Genetics Scale (SAEGS)

The scoring of SAEGS was as follows**:** Strongly Agree (SA) – 4 marks**,** Agree (A) – 3 marks

Disagree (DA) – 2 marks and Strongly Disagree (SD) – 1 mark. This goes for positively worded statement, while the reverse was used for negatively worded statements: Strongly Disagree (SD) – 4 marks, Disagree (DA) – 3 marks, Agree (A) – 2 marks and Strongly Agree (SA) – 1mark.

Validation of Students Attitude to Ecology and Genetics Scale (SAEGS)

For validation, the instrument containing twenty-seven items initially was given to experts in Biology Education, particularly Biology teachers in secondary schools in Oyo State. Copies were also given to English teachers and finally the supervisor of the research so as to make necessary correction and ascertain its workability for the study. The items were reduced to twenty-five, which were used for trial-testing. After validation, the items were eventually reduced to twenty. Cronbach alpha co-efficient of 0.79 was obtained. Therefore, the instrument was considered high enough to be used for the study.

3.4.4 Students' Self-Efficacy Scale (SSES)

The Students' Self-Efficacy Scale developed by Lisa-Looney (2003) was adopted and adapted for the purpose of this study. This instrument consisted of twenty (20) items graded based on a four-point Likert scale: Strongly Agree, Agree, Disagree and Strongly Disagree. The positive statements were graded 4,3,2,1, respectively; while the reverse 1,2,3,4 was the case for the negative statements. In order to validate the modified instrument, it was given to three experts in the Department of Teacher Education for their expert advice with respect to the language level, suitability and overall faces validity of the instrument. Correction was thereafter made based on their input. The instrument was also given to the candidate's supervisor to make the final modifications. The instrument was then administered to 30 SS II students who were not part of the main study. The reliability coefficient of the instrument was calculated using the Cronbach alpha and the value was obtained as 0.80

3.4.5 Students' Mental Ability Test (SMAT)

This instrument measured the mental ability of the learners. The instrument was adopted and adapted from one of the world's leading educational research centres –ACER. The instrument was re-validated before being adapted by testing it on SS2 students in a school quite different from the intended samples for this research and the discriminating level was ascertained.

Scoring of SMAT

The maximum score a student can obtain is 100%. Students who scored 60% and above were grouped into high mental group; 40% to 59% were assigned to medium-ability group; while students who obtained less than 40% were placed in low mental-ability group.

The instrument was validated using Alternate/Parallel forms of reliability and the value obtained was 0.85.

3.4.6 Computer Simulation Package on Ecology and Genetics in Biology (CSPEGB)

CSPEGB, a self-developed programme, involved the trained teachers as facilitators to operate during its use. CSPEGB was prepared according to the behavioural objectives of the topics ecology and genetics in the curriculum.

The validity of the instrument was done and the reliability was determined using Cronbach Alpha which gave 0.86.

3.4.7 Digital Puzzle Instructional Package

This is a package designed to break down the concepts ecology and genetics. The puzzle clues and the key used were adapted from www.TheTeachercorner.net. These are crossword and pictorial puzzles that can be digitalized using computer. They are beneficial in that they teach vocabulary, critical thinking skills, spellings and correct misconceptions in some concepts. In these stimulus instruments, the teacher introduces and demonstrates a new puzzle.

Procedure for Validation of the Package

This was adapted from Fakokunde (2014). This procedure was followed:

a. **Subject Content Validation:** The draft of the content on the selected topics were given to three Biology teachers to assess the adequacy of the content premised on the depth of coverage as required in the curriculum for the subject, appropriateness in terms of sequencing and use of language. Observations and corrections made by the teachers were incorporated before transforming it into puzzle-based package.

b. **Computer Expert Validation:** The prototype of the package was given to two computer experts to go through so as to express their opinion in terms of clarity, typography, legibility and navigation of the instructional package. Their suggestions were taken into consideration in the production of the final package.

c. **Educational Technology Expert Validation**: The prototype was shown to three lecturers in Educational Technology to ascertain conformity with the acceptable standard in educational technology in terms of simplicity, unity, emphasis, ease of navigation, appropriateness of the pictures and colours used in the package. The prototype was moderated based on their suggestions and re-presented to them. Their recommendations were effected and the prototype was presented to them.

d. **One-to-one Validation:** The prototype was trial-tested in a school that was not slated for the study by selecting five students through the assistance of the subject teacher. The first prototype was without separate content apart from what was incorporated in the real puzzle aspect of the package. The second stage of trial-testing was carried out after the provision for separate content menu in the package as suggested by the subject teacher during the first trial-testing. Another set of five students were selected to work on the package. The students read the content before working on the puzzle. The time taken to complete all the questions was recorded on their first trial. The same students were again exposed to the package and the number of students that were able to finish within the stipulated time was noted. The time stipulated for working on the package was ascertained based on the suggestions from the students.

3.4.8 Teacher Instructional Guide on Simulation Package

The instrument was developed by the researcher to guide the use of Computer Simulation Package (CSP) in the teaching of ecology and genetics. It was prepared according to the behavioural objectives of the ecology and genetics concepts. The teachers were trained to be able to guide the students during the treatment using the instructional guide provided by the researcher.

The following are the steps to follow in using Simulation Package:

Preparation Phase

1. Find out pupils prior knowledge of the topic through relevant questions
2. The teacher orientates the students on the objectives and expected performance in each phase
3. The students are allowed to put theoretical knowledge already gained into action – mount the disc (computer simulation CD) on the system already connected to the projector.

Teaching Phase

4. The teacher executes the lesson in line with the prepared plan and the time allotted for teaching the lesson. The presentation takes 10-15 minutes only.
5. The students identify, watch and listen to the simulation.

Evaluation Phase

6. The students ask questions on their observations or part of the simulation presentation that is not clear.

Reflection Phase

7. The teacher explains, models, illustrates, clarifies, and supplies missing information
8. The students generate important notes.

Modification Phase

9. The students give insights, feedback and comments gained during the teaching, when the teacher was answering the questions and supplying the missing information.
10. The students correct or modify previous information.

3.4.9 Teachers' Instructional Guide on Digital Instructional Package (TIGPP)

Preparation Phase

Step 1: The students are positioned by the computer they are to work with.

2. The students are given the package to work with.
3. The students are instructed on how to work with the package.
4. The teacher moves round the classroom to monitor the participants.

Introduction phase:

5. The teacher attracts students' attention to activate their background knowledge on the topic to be considered by asking questions based on their previous knowledge.

Presentation phase:

6. The students identify the keywords and sub-concepts using ecology and genetics puzzles clues.
7. The teacher asks the students more questions using the clues to generate additional information on the topic.
8. The students' views on the concept are clarified using the ecology and genetics puzzle.

Evaluation phase:

9. The teacher assesses the students for more critical analysis on the content using the ecology and genetics puzzle clues.
10. The students practise individually.

11. The students develop a deep understanding of the topics studied and improve their thinking abilities, through independent studies.
12. The students are given homework or assignment to further practise the skill developed.

The inter-rater reliability index was determined as 0.83.

Teacher's Instructional Guide on Computer Simulation – Digital Puzzle Package

Preparation phase:

1) The teacher asks the students some questions to test their previous knowledge on the sub-concept being considered.
2) The students are instructed on how to use the package.

Teaching Phase:

1) The teacher presents computer simulation package for 10-15 minutes depending on the scope of the topic.
2) The students identify, watch and listen to the computer simulation presentation.

Evaluation phase:

1) The teacher gives the clues on different topics under ecology and genetics to task the students critical thinking ability
2) The students supply the answers (keywords) and type them on the crossword puzzle sheet as across clue or down clue (column and rows).

Reflection phase:

1) The teacher approves or corrects the students' answers. He/she clarifies and supplies the missing answers if there is any.
2) The students write notes based on the correction given by the teacher.

Modification phase:

1) The teacher asks related questions that can generate correct and logical response, insight and feedback
2) The students modify knowledge on the topic.

3.4.10 Teachers' Instructional Guide on Conventional Package

The instrument was prepared according to the behavioural objective of the ecology and genetics concepts. The instrument was self-developed. The instrument was used in schools representing the control group.

Students are to sit individually throughout the lesson. The treatment for each lesson is in the form of a lecture:

Step 1 - The teacher presents the lesson in form of a lecture.

Step 2 - The teacher writes the topic for the lesson on the chalkboard.

Step 3 - The teacher states the objectives for the lesson.

Step 4 - The teacher outlines the content of the topic on the chalkboard.

Step 5 - The teacher explains the content, making use of the lesson note provided by the researcher in handling each topic.

Step 6 - The students listen to the teacher and write down chalkboard summary.

Step 7- The teacher allows the students to ask questions on areas of the topic that are not clear to them.

Step 8 - the teacher answers the students' questions.

Step 9 - The teacher summaries the lesson.

Step 10- The teacher gives the students home assignment.

The instrument was validated using the Scott's π statistical measure. The reliability coefficient of 0.85 was obtained.

3.4.11 Evaluation Sheet for Assessing Teachers' Performance on the Use of the Package (ESATPP)

This is the guideline for evaluating the performance of the trained teachers on the effective use of these packages:

Computer Simulation Instructional Package (CSIP).

Puzzle-Based Learning Instructional Package (PBLIP).

Computer Simulation – puzzle instruction package (SPIP)

Conventional Instructional Package (CIP)

Section A – This consisted of the personal data of the trained teacher.

Section B –This consisted of the items to be evaluated. The items were placed on a 5-point Likert type rating scale: Very Good, Good, Average, Poor, and Very Poor.

The scoring of ESATP was as follows**:** Very Good (VG) – 5marks, Good (G) – 4 marks, Average (AV) – 3 marks, Poor (P) – 2 marks, and Very Poor (VP) –1 mark.

The instrument was piloted to ensure its reliability. Experts were consulted to ascertain the appropriateness of the concepts and methods. Their observations and comments were considered in the final draft.

3.5 Research procedure

3.5.1 Training of teachers:

Three weeks was used to train the research assistants, who were Biology teachers in the schools for the study. The purpose and procedure for the study were explained to them. The teachers in the experimental groups were exposed to the use of the instructional package. Thereafter, they were allowed to use it so as to assess their competence. The teachers in the control group were also told the procedure for the study. The objectives and content of each topic were given to each of them.

3.5.2 Pretest

After the training of the teachers, the participants in each group were asked to allow students to fill the Self-Efficacy Checklist and the Mental Ability Test in order to categorise them according to their Self-Efficacy and Mental Ability Groups. This was followed by the administration of

(1) Students' Achievement Test in Ecology and Genetics (SATEG)

(2) Students' Problem-Solving Test in Ecology and Genetics (SPSTEG)

(3) Students' Attitude to ecology and Genetics Biology Scale (SAEGBS)

3.5.3 Treatments Procedures

The teachers administered the treatments for the groups for eight weeks. The researcher moved round the schools once a week to monitor compliance with the research procedure.

Experimental Procedures

Experimental group 1: Steps to follow in using Simulation Package are

Preparation Phase

1. Find out pupils prior knowledge of the topic through relevant questions.
2. The teacher orientates the students on the instructional objectives in each phase
3. The students are allowed to put theoretical knowledge already gained into action – mount the disc (computer simulation CD) on the system already connected to the projector.

Teaching Phase

4. The teacher executes the lesson in line with the given plan and time. The presentation takes 10-15 minutes only.
5. The students identify, watch and listen to the simulation.

Evaluation Phase

6. The students ask questions on their observations or part of the simulation presentation that is not clear.

Reflection Phase

7. The teacher explains, models, illustrates, clarifies, supplies missing information.
8. The students generate important notes.

Modification Phase

9. The students give insights, feedback and comments gained during the teaching, when the teacher was answering the questions and supplying the missing information.
10. The students correct or modify previous information.

Experimental Group 2:

Preparation phase

Step 1: The students are positioned by the computer they are to work with.

2. The students are given the package to work with.
3. the students are instructed on how to work with the package.
4. The teacher moves round the classroom to monitor the participants.

Introduction phase of the content involves

5. The teacher attracts students' attention to activate their background knowledge on the topic to be considered by asking questions based on their previous knowledge.

Presentation phase:

6. The students identify the keywords and sub-concepts using ecology and genetics puzzles clues.
7. The teacher asks the students more questions using the clues to generate additional information on topic.
8. The students' views on the concept are clarified using the ecology and genetics puzzle.

Evaluation phase:

9. The teacher assesses the students for more critical analysis on the content using the ecology and genetics puzzle clues.
10. The students practise individually.
11. The students develop a deep understanding of the topics, and through independent studies, and improve their thinking abilities.
12. The students are given homework or assignment to further practise the skill developed.

Teacher's Instructional Guide on Computer Simulation – Digital Puzzle Package

Preparation phase:

3) The teacher asks the students some questions to test their previous knowledge on the sub-concept being considered.
4) The students are instructed on how to use the package.

Teaching Phase:

3) The teacher presents computer simulation package for 10-15 minutes, depending on the scope of the topic.
4) The students identify, watch and listen to the computer simulation presentation.

Evaluation phase:

3) The teacher gives the clues on different topics under ecology and genetics to task the students critical thinking ability
4) The students supply the answers (keywords) and type then on the cross-word puzzle sheet as across clue or down clue (column and rows).

Reflection phase:

3) The teacher approves or corrects the students answers. He/she clarifies and supplies the missing answers if there is any.
4) The students write notes based on the correction given by the teacher.

Modification phase:

3) The teacher asks related questions that can generate correct, logical response, insight and feedback.
4) The students modify knowledge on the topic.

Control Group Procedure

Step 1 - The teacher writes the topic for the lesson on the chalkboard.

Step 2 - The teacher states the objectives for the lesson.

Step 3 - The teacher outlines the content of the topic on the chalkboard.

Step 4 - The teacher explains the content, making use of the lesson note provided by the researcher in handling each topic.

Step 5 - the students listen to the teacher and write down chalkboard summary.

Step 6- The teacher allows students ask questions on areas of the topic that are not clear to them.

Step 7 - The teacher answers the students' questions.

Step 8 - The teacher summaries the lesson.

Step 9- The teacher gives students home assignment.

3.5.4 Posttest

This was administered in the thirteenth week. The Students' Attitude to Biology (SAB) and Students' Achievement Test in Ecology and Genetics Ecology (SATEG) were administered before the Students' Problem Solving Test (SPST)

3.6 Methods of data analysis

The data collected were analysed using descriptive statistics; frequency count, mean, standard deviation aspects of descriptive statistics were used. Analysis of Covariance (ANCOVA) of inferential statistics was used in testing the hypotheses using the pretest scores as covariates and Estimated Marginal Means was computed to show how the groups performed, while Scheffe Post-hoc Analysis was used to detect the source of significant difference between the groups where they existed. All hypotheses were tested at 0.05 level of significance.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Testing of the null hypotheses

$H0_{1a}$: There is no significant main effect of treatment on students' achievement in ecology and genetics concepts in biology

Table 4.1: Analysis of Covariance (ANCOVA) of Post-Achievement by Treatment, Self- efficacy and Mental Ability

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	18466.567[a]	24	769.440	60.109	.000	.807
Intercept	7765.528	1	7765.528	606.643	.000	.637
Pre-achievement	144.251	1	144.251	11.269	.001	.032
Treatment	17188.754	3	5729.585	447.595	.000*	.795
Self-efficacy	5.335	2	2.668	.208	.812	.001
Mental ability	17.749	1	17.749	1.387	.240	.004
Treatment * Self-efficacy	55.893	6	9.316	.728	.628	.012
Treatment * Mental ability	5.904	3	1.968	.154	.927	.001
Self-efficacy * Mental ability	3.377	2	1.688	.132	.876	.001
Treatment * Self-efficacy * Mental ability	97.036	6	16.173	1.263	.274	.021
Error	4429.083	346	12.801			
Total	229830.000	371				
Corrected Total	22895.650	370				

R Squared = .807 (Adjusted R Squared = .793) * Denote significant difference at 0.05 level of significance

Table 4.1 shows that there was a significant main effect of treatment on students' achievement in ecology and genetics concepts in Biology ($F_{(3, 346)}$ =447.59; P< 0.05, partial η^2 = 0.795). The effect size was 79.5%. This implies that there was a significant difference in the mean post-achievement scores of students. Thus, hypothesis 1a was rejected. In order to determine the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was carried out. The result is presented in Table 4.8

Table 4.2: Estimated Marginal Means for Post-Achievement by Treatment and Control Groups

Treatment	N	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Computer Simulation Package (CSP)	91	27.77	0.374	27.031	28.502
Digital Puzzle Package (DPP)	93	26.72	0.381	25.970	27.470
Computer Simulation and Digital Puzzle Package (CSDPP)	94	27.41	0.364	26.695	28.129
Conventional Package (CP)	93	10.69	0.400	9.901	11.474

Table 4.2 reveals that the students in Computer Simulation Package Group had the highest adjusted post-achievement mean score (27.77), followed by Computer Simulation And Digital Puzzle Package Group (27.41), Digital Puzzle Package Group (26.72), while the Conventional Package Group had the least adjusted post-achievement mean scores (10.69). This order can be represented as CSP >CSDPP>DPP>CP.

Table 4.3: Scheffe Post-hoc Analysis of Post-achievement by Treatment and Control Group

Treatment	N	Mean	CSP	DPP	CSDPP	CP
CSP	91	27.77				*
DPP	93	26.72				*
CSDPP	94	27.41				*
CP	93	10.69	*	*	*	

* Denote significant difference at 0.05 level of significance

Table 4.3 reveals that students exposed to Computer Simulation Package (CSP) were not significantly different from their counterparts taught using Digital Puzzle Package (DPP), Computer Simulation and Digital Puzzle Package (CSDPP) but significantly different from those taught Conventional Package (CP) in their post-achievement scores. The students taught using DPP were significantly different from those exposed to CSDPP. Furthermore, students taught using computer simulation were significantly different from those exposed to conventional package. This implies that computer simulation, digital puzzle and computer simulation and digital puzzle package were the main sources of significant differences in treatment. There was no significant main effect of treatment on the students' problem-solving skills.

Table 4.4: Analysis of Covariance (ANCOVA) of Post-problem Solving Skills by Treatment, Self-efficacy and Mental Ability

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	17443.875[a]	24	726.828	111.590	0.000	0.886
Intercept	7087.904	1	7087.904	1088.207	0.000	0.759
Pre-problem-solving	140.079	1	140.079	21.506	0.000	0.059
Treatment	16346.714	3	5448.905	836.571	0.000*	0.879
Self-efficacy	6.282	2	3.141	0.482	0.618	0.003
Mental ability	1.063	1	1.063	0.163	0.687	0.000
Treatment * Self efficacy	40.534	6	6.756	1.037	0.401	0.018
Treatment * Mental ability	3.889	3	1.296	0.199	0.897	0.002
Self-efficacy * Mental ability	1.265	2	0.632	0.097	0.907	0.001
Treatment * Self-efficacy * Mental ability	51.735	6	8.622	1.324	0.246	0.022
Error	2253.629	346	6.513			
Total	206550.000	371				
Corrected Total	19697.504	370				

a. R Squared = .886 (Adjusted R Squared = .878) , * Denote significant difference at 0.05 level of significance

Table 4.4 indicates that there was a significant main effect of treatment on students' problem-solving skills scores ($F_{3,346)}$ =836.57; P< 0.05, partial η^2 = 0.879). The effect size was 87.9%. Therefore, hypothesis 1b was rejected. The magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was also carried out. The result is presented in Table 4.5.

Table 4.5: Estimated Marginal Mean for Post-Problem Solving Skills by Treatment and Control group

Treatment	N	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Computer Simulation Package(CSP)	91	25.66[a]	.266	25.143	26.187
Digital Puzzle Package (DPP)	93	25.80[a]	.271	25.265	26.331
Computer Simulation and Digital Puzzle Package (CSDPP)	94	26.62[a]	.259	26.108	27.129
Conventional Package (CP)	93	9.85[a]	.285	9.294	10.416

Table 4.5 shows that the students in the Computer Simulation and Digital Puzzle Package Treatment Group 3 had the highest adjusted post-problem-solving skills mean score (26.62), followed by the Digital Puzzle Package Treatment Group 2 (25.80), Computer Simulation Package Treatment Group 1 (25.66), while the students in the Conventional Package (CP) Control Group had the least adjusted post-problem-solving skills mean score (9.85). This order can be represented as CSDPP > DPP > CSP> CP.

Table 4.6: Scheffe Post-hoc Analysis of Post-problem-solving Skills by Treatment and Control Groups

Treatment	N	Mean	CSP	DPP	CSDPP	CP
CSP	91	25.66				*
DPP	93	25.80			*	*
CSDPP	94	26.62				*
CP	93	9.85	*	*	*	

* Denote significant difference at 0.05 level of significance

Table 4.6 reveals that the students exposed to Computer Simulation and Digital Puzzle Package (CSDPP) were significantly different from their counterparts taught using Computer Simulation Package (CSP), Digital Puzzle Package (DPP) and Conventional Package (CP) in their post-problem-solving skills scores. The students taught using Digital Puzzle Package were significantly different from those exposed to Computer Simulation and Conventional Package. Furthermore, the students taught using computer simulation significantly different from those exposed to conventional package. This implies that computer simulation and digital puzzle, digital puzzle and computer simulation packages were the main sources of significant differences in treatment.

$H0_{1b}$: There is no significant main effect of treatment on students' attitude to ecology and genetics.

Table 4.7: Analysis of Covariance (ANCOVA) of Post-attitude by Treatment, Self efficacy and Mental Ability

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	57065.993[a]	24	2377.750	43.506	.000	.751
Intercept	23197.625	1	23197.625	424.448	.000	.551
Pre-attitude	2050.829	1	2050.829	37.524	.000	.098
Treatment	53657.400	3	17885.800	327.257	.000*	.739
Self-efficacy	7.784	2	3.892	.071	.931	.000
Mental ability	39.979	1	39.979	.732	.393	.002
Treatment * Self-efficacy	58.038	6	9.673	.177	.983	.003
Treatment * Mental ability	168.611	3	56.204	1.028	.380	.009
Self-efficacy * Mental ability	216.834	2	108.417	1.984	.139	.011
Treatment * Self-efficacy * Mental ability	327.263	6	54.544	.998	.426	.017
Error	18910.152	346	54.654			
Total	980125.000	371				
Corrected Total	75976.146	370				

R. Squared = .751 (Adjusted R Squared = .734) * Denote significant difference at 0.05 level of significance

Table 4.7 indicates that there was a significant main effect of treatment on students' attitude to ecology and genetics concepts in Biology ($F_{(3,346)} = 327.26$; $P < 0.05$; partial $\eta^2 = 0.739$). The effect size was 73.9%. Hence, hypothesis 1c was rejected. The estimated marginal means of the treatment groups was carried out so as to determine the magnitude of the significant main effect across treatment groups,. The result is captured in Table 4.8.

Table 4.8: Estimated Marginal Means Post-attitude by Treatment and Control group

Treatment	N	Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
Computer Simulation Package (CSP)	91	55.69	.769	54.174	57.200
Digital Puzzle Package (DPP)	93	58.07[a]	.785	56.524	59.613
Computer Simulation and Digital Puzzle Package (CSDPP)	94	54.36[a]	.759	52.867	55.853
Conventional Package (CP)	93	26.77[a]	.826	25.146	28.396

Table 4.8 indicates that the students in the Digital Puzzle Package (DPP) Treatment Group 2 had the highest adjusted post-attitude mean score (58.07), followed by the Computer Simulation Package (CSP) Treatment Group 1(55.69), Computer Simulation and Digital Puzzle Package (CSDPP) Treatment Group 3 (54.36), while the students in the Conventional Package (CP) Control Group had the least adjusted post-attitude mean score (26.77). This order can be represented as DPP > CSP > CSDPP> CP.

Table 4.9: Scheffe Post-hoc Analysis of Post-attitude by Treatment and Control Groups

Treatment	N	Mean	CSS	DPS	CSDPS	CS
CSP	91	55.69				*
DPP	93	58.07				*
CSDPP	94	54.36				*
CP	93	26.77	*	*	*	

* Denote significant difference at 0.05 level of significance

Table 4.9 reveals that the students exposed to Digital Puzzle Package (DPP) were significantly different from their counterparts taught using Computer Simulation Package, Computer Simulation and Digital Puzzle Package (CSDPP) and Conventional Package (CP) in their post-attitude scores. The students taught using Computer Simulation Package were significantly different from those exposed to Computer Simulation and Digital Puzzle Package and Conventional Package.

Furthermore, the students taught using computer simulation were significantly better than those exposed to conventional package in problem-solving skills. This implies that digital puzzle, computer simulation and computer simulation and digital puzzle packages were the main sources of significant differences in treatment.

$H0_{2a}$: There is no significant main effect of self-efficacy on students' achievement in ecology and genetics concepts in Biology**.**

Table 4.1 shows that there was no significant main effect of self-efficacy on students' achievement in ecology and genetics concepts in Biology ($F_{(2,346)} = .21$, $P>.05$, partial $\eta^2 = .001$). Therefore, hypothesis 2a was not rejected.

$H0_{2b}$: There is no significant main effect of self-efficacy on students' problem solving skills.

Table 4.4 shows that self-efficacy had no significant main effect on students' problem solving skills ($F_{(2,367)} = 0.48$; $P>0.05$, partial $\eta^2 = .003$). Hence the null hypothesis 2b was not rejected.

$H0_{2c}$: There is no significant main effect of self-efficacy on students' attitude.

Table 4.4 shows that there was no significant main effect of self-efficacy on students' attitude ($F_{(2,346)} = 0.07$, $P>.05$, partial $\eta^2 = .000$). Therefore, hypothesis 2c was not rejected.

$H0_{3a}$: There is no significant main effect of mental ability on students' achievement in ecology and genetics concepts in Biology.

Table 4.1indicates that there was no significant main effect of mental ability on students' achievement in ecology and genetics concepts in Biology ($F(_{1,346}) = 1.39$, $P>.05$, partial $\eta^2 = .004$). Therefore, the null hypothesis 3a was not rejected.

$H0_{3b}$: There is no significant main effect of mental ability on students' problem solving skills.

Table 4.4 shows that there was no significant main effect of mental ability on students' problem solving skills ($F_{(1,346)} = 0.163$, $P>.05$, partial $\eta^2 = .000$). Therefore, the null hypothesis 3b was not rejected.

$H0_{3c}$: There is no significant main effect of mental ability on students' attitude.

Table 4.7 indicates that there was no significant main effect of mental ability on students' attitude ($F_{(1,346)}$ = 0.732, P>.05, partial η^2 = .002). Therefore, the null hypothesis 3c was not rejected.

$H0_{4a}$: There is no significant interaction effect of treatment and self efficacy on students' achievement in ecology and genetics concepts in Biology.

As seen in Table 4.1, there was no significant two-way interaction effect of treatment and self-efficacy on students' achievement in ecology and genetics concepts in Biology ($F_{(6,346)}$ = 0.75, P>.05, partial η^2 = .012). The null hypothesis 4a was not rejected. This depicts that self-efficacy (low, medium and high) and treatment has no effect on students' achievement in ecology and genetics concepts in Biology.

$H0_{4b}$: There is no significant interaction effect of treatment and self-efficacy on students' problem solving skills.

Table 4.4 reveals that there was no significant interaction effect of treatment and self-efficacy on students' problem solving skills ($F_{(6,346)}$ = 1.08, P>.05, partial η^2 = .018). Therefore, the null hypothesis 4b was not rejected.

$H0_{4c}$: .There is no significant interaction effect of treatment and self-efficacy on students' attitude.

Table 4.7 shows that there was no significant two-way interaction effect of treatment and self-efficacy on students' attitude ($F_{(6, 346)}$ = 0.18, P>.05, partial η^2 = .003). so the null hypothesis 4c was not rejected.

$H0_{5a}$: There is no significant interaction effect of treatment and mental ability on students' achievement in ecology and genetics concepts in Biology.

Table 4.1 indicates that there was no significant two-way interaction effect of treatment and mental ability on students' achievement in ecology and genetics concepts in Biology ($F_{(3,346)}$ = 0.15, P>.05, partial η^2 = .001). Based on this, the null hypothesis 5a was not rejected. This depicts that mental ability (low and high) and treatment has no effect on students' achievement in ecology and genetics concepts in Biology.

H0$_{5b}$: There is no significant interaction effect of treatment and mental ability on students' problem solving skills.

Table 4.4 reveals that there was no significant interaction effect of treatment and mental ability on students' problem-solving skills ($F_{(3,346)}$ = 0.20, P>.05, partial η^2 = .002). Therefore, the null hypothesis 5b was not rejected.

H0$_{5c}$: There is no significant interaction effect treatment and mental ability on students' attitude.

Table 4.7 shows that there was no significant two-way interaction effect of treatment and mental ability on students' attitude ($F_{(3, 346)}$ = 1.03, P>.05, partial η^2 = .009). in view of this, the null hypothesis 5c was not rejected.

H0$_{6a}$: There is no significant interaction effect of self-efficacy and mental ability on students' achievement in ecology and genetics concepts in Biology.

Table 4.1 reveals that the interaction effect of self-efficacy and mental ability on students' achievement in ecology and genetics concepts in Biology was not significant ($F_{(2, 346)}$ = 0.132, P>.05, partial η^2 = 0.001). Therefore, the null hypothesis 6a was not rejected.

H0$_{6b}$: There is no significant interaction effect of self-efficacy and mental ability on students' problem solving skills.

Table 4.4 indicates that the interaction effect of self-efficacy and mental ability on students' problem solving skills was not significant ($F_{(2, 346)}$ = 0.097, P>.05, partial η^2 = 0.001). Therefore, the null hypothesis 6b was not rejected.

H0$_{6c}$: There is no significant interaction effect of self-efficacy and mental ability on students' attitude.

Table 4.7 reveals that the two-way interaction effect of self-efficacy and mental ability on students' attitude was not significant ($F_{(2, 346)}$ = .0139, P>.05, partial η^2 = .011). Therefore, the null hypothesis 6c was not rejected.

H0$_{7a}$: There is no significant interaction effect of treatment, self-efficacy and mental ability on students' achievement in ecology and genetics concepts in Biology.

Table 4.1 shows that the three-way interaction effect of treatment, self-efficacy and mental ability on students' achievement in ecology and genetics concepts in Biology was not significant ($F_{(4,367)} = 1.091$, $P>.05$, partial $\eta 2 = .012$). So, the null hypothesis 7a was not rejected.

$H0_{7b}$: There is no significant interaction effect of treatment, self-efficacy and mental ability on students' problem solving skills.

From Table 4.4, it is evident that the three-way interaction effect of treatment, self-efficacy and mental ability on students' problem solving skills was not significant $F_{(6, 346)} = 1.324$; $P>.05$; $\eta 2 = 0.022$). Hence, the null hypothesis 7b was not rejected.

$H0_{7c}$: There is no significant interaction effect of treatment, self-efficacy and mental ability on students' attitude.

As obvious in Table 4.7, the three-way interaction effect of treatment, self-efficacy and mental ability on students' attitude was not significant $F_{(6,346)} =0.998$; $P>.05$; partial $\eta^2 = 0.017$). Hence, the null hypothesis 7c was not rejected.

4.2 Summary of findings

Based on the analysis and the interpretation of the data collected in this study, the findings are summarized as follows:

i. There was a significant main effect of treatment on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology.
ii. There was no significant main effect of self-efficacy on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology.
iii. There was no significant main effect of mental ability on students' achievement, problem solving skills, and attitude to ecology and genetics concepts in Biology.
iv. There was no significant interaction effect of treatment and self-efficacy on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology

v. There was no significant interaction effect of treatment and mental ability on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology

vi. There was no significant interaction effect of self-efficacy and mental ability on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology

vii. There was no significant interaction effect of treatment, self-efficacy and mental ability on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in biology

4.3 Discussion of findings

4.3.1 Treatment and students' achievement in ecology and genetics concepts in Biology

There was a significant main effect of treatment on students' achievement, problem-solving skills, attitude to ecology and genetics concepts in Biology. The students in Computer Simulation Package Group had the highest adjusted post-achievement mean score, followed by Computer Simulation and Digital Puzzle Package Group, then Digital Puzzle Package Group, while those in Conventional Package Group had the least adjusted post-achievement mean scores.

The greater influence of computer simulation is in support of the findings of Huppert, Lomask and Lazarowitz (2002), who also investigated the impact of computer simulations on the development of higher-level inquiry skills. Akpan and Andre (2000) investigated the effectiveness of computer simulations and hands-on frog dissection. They revealed that students who received simulations-before-dissection (SBD) and simulations-only (SO) learned significantly more anatomy than students receiving dissections-before-simulations (DBS) or dissection-only (DO). The efficacy of computer simulation package may be due to the fact that the use of the package empowers students to develop their own understanding of ecology and genetics concepts in Biology, by providing students the platform to learn by creating their own ideas and knowledge from their experiences, with supportive guide from the instructor. It opens up science, makes thinking real, helps students share ideas with one another and helps students learn independently. It also provides students the opportunity to apply knowledge by performing procedures, taking decisions, and critically thinking through a problem to proffer solutions (DeYoung, 2003; Billings and Halstead, 2005).

Efe and Efe, (2011) found that the use of a simulation enabled middle school science students studying an aquatic ecosystem to observe beyond the surface structures and functions they could see when an aquarium served as a physical model. Simulations allow users to do a lot of exploration (Pilli, 2008). Students are also able to apply newly acquired skills (Chen, and Howard 2010).

This finding is in agreement with Kiboss, Wekesa and Ndirangu (2006), who discovered that computer simulation package positively affected how students understood and perceived cell division concept in school Biology. Chen and Howard (2010) state that the use of realistic simulation often requires students to apply newly acquired skills while propelling them towards advanced learning. Anany and Mary (2002) assert that computer simulation improves the understanding of abstract concepts and the development of problem-solving abilities in students. In the same vein, Okoro and Etukudo (2001) found that the students exposed to the CAI were significantly better than those exposed to the extrinsic motivation-based traditional method. In a similar study, Akour (2006) found that students taught using traditional instruction combined with the use of computer performed significantly better than their counterparts taught using traditional instruction. Pektas, Türkmen and Solak (2006) indicated that the students taught digestion and excretion with computer-aided instructional process did better than those through the traditional lecture method.

The result of the effectiveness of computer simulation and digital puzzle packages is in agreement with the findings of Oduwaiye (2009), Abimbade (2011, 2014), Erhan and Okan (2011), Nsofor, Ala and Gambaki (2013), Onwumere and Kalu (2013) and Oguntude (2014) , who in their separate studies found that when students were exposed to computer simulation and digital puzzle instructional packages, they demonstrated a lot of intuition, self-discovery, motivation, enthusiasm, deep sense of direction and self-confidence, as they were fascinated with the use of computer. These findings also agree with those of , Afolabi (2006) and Ajadi (2007) that reported a significant improvement in achievement of science students using CAI modes of instruction in biological and physical sciences.

This finding supports Akcay, Aydoğdu, Yıldırım and Şensoy (2005) who found that, with regard to the increase of students' achievement, the computer-aided method in science education was more efficient than the traditional teaching method. Ozdener (2005) equally avers that the use of virtual laboratories to teach would support the normal laboratories. Karamustafaoglu, Aydın and Özmen (2005) discovered that the experimental group taught with the simulation-based dynamic-system instruction achieved more than the control group that was provided with traditional instruction. Bayrak (2008) found that the experimental group which was given the instruction through computer simulation was more successful than the control group that was provided with face-to-face instruction. The finding supports the conclusion of Elangovan (2014), that computer simulation improves Biology students' achievement and memory retention. Olanekan and Oludipe (2016) found that there was a significant main effect of computer simulation on students' mean achievement score in DNA replication and transcription.

Computer Simulation and Digital Puzzle Packages influenced the achievement in ecology and genetics concepts in Biology. This is in support of Oduwaiye (2009), Erhan and Okan (2011), Abimbade (2011, 2014), Nsofor, Ala and Gambaki (2013), Onwumere and Kalu (2013), and Oguntade (2014), in which students were exposed to the Computer-Assisted Instructions. While going through the treatments, the students demonstrated a lot of intuition, self-discovery, motivation, enthusiasm, deep sense of direction and self-confidence. This could have accounted for the improved achievement in ecology and genetics concepts in Biology that occurred among the participants in the Computer Simulation and Digital Puzzle Package over the conventional mode. These findings agree with those of Afolabi (2006) and Ajadi (2007), who reported a significant improvement in the achievement of science students using Computer-Assisted Instruction (CAI) modes of instruction in biological and physical sciences.

Computer Simulation and Digital Puzzle Package was found to be more effective than Digital Puzzle Package and Conventional Strategy. This might be because the package allows students to observe, manipulate and formulate scientific explanations for scientific phenomena. (Liao, 2005). It enables students to evaluate, recognize, verify and store experiences acquired for future use. The result on the effective of Computer Simulation and Digital Puzzle Package agrees with the assumptions of social cognitive theory that students learn by actively building or constructing their own knowledge and making sense out of this knowledge (Cobb, 2002).

Digital Puzzle Package also influenced the achievement in ecology and genetics concepts in Biology. This is in tandem with the findings of Idowu and Ige (2007), which showed that use of puzzles in teaching and learning in Nigeria schools was very effective. Puzzle as an educational resource enhances students' problem-solving skills because it helps them to think deeply to proffer solutions to a problem. Research carried out to demonstrate the effectiveness of puzzle learning by Serj (2002), noted that it is significantly better when compared with conventional package developing problem-solving skills in junior secondary school Mathematics.

Digital Puzzle Package was found to be more effective than Conventional Strategy. This might be connected to the fact that this package allows active participation of students in their own learning, thereby making them very responsible. Also, it might be due to the fact that puzzle-solving is an active type of learning that gets students engaged with materials more than the passive form of learning does. It makes learning more exciting and easy for learners, thereby helping them achieve the expected learning outcomes. The finding of main effect of Digital Puzzle Package supports Zmaczynski (2002), who found that the puzzle enabled students to recognize, verify and store chemical formula experiences for later use in chemical equations. Also, Vogel et al. (2006) found that traditional classroom instruction was not as influential on learners' cognitive gains as digital games. In the same view, Pange (2003) argues that digital games task the cerebral to perform more brilliantly and so absorb more intellectual materials than it would in a traditional learning setting. Yip and Kwan (2006) claim that students' attention can increase and knowledge can be easily transferred when students play digital puzzle games. This finding on Digital Puzzle Package buttresses the research findings of Coulter (2003), Kaka (2008), Falkner, Saoriamarthi and Michalewicz (2009), and Adedoja, Abidoye and Afolabi (2013), who found the effectiveness of puzzle in enhancing academic achievement in many subjects.

The finding of main effect of Digital Puzzle Package negates Harris (2001), who found no distinct fundamental link between academic performance and the use of digital games. Mitchell and Savill-Smith (2004) note that the findings on the effects of digital gaming on learners' achievement were inconclusive. Hays (2005) found mixed results.

The low performance recorded in Conventional Strategy, compared with the other treatment groups, is a clear indication that the method is teacher-centred, where the teacher does all the talking, and the learners do all the listening, thereby making the students passive learners. These finding is in agreement with Osokoya (2002), who notes that the teacher "gives out" the facts to the students and the students listen and digest the knowledge. Olagunju (2006) argues that the conventional lecture method commonly used by science teachers is monotonous, students are passive and no meaningful learning takes place.

4.3.2 Treatment and students' problem-solving skills

There was a significant main effect of treatment on students' problem solving skills scores. The students in the Computer Simulation and Digital Puzzle Package Treatment Group had the highest adjusted post-problem-solving skills mean score, followed by the Puzzle Package Treatment Group, and then the Computer Simulation Group, while the Conventional Package Group had the least adjusted post-problem-solving skills mean score. This might be due to the fact that the use of the combined packages enhances retention, as they engage the use of some of their sense organs – the eyes to see and the ear to hear and they interact with the packages using their hands, thereby creating an environment where the real phenomenon being studied could be observed with ease. The students are active, and they click, drag, type and make progress in the process of learning. The psychomotor skill is improved. The efficacy of Computer Simulation and Digital Puzzle Package may be due to the fact that the packages empower students to develop their own understanding of ecology and genetics concepts in Biology, by providing them the opportunity to learn by building their own ideas and knowledge from their experiences, with supportive guide from the instructor.

Cobb (2002) claims that people construct new knowledge internally and externally. They do the former when they transform, organize, and reorganize previous knowledge; they do the latter through ecological and social factors which are controlled by culture, language, and interactions with others. According to Okurumeh

(2009), students who are allowed to actively participate in their own learning usually end up becoming more independent learners and adept problem solvers.

The result on the effectiveness of Computer Simulation and Digital Puzzle Package is in agreement with the findings of Oduwaiye (2009), Erhan and Okan (2011), Abimbade (2011, 2014),Nsofor, Ala and Gambaki (2013), Onwumere and Kalu (2013), Oguntude (2014) who found that when students were exposed to computer Simulation and Digital Puzzle Instructional Packages, they demonstrated a lot of intuition, self-discovery, motivation, enthusiasm, deep sense of direction and self-confidence, because they were fascinated with the use of computer. These findings also agree with those of Afolabi (2006) and Ajadi (2007), who reported a significant improvement in achievement of science students using CAI modes of instruction in biological and physical sciences. Maal (2004) found that using combined approaches or multi-sensory instruction to teach normal and disabled students enabled them to gain maximally in their teaching and learning processes.

Puzzle Package was found to be more effective than Computer Simulation and Conventional Method on problem-solving skill in ecology and genetics concepts. This might be due to the fact that it enables students to learn science concepts and principles, such as sorting, classifying, comparing and setting relationships. It increases students' interest in learning, making them feel pleased with themselves and boosting their confidence as problem-solvers. They feel willing to try new puzzles or other challenging activities. It may also be due to the fact that it helps students to develop negotiation skills, control their own actions and learn various critical thinking and problem-solving techniques. Digital Puzzle Package was ranked second possibly because teaching with puzzle helps young learners learn motor skills and hand-eye coordination as they fix the pieces of puzzles together; to teach logical thinking skills, deductive and inductive reasoning, spatial concepts, motor coordination and planning of advance gambits and for students who often cannot absorb traditional educational method(Scotts, 2006). Lauric and Robbert (2001), in their experiment with the use of puzzle in teaching and learning Computer Science Education, discovered that students understood abstract concepts by solving puzzle. This finding is in agreement with the findings of Serj (2002), who found that puzzle package was significantly better when compared with Conventional Method in developing problem-solving skills in junior secondary school Mathematics. Idowu and Ige (2007) are of the opinion that puzzle packages build problem-solving skills in students by experience, imitation and reflection.

Computer Simulation Package was more effective than Conventional Strategy on problem-solving skill in ecology and genetics concepts. This might be due to the fact that computer simulation affords learners the privilege of freely creating, testing, and evaluating their own hypotheses in a more richly contextualized environment. Furthermore, it allows learners to choose the way they represent information on the computer screen and it allows them to develop hypotheses about phenomena they accommodate on their ways of solving problems (Windschitl and Andre, 1998). This supports the research finding of Huppert, Lomask and Lazarowitz (2002), that high school students using a simulated yeast cell lab outperformed those completing a hands-on lab. Akpan and Andre (2000) found that students receiving simulations-before-dissection (SBD) and simulations-only (SO) learned significantly more anatomy than students receiving dissections-before-simulations (DBS) or dissection-only (DO). This finding disagreed with of Barlis and Fajardo (2013), who, while comparing the performance of traditional and computer simulation groups, found that students' scores increased significantly from the pretest to the posttest in both multiple-choice questions and problem solving regardless of methods used. Barlis and Fajardo (2013) found that both the traditional method and computer simulation, individually, are effective in teaching the students.

Moreover, the low performance of the conventional strategy students on problem-solving skill as compared with the other treatment groups might be due to the fact that the method is teacher-cantered, where the teacher does all the talking and the learners do all the listening, thereby making the students passive learners. The teachers make use of this method to provide critical information to students and emphasise instructor behaviour rather than students' behaviour. This is in tandem with the finding of Serj (2002) and Scotts (2006), that the conventional method was less effective in developing problem-solving skills in junior secondary school Mathematics as compared with other packages, like Digital Puzzle Package.

4.3.3 Treatment and students' attitude to ecology and genetics concepts in Biology

There was a significant main effect of treatment on students' attitude to ecology and genetics concepts in Biology. Digital Puzzle Package (DPP) Treatment Group had the highest adjusted post-attitude mean score, followed by Computer Simulation Package (CSP) Treatment Group, then Computer Simulation And Digital Puzzle Package (CSDPP) Treatment Group, while students in Conventional Package (CP) Control Group had the least adjusted post-attitude mean score. This may be due to the students focussing on achieving the learning objectives as they interact with the digital puzzle in solving problems on ecology and genetics. They display a higher level of cognition and distraction is minimized.

The effectiveness of Digital Puzzle Package (DPP) Treatment as different from other instructional packages might also be as a result of the students participation in learning activities in a heuristic, non-didactic pattern of learning, which brings about experiencing the stimulating, interesting and motivating effects of the varieties of stimuli in the form of texts, sound, graphics, animations, reflective questions, immediate knowledge of response as reinforcement and other vicarious experiences in the learning process. Another possible reason for the higher attitudinal score recorded by students in using Digital Puzzle Package may be the fact that it makes learning more exciting and easily takes place in learners, leading to the desired learning outcomes. It also gives room for student-student interaction. This shows that DPP is an active learning instruction that helps to develop a positive attitude towards the learning of ecology and genetics concepts. The result is in tandem with Pilar (2013), who found a significant increase in mathematical achievement and attitudes toward Mathematics for all the pupils who played the digital game compared to their counterparts exposed to the traditional strategy. Also the significant role of simulation might have influenced students' attitude towards science over time.

This result is confirmed by prior research into realistic simulations showing the relevance of science and change in how students perceive science (Zubair and Nasir, 2011). Using simulation in a learning environment has potential for changing students' self-perception and goal orientation. This agrees with Onwumere and Kalu (2012), Olabiyi, Aiyelabowo and Keshinro (2013), Achor and Ukwuru (2014), Karen (2015) and Heitin (2015), who found that computer-based instruction raises students' attitude to learning. Besides, this finding corroborates the Next Generation Science Standards' submission that science should be taught with technology (such as computer machine) and reflective thinking in order to improve students' attitude to science and raise learners' academic achievement in science. Anatsui and Fagbemi (2014) and (Heitin, 2015) posit that educational systems around the world are under pressure to use new information and communication technology (ICT). The National Policy on Education (FRN, 2004 section 1, sub-section 9, p. 8; 2013 section 1, sub-section 7) avers that "the incorporation of educational technology tools such as computer hardware and software in the education pedagogy in Nigeria and the promotion of information and communication technology capacity at all levels of education enhance, enrich, engage and empower both the learners and the teachers involved in the teaching-learning process."

Computer Simulation and Digital Puzzle Package was more effective than Conventional Strategy. This might be due to the fact that it helps students to control their own actions and also provides a learning experience which makes participants to visualize, explore, and formulate scientific explanations for scientific phenomena. The result of computer simulation and digital puzzle package is in agreement with Sahin (2006), who found that computer simulations give students the opportunity to observe a real-world experience and interact with it.

Main effect of self-efficacy on students' achievement in ecology and genetics in Biology

Self-efficacy was found to have no significant main effect on students' achievement in ecology and genetics in Biology. This implies that the students' self-efficacy, high, medium or low, had no influence on their achievement in ecology and genetics. This means that if students, irrespective of their levels of self-efficacy, are exposed to similar conditions to participate actively in the process of knowledge construction, they may have equal gain in achievement score. This finding of non-significant main effect of self-efficacy supports Tella (2015) who found that there was no significant main effect of self-efficacy on students' achievement in Chemistry. However, this finding disagrees with of Elsevier's (2009), that self-efficacy had positive relationship with academic achievement. Aremu and Tella (2009) found that Mathematics self-efficacy was the best predictor of Mathematics achievement, followed by gender and anxiety. Shahrzad, Kourosh, Mohammad, Haitham and Hossein (2011) note that self-efficacy is a considerable factor in academic achievement.

4.3.4 Main effect of self-efficacy on students' problem-solving skill in ecology and genetic in Biology

The results of this study showed that self-efficacy had no significant main effect on students' problem-solving skills in ecology and genetics in Biology. This may not be unconnected with the fact that the students were exposed to similar conditions to participate actively in the process of knowledge; which might have accounted for the equal gain in knowledge. The findings of non-significant main effect of self-efficacy is in disagreement with Fend and Scheed (2005), who claim that self-efficacy influence students' academic performance in science. This also negates the findings of Aurah, Cassady and McConnell (2014), who found that metacognition and self-efficacy significantly predicted genetics problem-solving ability.

4.3.5 Main effect of self-efficacy on students' attitude to ecology and genetic in Biology

The results showed that self-efficacy had no significant main effect on students' attitude to ecology and genetics in Biology. This implies that self-efficacy had no influence on students' attitude to ecology and genetics in Biology. This finding of non-significant main effect of self-efficacy negates the research reports of Woolfolk Hoy and Davis (2005), who established that self-efficacy positively affected the achievement and attitude of the students sampled. Tschannen-Moran and Hoy (2001) found self-efficacy to be directly related to the classroom behaviours of the teacher. This finding is also in disagreement with Tella (2015), who found no significant main effect of self-efficacy on students' attitude to Chemistry.

4.3.6 Main effect of mental ability on students' achievement in ecology and genetics in Biology

The results of the study revealed that there was no significant main effect of mental ability on students' achievement in ecology and genetics in Biology. This implies that the treatment had equal effect on students' achievement, irrespective of their mental ability levels. The finding of non-significant effect of mental ability negates Sangodoyin (2011) and Dada (2014), who found that mental ability affected the achievement of students in Chemistry and Mathematics, respectively. It also disagrees with the Vocka, Preckelb and Hollingc (2011), who discovered that mental speed and short-term memory exerted an indirect influence on academic achievement by affecting reasoning and divergent thinking. In the same vein, Akinlana (2013) revealed that mental ability was the most potent out of the predictor variables. Babayemi and Akinsola (2014) found that mental ability had significant main effect on achievement.

4.3.7 Main effect of mental ability on students' problem-solving skill in ecology and genetics in Biology

Mental ability was found to have no significant main effect on students' problem solving in ecology and genetics in Biology. This might be as a result of the fact that the treatment provided equal learning opportunities for students, irrespective of their mental ability levels. The finding is in disagreement with Pajares and Kranzler (1995), who found that mental ability had strong direct effects on problem-solving performance. The finding, however, negates Olagunju and Abiona (2004), who found that mental ability influenced students learning in Biology.

4.3.8 Main effect of mental ability on students' attitude to ecology and genetics in Biology

Mental ability had no significant main effect on students' attitude to ecology and genetics in Biology. This means that the mental ability, high, medium or low, had no influence on students' attitude to ecology and genetics. This finding of non-significant main effect of mental ability negates Dada (2015), who found that mental ability had effects on the students' attitude in Chemistry. This finding also disagrees with Morribend (2004), who found that mental ability had significant effect on students' attitude.

4.3.9 Two-way interaction effects of treatment and self-efficacy on students' achievement in problem-solving skill, and attitude to ecology and genetics in Biology

The results indicated that there was no significant interaction effect of treatment and self-efficacy on students' problem solving skills, attitude to and achievement in ecology and genetics. This could mean that the treatment was suitable to all the students, irrespective of their self-efficacy levels.

4.3.10 Two-way interaction effects of treatment and mental ability on students' achievement in problem solving skill and attitude to ecology and genetics in Biology

The results revealed that there was no interaction effect of treatment and mental ability on students' achievement in problem solving skills and attitude to ecology and genetics. This could mean that the treatment was suitable to all the students, irrespective of their mental ability levels.

4.3.11 Two-way interaction effects of self-efficacy and mental ability on students' achievement in problem solving skill and attitude to ecology and genetics in Biology

The results revealed that there was no significant interaction effect of self-efficacy and mental ability on students' achievement in problem solving skill and attitude to ecology and genetics concepts in biology. This implies that when the combined effects of self-efficacy (high, medium and low) and mental ability (high, medium and low) taken together had no significant on students' achievement in problem solving skill and attitude to ecology and genetics. Thus, the treatment was not self-efficacy-biased and mental ability-biased.

4.3.12 Three-way interaction effects of treatment, self-efficacy and mental ability on students' achievement in, problem-solving skill and attitude to ecology and genetics in Biology

The result obtained showed that the three-way interaction effect of treatment, self-efficacy and mental ability on students' achievement in problem-solving skill and attitude to ecology and genetics concepts in biology was not significant. This means that, if the same treatment is given to students with low, medium and high self-efficacy and mental ability levels, similar results will be obtained in problem-solving skill as well as attitude to and achievement in ecology and genetics concepts in Biology.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study examined the effects of computer simulation and digital puzzle packages as determinants of students' learning outcomes in senior secondary schools in Oyo State, Nigeria. The study also examined the moderating effects of students' self-efficacy and mental ability on the learning outcomes. The study was anchored in socio-cognitive theory. SS II students from 8 selected senior secondary schools of the four randomly selected local government areas in Oyo State participated in the study. Ten research instruments were used to collect data for this study. Seven null hypotheses were generated and tested at 0.05 level of significance. The data collected were analysed using Analysis of Covariance (ANCOVA), Estimated Marginal Mean and Scheffe Post-hoc Analysis. Based on the results, the findings are summarised as follows:

i. There was a significant effect of treatment on students' achievement, problem-solving skills, attitude to ecology and genetics concepts in Biology.
ii. There was no significant main effect of self-efficacy on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology.
iii. There was no significant main effect of mental ability on students' achievement, problem solving skills, and attitude to ecology and genetics concepts in Biology.
iv. There was no significant interaction effect of treatment and self-efficacy on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology.
v. There was no significant interaction effect of treatment and mental ability on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in Biology.
vi. There was no significant interaction effect of self-efficacy and mental ability on students' achievement, problem-solving skills, attitude to ecology and genetics concepts in Biology.

vii. There was no significant interaction effect of treatment, self-efficacy and mental ability on students' achievement, problem solving skills, and attitude to ecology and genetics concepts in Biology.

5.2 Conclusion

The findings of this study showed that both Computer Simulation and Digital Puzzle Instructional Packages are more sensitive in enhancing students' achievement, problem solving skill, and attitude to ecology and genetics than Conventional Package. Using simulation in a learning environment has potential of changing students' self-perception and goal orientation. Digital puzzle could allow for interactivity, immediate knowledge of result, reinforcement and practice. It could be concluded from this study that computer simulation and digital puzzle explicit teaching of ecology and genetics is required for students to be grounded in the principles of the ecology and genetics concepts

The result further showed that students' self-efficacy and mental ability have greater influence on students' achievement, problem-solving skills, and attitude to ecology and genetics concepts in biology. This implies that some relationship exists between the students' self-efficacy and mental ability, with greater influence on students' achievement, problem-solving skills, attitude to ecology and genetics concepts. This study has, therefore, shown that Biology is an area where the use of Computer Simulation and Digital Puzzle Instructional Packages enhance students' interest in the learning process.

5.3 Implications of findings

Computer Simulation Package has been found to be effective in instructional delivery and attitudinal change. It provides intermediate models that students will understand more readily than detailed and complex model. Also, the use of puzzles that represent materials and objects from the students' immediate environment enables them to recognize, verify and store experience for later use.

Computer Simulation and Digital Puzzle Instructional Packages improve students' achievement in ecology and genetics because the packages mimic an environment in which students have the opportunity to observe the phenomenon being studied using some of the sense organs (eyes and ears). The packages also help develop skills in problem identification, seeking, organizing, analysing, evaluating and communicating information. The students' attitude to ecology and genetics is enhanced because students' attention is focused on achieving the learning objective. The real world environment is simplified, casualty of events is clearly visualized and unnecessary cognitive tasks are reduced. Hence, Computer Simulation and Digital Instructional Packages should be adapted as viable aids in the study of environmental concepts and hereditary problems. These are effective teaching packages for improving students' achievement, developing their problem- solving skill and correcting their attitude.

Teachers of Biology should recognize the importance of applying these instructional packages to boost their teaching methods and the manner with which students receive and process information in the classroom. The cognitive style of students in mediating learning and right attitude that will result in profound achievement should be the teachers' concern. Students will be encouraged to think about and formulate new ideas in providing additional sources of information from their backgrounds which would enhance their attitude towards mastering ecology and genetics. Hence, it could be used to reduce anxiety in learning for both male and female students.

The findings would serve as a basic foundation for future studies in computer simulation and digital puzzle and their proper utilization for effective dissemination of Biological knowledge in secondary schools.

5.4 Contributions to knowledge

This study has contributed to knowledge in the following ways:

1. This study showed that CSP and DPP are effective in enhancing secondary school students' achievement, problem solving skill and attitude in ecology and genetics.
2. CSP and DPP are better methods of teaching ecology and genetics concepts in secondary schools than the conventional method.
3. The study has motivated students to learn faster and retain knowledge using new technologies, like computer simulation and digital puzzle.
4. The study has helped students to be computer literate and master the act of using CSP and DPP packages.

5. The study made students to reflect on their metacognitive abilities and improve on them.
6. The study has improved problem-solving skills, performance and provided opportunities for well-constructed learning, increased mastering of subject matter, improved confidence and attitude of students in ecology and genetics.
7. The study has also helped in realising the objective of Nigeria educational curriculum for teacher education programme which states that teacher education will perpetually recognise viable aids in the methodology and regularly expose several forms of innovation in their different profession.

5.5 Recommendations

Based on the findings of the study, the following recommendations were made:

1. Computer Simulation and Digital Puzzle Packages should be an adopted package for teaching and learning concepts in ecology and genetics by students.
2. Computer Simulation and Digital Puzzle Packages are recommended for inclusion in the curriculum of the educational system, as they could help in improving the students' achievement, problem-solving skill, and attitude to ecology and genetics, which are needed to equip the students to manage and solve different environmental and health issues.
3. The use of Computer Simulation and Digital Puzzle Packages should be applied to the teaching of other Biology-related courses in helping produce qualified and well-groomed students for related courses in higher institutions.
4. The Nigeria Union of Teachers and the Science Teachers Association of Nigeria should organize periodic in-service training programmes, conferences and seminars using Computer Simulation and Digital Puzzle Instructional Packages for Biology teachers.

5.6 Limitations of the study

Some constraints were encountered in the process of carrying out this study and they may limit the generalizability of the results. The study was conducted in only eight schools in four local government areas of Oyo State. Therefore, there is need to replicate this study to the larger population in Oyo State. Self-efficacy and mental ability were the only moderator variables used in this study. It is possible that many other moderator variables, like socio-economic status of students, personality traits, and location of the school, could put a limitation on the extent to which the results of this study could be generalized.

5.7 Suggestions for further studies

The researcher conducted this study only in eight local government areas of Oyo State. There is need to replicate this study in other local government areas in more states of Nigeria in order to give room for valid generalization. Higher institutions may be included as schools where samples could be obtained for further studies. Also, similar studies could be extended to other moderating variables, like parental education, socio-economic status and subject specialization. Other environmental concepts in Biology, such as acid rain, ozone layer depletion, and greenhouse effect can also be explored.

REFERENCES

Abimbade, A. 2007. Hierarchical study science process skills in West African Senior Secondary School Certificate Physics Practical Examination. Retrieved 12 February, 2016 from Http://www.academic.edu/6468590/

Abimbola, I. O. 2013. The misunderstood word in science towards a technology of perfect understanding of all. In *123rd Inaugural Lecture of University of Ilorin*, Unilorin Press. 22–31.

Achor, E. E. and Kalu, R. U. 2014. Incorporating error analysis approach into the teaching of practical Chemistry in senior secondary schools in Makurdi Nigeria: any effect on achievement? *International Journal of Education and Practice.* 2(2): 21-34.

Achor, E. E., Wude, M. H. and Duguryil, Z. P. 2013. Do cooperative learning strategies have? The potentials to eliminate gender difference in students' achievement in Biology? The effect of stad and jigsaw cooperative strategies. *Journal of Science, Technology, Mathematics and Education (JOSTMED).* 10(1): 136-146.

Ackert, L. 2009. Educational benefits of puzzles. Retrieved 28 June, 2016 from http.//www.examiner.com/x 22987-littlefon-homeschooling-Examiner-

ACM, A. F. 2006. *A model curriculum for K-12 computer science: Final Report of the ACM K-12*. New York: Task Force Curriculum Committee.

Adedoja G. Adelore O., Egbokhare F. & Oluleye A. 2013. Students acceptance of Mobile phone for distance learning tutorials: A case study of University of Ibadan. *Unlocking the potential of ICT in higher education :case studies of the Educational Technology initiatives at African Universities.*80-93

Adedoja, G. 2016. Pre-service teachers' challenges and attitude toward the flipped classroom. *African Educational Research Journal*, 491): 13-18.

Adedoja, G. O., Abidoye, J. A. and Afolabi, A. K. 2013. Effect of two puzzle-based instructional strategies on primary school pupils learning outcomes in Ondo State. Nigeria. *African Educational Research Journal.* 1(2):58-63.

Adegbile, J.A. 2002. Advance Organizer and Secondary School Teacher, Teaching strategies for Nigerian Secondary Schools unpublished Ph.D Thesis, University of Ibadan.

Adegoke, A. I. 2000. Gender differences in acquisition of science practical skills. Unpublished B.Ed Project, University of Ado-Ekiti, Nigeria.41-43.

Adekunle, M.O. 2005. Problem Solving and Concept Mapping Strategies as Determinants of Students' Achievement and Attitudes to Some Environmental Education Concepts in Social Science. Unpublished Ph.D Thesis, University of Ibadan

Adeoye, T. O. 2011. Effects of pictorial and written advance organizers on students' achievement in and attitude to biology in selected senior secondary schools in Ibadan, Nigeria. Unpublished M.Ed. Thesis, University of Ibadan, Ibadan.10-17.

Adepitan, J. O. 2004. Perceived difficult levels of topics in the teaching curriculum of senior secondary school physics. *Journal of Educational Focus.* 5(3): 106–115.

Adesoji, F. A 2004. Science and curriculum development. Unpublished Lecture note, University of Ibadan.7-9.

Adesoji, F. A. 2008. Managing Students attitude toward science through problem-solving instruction strategy. *Anthropologist.* 10(1): 21-24.

Adeyemo, D.A. 2007. Moderating influence on emotional intelligence on the link between academic self-efficacy and achievement of university students. Psychology developing societies, 19(21): 199-213.

Afolabi, A. O. 2006. Effects of computer assisted instructional package on secondary school students' performance in Biology, in Oyo, Nigeria. A. Ph.D Thesis, University of Ilorin.

Aina, F.O.A, 2006. Our Environment Government Initiatives and Children's Environmental Education as Instruments of Change, Keynote Address, the NERDC/UNESCO Sub regional Training Workshop.

Ajadi, T. A. 2007. The relative effects of computer and text-assisted programmed instruction on students' problem-solving ability and attitude to Mathematics, *Nigeria Journal of Computer Literacy*. 8(1): 89-104

Ajagun, G. A. 2006. Toward good performance in science education. In E. J. Maduenesi. Ed. *Nigeria Journal of Teachers Education and Teaching.* 2(1): 117-125.

Ajayi, D. O. 2005. Assessment of teacher's effectiveness in teaching biology: Essential ingredient for the 21st century biology educators. *Journal of Ekiti State Science Teacher's Association of Nigeria.* 1(2): 19 – 18.

Akçay, S., Aydoğdu, M., Yıldırım, H.İ. & Şensoy, Ö. (2005). Fen eğitiminde ilköğretim 6. sınıflarda çiçekli bitkiler konusunun öğretiminde bilgisayar destekli *öğretimin öğrenci başarısına etkisi, Kastamonu Eğitim Dergisi* 13(1): 103-116.

Akinbobola, A. O. 2009. Enhancing students' attitude towards Nigerian senior secondary school physics through the use of cooperative, competitive and individualistic learning strategies. 25-28

Akingbemisilu A.A. 2016. Mobile Devices: A patent need for current re-defining education and innovative pedagogies. *International Journal of Information and Education Technology* Official publication of International Association of Computer Science and Information Technology, Singapore 6,8: 638-642. Available at www.ijiet.org/2016.V6.765

Akinlana, T. 2013. Academic optimism, motivation and mental ability as determinants of academic performance of secondary school students in Ogun state, Nigeria. *European Journal of Business and Social Sciences.* 1(12): 68 – 76. Retrieved 11 October, 2016 from http://www.ejbss.com/recent.aspx

Akinsola, E. F. 2011. Omoluwabi's Approach to Educating the African Child in hand book of African Educational Theories & Practices: A generative teacher Education Curriculum. Cameroon Human Development Resource Centre (HDRC)

Akpan, J. P., & Andre, T. 2000. Using a computer simulation before dissection to help students learn anatomy. *Journal of Computers in Mathematics and Science Teaching.* 19(3): 297-313.

Akpan, Joseph, P. 2001. Issues Associated with Inserting Computer Simulations into Biology Instruction: A Review of the Literature. *Electronic Journal of Science Education* 5(3): 1-32.

Ali, M. and Aigbohan, A. S. 2013. Students' achievement in science. *Interdisciplinary Journal of Contemporary Research in Business.* 4(10): 707 – 718.

Anany, L, 2002. *Introduction to the design and analysis of Algorithms*. Boston: Addson
Westley. Retrieved 25 June, 2011 from http://www.carnegiefoundation.org/cl assification index asp

Anany, L. and Mary, A. P. 2002. Using puzzles in teaching algorithms. *Proceeding of 23 SIGLSE technical symposium on computer science education,* Antinnati, Kentuky, Anatsui, T. C. and Fagbemi, O. P. 2014. Rationale behind Incorporating Educational Technology in Education Sector in Nigeria. *Journal of Educational Media and Technology*. 18(1): 68 – 74

______ and Ado, I. B. 2007. Hands-on and minds-on strategies for teaching of force: Guided discovery approach. In E.Udo, U., Uyoata, N. E. U., Inyang, H.Y. and Bello, G. Eds., Hands-on and minds-on strategies in the teaching of force. Proceeding of the Science Teachers Association of Nigeria (STAN) primary science workshop. Uyo: Afahaide and Bros. Printing and Publishing co. 65-72.

_____and Olasunkanmi, I. 2007. Using sodoku puzzle to enhance logical reasoning. *African Journal of Education Research.* 5(1): 111-117.

_____and Tella, A. 2009. The relationship between gender, age, mental ability, anxiety, mathematics self-efficacy and achievement in mathematics. Cypriot Journal of Educational Sciences. 4(3): 113 - 124. Retrieved 21, October, 2016 from www.world-education-center.org/index.php/cjes

Anderson, R. 2007. Teaching the theory of evolution in social, intellectual, and pedagogical context. *Science Education.* 10(2): 664-677.

Andren, R. J. 2001. The use of a problem-solving model in environmental education. Ph.D. dissertation, Columbia University Teachers college. *Dissertation abstract International.* 39(12): 72 - 36.

Ann, B. 2006. Teaching with Puzzles Retrieved. 11/10/2017 from http://educational.more4kids.infor/26/teaching-with-puzzles

Aremu A. & Obideyi E. 2014. Nigerian learners' levels of acceptability and usability of Microsoft learning content development system (LCDS) based instruction in basic technology Proceedings of the 8th International Multi-Conference on Society, Cybernetics and Informatics (IMSCI). July 15 -18, 2014, Orlando, Florida, USA, pp 140 – 145.

Aremu A. and Sangodoyin A. 2010. Computer Animation and the academic achievement of Nigerian Senior Secondary School Students in Biology. *Journal of the centre for Educational Technology* 6,2: 148-161

Ashmore, A. D., Frazer, M. S. and Casey, R. T. 1979. Problem-solving and problem solving networks in chemistry. *Journal of Chemical Education.* 56(1): 377-379.

Asiyai, A. A. 2012. Strategies for enhancing the instructional performance of secondary school science Teachers. *Nigerian Journal of Curriculum and Instruction.* 19(1): 42 – 46.

Aslan-Efe, H., Oral, B., Efe, R. and Sünkür, M.O. 2009. The Effects Of Teaching Photosynthesis Unit With Computer Simulation Supported Co-Operative Learning On Retention And Student Attitude To Biology. Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED). Pg. 313-329.

Association of American Colleges and Universities. Liberal Education Outcomes: A Preliminary Report on Student Achievement in College. Washington, DC: AACU, 2005.

Aurah, C. M., Cassady, J. C. and McConnell, T. M. 2014. Predicting problem solving ability from metacognition and self-efficacy beliefs on a cross validated sample. *British Journal of Education*. 2(1): 49-72

Awolere, M. A. 2006. Teachers-Students Classroom Interaction, as Correlates of Students Level of Participation and Learning Outcomes in Environmental Pollution in Biology. An Unpublished M.Ed thesis, University of Ibadan.

Ayanda, O. E. 2006. The Influence of Teachers Acquisition, Preservation and Improvisation of Biological Specimen on Students' Learning Outcomes in Selected Secondary Schools in Lagos State. An Unpublished Masters Degree Project, Department of Teacher Education, University of Ibadan.

Aydoğdu, M. & Kesercioğlu, T., 2005. İlköğretimde Fen ve Teknoloji Öğretimi, Ankara: Anı Yayıncılık, 56–66

Aydogdu, M. and Kesercioglu, T. 2005. Ilkogretimde Fen ve Teknoloji Ogretimi, Ankara: Aniyayincihic 56 -66.

Babayemi, J. O. and Akinsola, M. K. 2014. Effects of crossword-picture puzzle teaching strategy and mental ability on students' achievement in basic science in southwestern Nigeria. *IOSR Journal of Research & Method in Education (IOSR-JRME).* 4(3): 8 – 13.

Bajah, S.T. 1992. Papers presented at 33rd annual conference of science teachers association of Nigeria

Bandura, A. 1977. Self-efficacy: toward a unify theory of behavioural change. *Psychological Review.* 84(2): 191 - 215.

Bandura, A. 1994. Self – efficacy: The exercise of control, New York: Freeman.

Barlis, J.M. and Fajardo, J.D. 2013. P Effectiveness of Simulation and Computer Assisted Instruction (CAI) on the Performance of Students under Regimental Training on Selected Topics in Physics II. *International Journal of Applied Physics and Mathematics*. 3(1):

Bayrak, C. 2008. Effects of computer simulations programs on university students achievement in physics. *Turkish Online Journal of Distance Education,* 9(4), 53-62.

Bayturan, S. and Kesan, C. 2012. The effect of computer assisted instruction on the achievement and attitudes towards mathematics of students in mathematics education. *International Journal of Global Education.* 1(2): 50-57.

Billings, D. A., & Halstead, J. A. (Eds.). 2005. Teaching in nursing: A guide for faculty (2nd ed.). St. Louis, MO: Elsevier.

Britner, G. and Pajares, F. 2000. Sources science self-efficacy beliefs of school students. *Journal Research Science Teaching.* 43(4): 485-499.

Brunning, H., Schraw, N. and Running, K. 1999. *A formative Evaluation of the training*
Effectiveness of a computer game. Retrieved 16 April, 2016 from http://www. classes.vsc.edu/…tp/wainess/Dissertation/Phd

Burbach, M. E., Matkin, G. S., and Fritz, S. M. 2004. Teaching critical thinking in an introductory leadership course utilizing active learning strategies: A confirmatory study. *College Student Journal.* 38(3): 482-493.

Bybee R. W., Fuchs B. Preparing the 21st century workforce: a new reform in science and technology education. J. Res. Sci. Teach. 2006;43(4):349–352.

Chamber, D. G. 2009. The effects of gender-based class grouping on middle school student achievement: Teachers' administrators' and parents' perceptions. *CIA World Facebook 2010*, Anambra State University, Nigeria. 5-6.

Chen, C. H. and Howard, B. 2010. Effect of live simulation on middle school students' attitude and learning toward science. *Educational Technology and society.* 13(1): 133-139.

Chin, L. 2004. Problem-solving-based learning in real estate education. *Journal of Real Estate Practice and Education.* 3(1): 35-41.

Chukwuka, E. U. 2006. Moral dilemma and problem-solving strategies effects on students learning outcomes in selected environmental education concepts in biology. An Unpublished PhD Thesis. Teacher Education Department. University of Ibadan.

Cimer, A. 2007. Effective Teaching in Science: A Review of Literature. *Journal Turkish Science Education.* 4(1): 24-44

Cobb, C. D. 2002. Assessment of a problem in centered second grade mathematics project. *Journal for Research in Mathematics Education,* 16(1): 37-49.

Collins, A. and Morrison, D., 1992, "Strategic simulations in undergraduate biology: An opportunity for instruction," The 65th Annual Meeting of the National Association for Research in Science Teaching (NARST), Boston, MA, USA.

Coulter, B. 2003. *Puzzles and games balance view classroom*. Retrieved 19 January, 2011 from *http://cf.synergylearning.org/displayarticle.cfm?selectedarticle=444*

D'Avanzo, C. 2008. Biology concept inventories: overview, status, and next steps. *BioScience* 58, 10:79-85

Dada, E.M. 2009. Policy Evaluation of the Curriculum Nigeria Certificate in Education (NCE). *European Scientific Journal* 4,(8) 24-35.

Danmole B.T. 2012. Biology teachers view on practical work in senior secondary schools of south western Nigeria. *Pakistan Journal of Social Sciences* 9, 2: 69-75

Daramola, C. A. 2010. Relative contributions of selected teachers' variables and students' attitude toward academic achievement in biology among senior secondary schools' student in Ondo State, Nigeria. *Journal of Research Education,* 2.4.

Daramola, F. O., Yusuf, M. O., & Oyelekan, O. S. 2015. Information and Communication Technology Literacy among Student-Teachers in Universities in Nigeria. Malaysian Online Journal of Educational Technology.

Daramola, I. 2006. Relationship between mass media and society. International Journal of Communication. No 6, pg 106-120.

De Castro, E. L., Prenda, M. T. B., Laguador, J. M. and Pesigan, M. 2015. Mental ability, work behavior and trait survey of high and low performing first year computer engineering students. *Asian Journal of Educational Research*, 3.4: 1 – 9.

de Jong, T., van Joolingen, W.R., Swaak, J., Veermans, K., Limbach, R., King, S., and Gureghian, D. 1998. Self-directed learning in simulation-based discovery environments. Journal of Computer Assisted Learning, 14, 235-246.

DeYoung, S. 2003. Teaching strategies for nurse educators. Upper Saddle River, NJ: Prentice Hall.

Duyilemi, A. N. 2006. Girl Child Education and Empowerment. Keynote Address Presented at Workshop for Senior Secondary School Female Student Teachers and Education Officers in Ondo South West Senatorial Districts, Okitipupa

Earpol, N. W. 1970. Procedure for teaching reading mathematics. *American Teacher,* 17(25): 75-79.

Edith, E. C. 2013. The role of information and communication technology in enhancing effective instructional delivery in tertiary institutions. *Journal of Educational Media and Technology*, 17(1): 75 - 83.

Efe, H. A. and Efe, R. 2011. Evaluating the effect of computer simulations on secondary biology instruction: An application of Bloom's taxonomy. *Scientific Research and Essays,* 6.10: 2137 – 2146. Retrieved 16/4, 2017 from http://www.academicjournals.org/SRE ISSN 1992-2248

Egbugara, U. O. 1989. An investigation of aspects of students' problem-solving difficulties in ordinary level physics. *Journal of Science Teachers Association of Nigeria.* 21(1): 57-67.

Egbunonu, R. N. and Ugbaja, C. 2011. Biology teachers' perception of the factors affecting the effective implementation of biology curriculum: the way forward for education reform. In Abonyi, O. S. Ed. *Proceedings of the 52nd Annual Conference of Science Teachers Association of Nigeria*, 235 - 241.

Elsevier, B. V. 2009. Self-efficiency and academic achievement in Australia science. *Direct Journal of Adolescent.* 23(4): 797 – 817.

Erhan, D. and Okan, B. 2011. The relationship between students' exposure to technology and their achievement in Science and Mathematics. *The Turkish online Journal of Educational Technology*. 10

Esan, A. O. 2002. Effects of cooperative and individualistic problem solving strategies on students learning outcomes in secondary school mathematics. Unpublished Ph.D. Thesis, University of Ibadan vii+122pp.

_____ Fakolujo O.,& Oluleye A. 2013. Designing and developing e-Content in higher education : The University of Ibadan model. *Unlocking the potential of*

ICT in higher education :case studies of the Educational Technology initiatives at African Universities. 80-93

Falker, N., Sooriamurthi, R. and Michalewicz, Z. 2010. *Puzzle-based learning for engineering and computer science.* Computer practices. The IEEE Computer Society

Falkner, N., Saoriamarthi, R. and Michalewicz, Z. 2009. *Puzzle-based learning: the first experience*. Retrieved, 23 June, 2010 from http://*doi.ieeecomputersociety.org/10.1109/MC.2010.113.*

Farahaz, M. 2012. *Improving students' attitude toward science through blended learning*. Department of Biological Sciences. Harold Washington College.

Federal Ministry of Education, 2013. *Senior secondary school curriculum: biology for senior secondary school.* Abuja: *Educational Research and Development Council* (NERDC).

Fend, H. and Scheel, 2005. *From theory to action*. Retrieved, 22 May, 2009 from http://springs.com/pter/10 100 7/978-90.481-8598-62.

Fisher, A. 2001. Critical Thinking: An Introduction, Cambridge University Press, Cambridge, UK.

Franklin, S., Peat, M, and Lewis, A. 2003. Non-traditional interventions to stimulate discussion: the use of games and puzzles. *Journal of Biological Education,* 37(2), 79- 84.

Gambari, Isiaka, A., Emmanuel and Ikusanu, T. 2014. Efficacy of computer-based simulation on students' achievement in physics education. *Indo-African Journal of Educational Research.* 2(1): 15 - 20.

Garba Grace Macdonald 2009. Science Education and the Achievement of the Millennium Development Goals (MDGs) by 2015. *Journal of the voice of the teachers.* 3(1): 29 - 56

Gardener, P. L. 2006. Mathematics attitudes to science. *Research in Science Education,* 25(3): 283-295.

Giancarlo C. A., Facione P. A. 2001. A look across four years at the disposition toward critical thinking among undergraduate students. *J. Gen. Educ.* 50(1):29–55.

Gladys C. and Cheta W. 2015. Flipped classroom versus a conventional classroom in the learning of mathematics. *British Journal of Education* 3, 6: 71-77

Graham, D. C. 2005. Cooperative learning methods and middle school students. A Published Ph.D Thesis, Capella University. 25-60

Gul, S. and Yesilyurt, S. 2011. The effect of computer assisted instruction based constructivist learning approach on students' attitudes and achievements. *Electronic Journal of Science and Mathematics Education.* 5(1): 94 - 115.

Hansen, P. A. and Sefton, A. J. 2005. Global future for education in physiology. International Union of Physiological Science Teaching Workshop, April 7-10, Pali Mountain, California. *Adv Physiol Educ,* 29: 216 – 226. Retrieved, 12 January, 2016 from http://daphine palomer,edu/…t/HAPS 05/msg 01168.

Harris, J. 2001. The effects of computer games on young children – a review of the research. RDS Occasional Paper No. 72. London: Research, Development and Statistics Directorate, Communications Development Unit, Home Office.

Hays, R.T. 2005. The effectiveness of instructional games: A literature review and discussion.
Retrieved 11/10/2017, from. http://adlcommunity.net/file.php/23/GrooveFiles/Instr_Game_Review_Tr_2005.pdf

Heller, P., Keith, M. and Anderson, S. 1992. Teaching problem-solving through co-operative grouping part I. group versus individual problem-solving. *American Journal of Physics,* 60(7): 627 - 636.

Hichi, H. and Renniger, H. 2006. Four-phase model of interest development. *Educational Psychologist Journal.* 42(2): 98 - 127

Hidi, K. and Harackiewicz, E. 2002. *The four-phase model of interest development*. Retrieved, 12 January, 2016 from http://www. Unco.edu/…/resources/hidi-renmiger 06 pdf

Hill, J. M. D. 2003. *Puzzles and games: addressing different learning styles in teaching operating system concept*. ACM Press.182-186.

Hofstein, A. and Lunetta, V. N. 2003.The Laboratory in Science Education: Foundations for the Twenty First Century, Science Education, 88, 28–54.

Hofstein, A. and Naaman, R. M. 2007. The Laboratory in Science Education: The State Of The Art. *Chemistry Education Research and Practice,* 8(2), 105-107

Howe, R. W. and John, F. D. 2000. *Environmental activities for teaching critical thinking*. ERIC/SMEAC, Columbus, OH, 2000 (in press). Retrieved, 12 May, 2001 from http://thenationalonlineng.net/web3/mobile/education/12573.html

Huppert J, Lomask SM, Lazarowitz R. 2002. Computer simulations in the high school: students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education*. 24:803-821.

Idowu Y. A. 2010. *Gender dimensions of agriculture, poverty, nutrition and food security in Nigeria*. Department of Agricultural Economics. University of Ibadan, Nigeria. Pgs. 14-19.

______ and Ige, T. A. 2007. Science teachers' assessment of puzzle games in the teaching of environmental concepts of integrated science. Retrieved, 7 January, 2009 from http://Iosrjournals.Org/…r-jrme/papers/vol-

Ige, T. A. 2001. Concept mapping and problem solving teaching strategies as determinates of achievement secondary school ecology. *Journal of Educational Studies.* 1(1): 34 - 67.

Ikitde, G. A. 1993. Fostering Experimental Proficiency of students in Biology through Problem-solving Approaches. Unpublished Ph.D Thesis. University of Ibadan, Ibadan. 35-38.

Iroegbu, T. O. 2002. Language proficiency, level of commitment and class-size as determinants of science achievement at the secondary school level. In Abdul-Mansaray and Osokoya, I. O. Ed. *Curriculum development at the turn of the century*. 41-155.

Ivowi, U. M. O 2000. The student's women in Physics in Nigeria. *42nd Annual Conference proceeding science Teacher Association of Nigeria*

Jegede S.A. & Ayeni M.F. 2013. Effect of fieldwork on secondary school teachers' attitude towards the study of Ecology in Ekiti State. *International Journal of Academic Research in Progressive Education and Development* 2,1:109-116

Jegede, O. 2007.*The knowledge base for learning in science and technology education. African science and technology education in the new millennium: practice, policy, and Priorities*. Kenwyl: Juta and Co Ltd. 151 -176.

Kaka, O. 2008.*Chemistry puzzle fetches teacher*. Retrieved 29 January, 2011 from

Kan, A. and Akbas, A. 2006. Affective factors that influence chemistry Achievement (Attitude and self-efficacy) and the power of these factors to predict chemistry achievement. *Journal of Turkish Science Education.* 3(1): 77 - 85.

Karamustafaoğlu, O., Aydın, M. & Özmen, H. 2005. Bilgisayar destekli fizik etkinliklerinin öğrenci kazanımlarına etkisi: basit harmonik hareket örneği, *The Turkish Online Journal of Educational Technology* 4(4), 67-81.

Karen, S. 2015. Toward Combining Programmed Instruction and Constructivism for Tutorial design. Retrieved 3rd March, 2015 from users/username/documents programmed%20instruction%20contructivism

Kasali, S. O. 2000. Students' reasoning ability as a predictor of performance and attitude towards integrated science. Unpublished B.Ed. Project, University of Ado Ekiti, Nigeria. 28-30.

Ke, F., and Grabowski, B. 2007. Gameplaying for maths learning: Cooperative or not? British Journal of Educational Technology, 38(2), 249-259.

Kebritchi, M., Hirumi, A., and Bai, H. 2010. The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers & Education,* 55(2), 427-443.

Kendalls, G., Parks, A. and Spoerer, E 2008. A survey of NP – complete puzzles. *International Computer Games Association Journal.* 31(1): 13 - 84.

Kerlinger, F. N. 1977. *Foundations of behavioural research*. 2nd Ed. New York: Holts, Rinehart and Winston Inc.

Kiboss, J., Wekesa, E. & Ndirangu, M. 2006. Improving Students' Understanding and Perception of Cell Theory in School Biology Using a Computer-Based Instruction Simulation Program. *Journal of Educational Multimedia and Hypermedia, 15* (4), 397-410. Retrieved from http://www.editlib.org/p/19985.

Kim M. & Song J. 2009. The effect of dichotomous attitude towards science on interest and conceptual understanding in physics. *International Journal of Science Education* 31,17: 2385-2406

Klymkowsky M. W. 2006. Can nonmajors courses lead to biological literacy? Do majors courses do any better? Cell. *Biology Educational Journal.* 4(1): 42–44.

Kocakülah, S.M. & Kocakülah, A. 2006. Öğrencilerin bilgisayar simülasyonları ve deney düzeneklerinin kullanımına ilişkin tutumları, 7. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Özetler Kitabı, 07- 09 Eylül, Ankara, s. 419

Krapp, A. 2002. Structural and dynamic constructs of interests' development, theoretical consideration from an ontogenetic perspective. *Learning and Instruction.* 12(4): 383 - 409.

Kuncel, N. R., Crede, M. and Thomas, L. L. 2005. The validity of self-reported grade point averages, class ranks, and test scores: A metaanalysis and review of the literature. *Review of Educational Research.* 75(3): 63 – 82.

Lauric, Williams Robbert Kessler 2001: Experimenting with industry pair programming model in the Computer Science Classroom. *Journal of Science Education*. 5(1): 53 – 76

Laurillard, D. (1993). Rethinking University Education: a framework for effective use of educational technology, Routledge.

Lee, A. T., Hairston, R. V., Thames, R., Lawrence, T. and Herron, S. S. "Using a computer simulation to teach science process skills to college biology and elementary education majors" Bioscene: Journal of College Biology Teaching, 28(4), 35-42, 2002.

Liao, H. 2005. *Effects of cooperative learning on motivation, learning strategy utilization, and grammar achievement of English language learners in Taiwan*. University of New Orleans Theses and Dissertations. Paper 329.

Liao, Y. C, 2007, "Effects of computer assisted instruction on students' achievement in Taiwan: A meta-analysis," Computers and Education, vol. 48 , no. 2, pp. 216-233

Light, P. H. and Mevarech, Z. R. 1992. Cooperative learning with computers: An introduction. *Learning and Instruction*, 2, 155-159.

Lindgren, R. and Schwartz, D.L. 2009. Spatial Learning and Computer Simulations in Science. *International Journal of Science Education* 31(3): 419–438

Lock, R. 2010. Gender and practical skill performance in science. *Journal of Research in Science Teaching and Research in Science.* 29(3): 227 - 241.

Lovelace, M. 2005. Meta-analysis of experimental research based on the Dunn and Dunn Conversation between Psychology and Anthropology. *Ethos*. 36(1): 1-28.

Loveless, A. and Ellis, V. 2002.Information and communication technologies, pedagogy and the curriculum. *Education Information Technology.* 7(1): 81-83.

Maal, N. 2004. *Learning via multisensory engagement.* Association Management. Wa shington, D.C.: American Society of Association Executives. 15-18.

Malcom S. M., Abdallah J., Chubin D. E., Grogan K. A System of Solutions: Every School, Every Student. Washington, DC: American Association for the Advancement of Science; 2005.

Maldonado, M. 2005. Model for development, using and evaluating puzzles for teaching puzzles: a pathetically neglected, commonly available resource children 51(4).

Margolis, H. and Mccabe, P. P. 2000. Improving self-efficacy and motivation: what to do, what to say. *Intervention in School and Clinic.* 41(4): 218 - 277.

Mayer, J. D. and Cobb, C. D. 2000. Educational policy on emotional intelligence*: does it make sense? Educational Psychology Review,* 12.2: 163-183. Retrieved 21 Ma rch, 2016 from http://www.pacific.edu/…nts/library/acrobat/mayer-ed/0

______and Moreno, R. 2000. Cognitive principles of multimedia learning: The role of modality and contiguity. Journal of Educational Psychology. 91(2): 358 – 368.

Mayer, R. E. 2004. *Thinking problem-solving*. Englewood Cliffs, New Jersey: Prentice Hall. 33-35.

McGlynn, A. P. 2007. Comparing generations of students. In A. P. McGlynn (Ed.), Teaching today's college students: Widening the circle of success. Madison, WI: Atwood Publishing.

Moemeke, C. D. 2003. Effectiveness of individual is fieldwork collaborative field work and expository approach on biology students' ability to solve problems. An unpublished seminar paper presentation. University of Ibadan.9-15.

______ 2003. Potency of Fieldwork in the Development of Problem-solving Abilities in Ecology by senior secondary school biology Students. Paper presented at 44th STAN Annual Conference, 2003.

Morribend, B. 2004. Gender and Academic ability as Determinant of Students' affective and Cognitive Achievement in Environmental Education. *Journal Environ. Value. Edu.,* 98(2): 10-25.

Muhammad, K. and Fadzlliyati, K. 2010. "Engaging learners' comprehension, interest and motivation to learn literature using the reader's theatre," English Teaching: Practice and Critique, vol. 9, no. 3, pp. 132–159,

National Research Council (NRC) 2011.*Science Teaching Reconsidered,* National Academy Press, Washington D.C

National Teachers' Institute, 2011.manual for the re-training of junior secondary school teachers' basic science and technology: Millennium Development Goals (MDGs) Project. NTI Press.

Nelson, B. 2011. *Puzzles for Education*. Retrieved 29 January, 2011 from http://searchwarp.com/swa68008.puzzlefor-education.htm.

NERDC (Nigerian Educational Research and Development Council). 2009. 3-Year Biology Curriculum. for SSS 1-3.

Nerdel, C. and Precht, H. 2004. *Learning complex systems with simulations in science education.* Retrieved 29 January, 2011 from http://www.iwm kmrc.de/workshops/SIM2004/pdf_files/Nerdel_et_al.pdf.

Nsofor, C.C., Ala, N. A. and Gambaki, A. A. 2013. Effects of computer aided instructional package on students' academic achievement in biology concepts in Bauchi State, NAEMT International Conference Proceedings, 390-397

Obioma 2007: In preface for national Community for Schools, NERDC Press. Nigeria Proceedings of 47th Annual Conference of Science teacher Association of Nigeria, Nzewi, V. Ed. 3-2

Obstfeld, M. and Kenneth, R. 2001. The six major puzzles in International Macroeconomics: is there a common cause? In Ben S. Bernanke and Kenneth R. Eds. *NBER Macroeconomics Annual,* 2002, Cambridge, MA: MII Press. 339-390.

Oduwaiye, J.O. 2009. Impact of Computer-Assisted and Programmed Instructions on Pre-service Teachers Learning Outcomes in some Environmental Education Concept in Biology. unpublished doctoral thesis to the faculty of Education, University of Ibadan, Nigeria

Ogundiwin, O. A 2013. Effect of pre-theoretic intuition quiz and puzzle-based critical thinking motivation strategies on students learning outcomes in selected environment related concepts, in biology. Unpublished Ph.D Thesis University of Ibadan. 38-40.

______ and Ahmed A. A. 2015. Effects of meaning focus, practice and invention, strategies on problem-solving skills of senior secondary school students in ecology.Journal of Education and Policy Review, 7.1: 28 – 48.

Oguntunde, A. S. 2014. Development and effect of two computer based multimedia instructional packages on learning outcomes of colleges of education pre-service distance learning teachers. A Post-field Report presented at the Joint

Staff/Higher Degree Students Seminar Series, Department of Teacher Education, Faculty of Education, University of Ibadan.

Ojo, T. A 2009. The impact of video-cd and audiocassettes-based Instructions on secondary school students' environmental knowledge, attitudes and practices. Unpublished Ph.D Thesis University of Ibadan. 49-50.

Ojo, T. A. 2008. Impact of Video CD and Audio Cassette Instructions on Students Learning Outcomes in some Environmental Education Concept in Biology. Unpublished PhD thesis to the faculty of Education, University of Ibadan, Nigeria

Okafor, N. 2006. Instructionalization of eyes clubs in Nigerian primary schools: panacea for scientific and technological skills acquisition. In Okafor, N. Ed. Enhancing the status of Science Education. *A proceedings of EYES Workshops*, Lagos: Mukugamu and Brothers Enterprises. 6-10.

Okoro, C. A. and Etukudo, U. E. 2001. CAI versus extrinsic motivation based traditional method: It's effect on female genders' performance in chemistry. A paper presented at 42nd STAN conference in Ilorin

Okurumeh, A. E. 2009. The effect of meaning focus practice and invention, interaction and discussion strategies on achievement and problems solving skills of senior secondary school students in mathematics. Unpublished Ph.D. Thesis University of Ibadan.

Olabiyi, O. S., Aiyelabowo, O. P. and Keshinro O. T. 2013. Relevance of Computer Assisted Instruction (CAI) for effective skill development among technology education students in Nigeria. *journal of Education and Practice.* 4. 21:80 – 90.

Olagunju A. M. and Ojo T. A. 2006, Impact of Video CD and Audio Casette. Basco Instruction Secondary School Education's environmental knowledge in selected environmental Topics in Biology. *Nigeria Journal of Computer Literacy (NJCL),* 5(2): 7-1

Olagunju, A. M. 2002. Environment Education for sustainable Development in Nigeria. Implication for Biological. *Conference proceeding of STAN on difficult concepts in STM.* Abeokuta. 12-15.

Olagunju, A. M. 2005. An Investigation into Teachers' Attitude Towards and Extent of Improvisation of Resources for Effective Teaching of Biology. STAN 41st Annual Conference Proceedings. 2, 120-125.

______and Abiona O. F. 2004. Effectiveness of three modes of instruction on Nigerian biology students' environmental knowledge and attitudes to solid wastes disposal for sustainable development. A paper presentation for publication for CASTME international and CASTME Europe Conference in Nicosia, Cyprus. 15th- 18th April, 2004.

Olagunju, A.M. and Chukwuka, E.U. 2008.The effect of gender and two curriculum packages in environmental education in Biology on Students' problem-solving and cognitive achievement. 2(2): 154-156

Olanekan, A. and Oludipe, F. 2016. Effects of Computer Simulation Instructional Strategy on Biology Students' Academic Achievement in DNA replication and transcription.

Olatoye, R. A. and Adekoya Y. M. 2010. Effect of project based, demonstration and lecture teaching strategies on senior Secondary Students achievement in an aspect of agricultural science. *International Journal of Educational Research and Technology.* 1(1): 19 - 29.

Oloyede, O. O. 2014. Effect of Anchored Instruction and Congestive Flexibility Strategies on Secondary School Education's Knowledge's attitude and practices in Bool in Oyo State. An unpublished Ph.D. Thesis from Teacher Education Department.

Olubela, R. A. 2013. Effects of appreciative inquiring and reflective discourse strategies on undergraduate students learning outcomes in citizenship education concepts in South/West, Nigeria. Unpublished Ph.D Proposal. University of Ibadan, Ibadan.

Olumide, O. J. 2012. Effect of computer simulation instructional package on students' achievement in biology and attitude towards biology. Unpublished M.Ed. Project. University of Ibadan, Ibadan. 37-40

Onwumere, A.A. & Kalu, J. N. 2012. The integration and use of computer-assisted instruction(cai) to enhance understanding in the learning and competency in the use of English Language in Primary Schools in Nigeria. NAEMT International Conference Proceedings. 1: 46-55

Orlich, D. C., Harder, R. J., Callahan, R. C., Trevisan, M. S. and Brown, A. H. 2010. *Teaching strategies – guide to effective instruction*. 9th edition. Wadsworth Engage Learning.

Orukotan, A. F. 2006. The relative effect at instructional strategies of framing and rehearsal on senior secondary school students learning outcomes in some biology topics. (Unpublished doctoral dissertation). University of Ibadan, Ibadan, Nigeria.

Orukotan, A.F 2006. The relative effect of instructional strategies of framing and rehearsal on Senior Secondary School Students" learning outcomes in some Biology Topics. Unpublished Ph .D Thesis Department of Teacher Education. University of Ibadan

Osborne, J., Simon, S. and Collins, S. 2003. Attitude towards science: a review of the literature and its implications. *International Journal of Science Education* 25.9:
1049-1079. Retrieved July 3, 2014 from http://dx.doi.org/10.1080/095006903
2000032199

Osokoya, M. M. 2002. Modern Trends in the Teaching of Secondary Schools Chemistry – In Ayodele, S. O. Ed. *Teaching Strategies for Nigerian Secondary Schools.* 3(1): 213-229.

Oyeleke, O. 2011. The Democratization Process and Classroom Teaching in Nigeria. *Journal of Citizenship Social and Economic Education.* 10(1): 25 - 42.

Özdemir, M. 2005. Fen Eğitiminde Bilimsel Süreç Becerilerine Dayalı Laboratuar Yönteminin Akademik Başarı, Tutum Ve Kalıcılığa Etkisi. Yayımlanmamış Yüksek Lisans Tezi, Zonguldak Karaelmas Üniversitesi, Zonguldak.

Özdener, N. 2005. Deneysel öğretim yöntemlerinde benzetişim (simulation) kullanımı, *The Turkish Online Journal of Educational Technology* 4(4), 88-92.

Pajares, F. 2006. *Adolescence and education self-efficiency of adolescents*. Greenwich C.T. information Age Publishing: New York. 24-27.

_______and Kranzler, 1995. Self efficacy beliefs and general mental ability in mathematical problem solving. Contemporary Educational Psychology, 20.4: 426 - 443.

_______ and Urdan, O. 2006. Adolescence self efficacy 2015 in the adolescents and education series. Greenwich Information Age Publishing: New York.

Pange, J. 2003. Teaching probabilities and statistics to preschool children. *Information Technology in Childhood Education Annual,* 163-172.

Pareto, L., Arvemo, T., Dahl, Y., Haake, M. and Gulz, A. 2011. A teachable-agent arithmetic game's effects on mathematics understanding, attitude and self-efficacy.

Pektaş, M., Türkmen, L. & Solak, K. 2006. Bilgisayar destekli öğretimin fen bilgisi öğretmen adaylarının sindirim sistemi ve boşaltım sistemi konularını *öğrenmeleri üzerine etkisi, Kastamonu Eğitim Dergisi* 14(2), 465-472

Piaget, J. 1957. The equilibration of cognitive structure: the central problem of intellectual development. Chicago, IL: University of Chicago Press.

Pilar, L.S. 2013. The Effects of Digital Games on Middle School Students' Mathematical Achievement. Lehigh University Lehigh Preserve. Theses and Dissertations.

Pilli, O. 2008. The Effects of computer-assisted instruction on the students' achievements, attitudes and retention in the of fourth grade mathematics course. Unpublished Ph.D Dissertation, University of Middle East Technical, Ankara, Turkey.

Pilli, O. and Aksu, M. 2012. The effects of computer-assisted instruction on the achievement, attitudes and retention of fourth grade mathematics students in North Cyprus. Computers & Education. Advance online publication. doi: 10.1016/j.compedu.2012.10.010

Polya, G. 1957. *How to serve it, Garden City*. New York: Double day.

Popoola, B,Y. 2004. Use of English Language and communication skills series 4. Oyo: Tobistic Printing and Publishing ventures.

Popoola, B. I. 2012. Personality Characteristics, Socuo-Demographic Variables and Work Attitudes as Correlates of counseling Effectiveness in South Western Nigeria. Unpublished Ph.D Thesis, Obafemi Awolowo University, Ile-Ife, Nigeria.

Powell, K. and Wells, M. 2002. The Effectiveness of three Experimental Teaching Approaches on students' science learning in fifth grade public school classrooms. *The Journal of Environmental Education 13 pp.33-38*. Purdue University. April 7, 2008:

Raimi, S. M. 2003. Gender difference in acquisition of practical skills. Unpublished Paper Presented at the *1st National Conference on Science, Technology and Mathematics Education.* School of Science, St. Andrew's College of Education, 17th-20th, July.

Renshaw C. E. & Taylor H. A. 2000. The Educational Effectiveness of Computer Based Instruction. *Computer Geosa Journal.* 26(6): 67 - 98

Resnik, L. B. and Glasser, R. 1976. Problem-solving and Intelligence. In Resnick, L. Ed. *The nature of intelligence*. Hillsdale, New Jersey: L. E. Associates.

Robert, L. 2003. Assesment of Active Learning with Upper Division Computer Science Students. 33rd- ASEE/TEE. Frontiers in Education Conference, November, 5-8, 2003, Bounder. Co.

Rosas, R., Nussbaum, M., Cumsille, P., Marianov, V., Correa, M., Flores, P. 2003. Beyond Nintendo: design and assessment of educational video games for first and second grade students. *Computers & Education,* 40(1), 71–94.

Ross, J. M, and Huang, O. 2001. Guiding students thought programming puzzles: value and examples of java games assignment. *SIGCSE Journal.* 34(4): 94 – 98.

Saat, R.M, 2004. The Acquisition of Integrated Science Process Skills in a Web-based Learning Environment, Research in Science & Technology Education, 22(1), 23-40.

Sahin, S. 2006. Computer Simulations in Science Education: Implication for Distance Education. *Turkish Online Journal Dist. Educ.,* 7(4): 132-146

Saleh., E. 2004. The ability to solve non-routine problems among high achievers. Unpublished Master's Project, University Kebanysan, Malaysia.

Sangodoyin, 2011. Municipal solid waste management strategy. *Ocean DYN Journal*, 61(4): 403 – 410.

Schnotz, W, and Bannert, M. 2003. Construction and interference in learning from multiple representation. *Learning and Instruction Journal*. 13(1): 141-156.

Schunk, D. and Pajares, F. 2006. *Self efficacy development in adolescents*. Retrieved 2 June, 2016 from http://www.vkyedueushe2/pajares/03schrikmeeceAdoEd5.pdf

Scott, K. 2002. *Ten ways to use puzzle in mathematics education*. Retrieved 28 June, 2010 from http:/www.scott kim. com/education/tenways.html.

Seifert, B. 2007. Die Ameisen Mittel- und Nordeuropas. Lutra Verlags- und Vertriebsgesellschaft, Tauer

Serj, T. 2002. Thinking and Literacy. *Statistical Educational Research Journal*, 1.1: 30-45.

Serpell, Z. N., 2002, “Ethnicity and tool type as they relate to problem-solving, transfer and proxemic behavior in a communal learning context,” Unpublished doctoral dissertation, Howard University, WA

Shaffer, D. W., Squire, K. D., Halverson, R. and Gee, J. P. (2005). Videogames and the future of learning. *Phi Delta Kappan,* 87(2), 104–111.

Shahrzad, E. M. Kourosh, A., Mohammad, J. Y., Haitham, A. A. and Hossein, S. 2011. The relationship between self-efficacy and academic achievement in high school students. *Procedia Social and Behavioral Sciences Journal.* 15(2): 765 – 768.

Shapiro, B. C. D. 2005. Review a 21st century view of evolution genome system architecture, repetive DNA, and natural genetic engineering. Retrieved 8 March, 2016 from http//uchicago.edu/shapiro2005.gene.pdf. 7-15.

Sjoberg, S. 2006. *Cross-cultural evidence and perspectives on pupils' interests, experiences and perceptions, Osolo Norway*. Department of Teacher Education and School Development, University of Oslo.

Slack, S. and Stewart, J. 1989. Improving students' problem-solving in genetics. *Journal of Biological Education.* 23(4): 308 - 312.

Squire, K., Giovanetto, D., Devane,S. and Durga, A.S. 2005. Electromagnetism supercharged!: learning physics with digital simulation games. In Proceedings of the 6th international conference on Learning sciences. Santa Monica, California: International Society of the Learning Sciences, pp. 513-520.

Squire, K., Giovanetto, K., Devane, B., and Durga, S. 2005. From users to designers: Building a self-organizing game-based learning environment. TechTrends: Linking Research & Practice to Improve Learning, 49(5), 34-42.

Teke, H., Doğan, B., and Duran, A. 2015. Influence of the Simulation Method on 7th Grade Students' Achivements in Science and Technology Lessons. International Journal of Research in Education and Science, 111-118.

Tella, A. 2007. The Impact of Motivation on Student's Academic Achievement and Learning Outcomes in Mathematics among Secondary School Students in Nigeria. Eurasia Journal of Mathematics, Science & Technology Education, 3(2), 149-156. https://doi.org/10.12973/ejmst..

Thomas, R.C. and Milligan, C.D. 2004. Putting Teachers in the Loop: Tools for Creating and Customising Simulations. *Journal of Interactive Media in Education (Designing and Developing for the Disciplines Special Issue),* 2004 (15).

Tschannen-Moran, M., and Woolfolk Hoy, A. 2001. Teacher efficacy: capturing and elusive construct. *Teaching and Teacher Education.* 17(3): 783 – 805.

Ukoh, E. E. 2012. Effects of problem-based learning instructional strategy and interactive invention strategy on pre-service NCE students' achievement and acquisition of science process skills in physics. Unpublished Ph.D Thesis, University of Ibadan.

Umoke, J. and Nwafor, E. 2014. Integrating computer Technology in the teaching of biology Journal pg. 7.

Usher, E. L. and Pajares, F. 2007. Self-efficacy for self-regulated learning: a validation study. *Educational and Psychological Measurement.* 68(1): 443 – 463.

Vocka, M., Preckelb, F. and Holling, H. 2011. Mental abilities and school achievement: A test of a mediation hypothesis. *Intelligence,* 39(5): 357 – 369. Retrieved 11 October, 2016 from http://www.sciencedirect.com/science/article/pii/S0160289611000808?np=y

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., and Wright, M. 2006. Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research,* 34(3), 229-243.

Von-Glassfeld, E. 1987. *Constructivism in education*. Oxford England: Pergamon Press. Retrieved, 20 May, 2009 from http://eric.ed.gov/PDFS/ED444966.pdf. 9-10.

Wagner, K.V. 2005. *Self-efficiency*. Psychology definition of the week. Retrieved 18 August, 2011 from https://www.psychologypress.com

Ward, E. A. (2001). Multidimensionality of Achievement Motivation among Employed Adults. The Journal of Social Psychology, 137(4), 542-544

West African Examination Council 2007. WAEC Chief Examiners' report for the West African Senior School Certificate Examination (WASSCE). WAEC press.

West African Examinations Council 2009. WAEC Chief examiners' report for the West African Senior school certificate examination (WASSCE). WAEC press.

West African Examinations Council 2010. WAEC Chief examiners' report for the West African Senior school certificate examination (WASSCE). WAEC press.

West African Examinations Council 2012. WAEC Chief examiners' report for the West African Senior school certificate examination (WASSCE). WAEC press.

Wikipedia: https: en.m.wikipedia.org/wiki/social_cognitive theory.

Wood, W. B. and Gentile, J. M. 2003.Teaching in a Research Context.*Science.* 30(2): 15 - 37

Woolfolk, Hoy, A. and Davis, H. 2005. Teachers' sense of efficacy and adolescent achievement. In Urdan, T. and Pajares, F. Eds. Self-efficacy beliefs during adolescence. *Adolescence and education Journal.* 5(2): 117 – 137.

Wright, D. S. and Williams, C. D 1986. A WISE Strategy for Introductory Physics. *Physics Teacher.* 24(4): 211 – 216.

Yip, F.W.M. & Kwan, A.C.M., 2006. Online vocabulary games as a tool for teaching and learning English vocabulary. Educational Media International, 43(3), 233-249.

Yusuf, S. and Afolabi, Y. 2010. Effects of Computer Assisted Instruction (CAI) on Secondary

Zacharia, Z. and Barton, A. C. 2004. Urban Middle-School Students' Attitudes toward a Defined Science. Science Education, 88(2).

Zingaro, D. 2008. *Group investigation: theory and practice*. Ontario Institute for Studies in Education, Toronto, Ontario.

Zmaczynski, S. K. 2002. Triangular table: chemistry puzzle and teaching device. *United States Patent No. 20020072046*.

Zubair, A. S. and Nasir, M. 2011. Developing a scale to measure attitude towards science learning among school students. *Bulletin of Education and Research Journal*. 33(1): 71 –81.

APPENDIX 1A

STUDENTS PROBLEM- SOLVING TEST IN BIOLOGY (SPSTB)

SECTION A

Name of School --- Class------Sex:-------------------

Time: 1 hour

SECTION B - PART I

Sex: Male -------------------- Female ----------------------------

INSTRUCTION: The purpose of the questions is to find out how logically and accurately you think. Your reason for choosing an answer is as very important as the answer selected.

Please record your answer to each of the questions on the separate answer sheet provided. Use the following steps in answering each question.

(1) Read the question thoroughly and carefully

(2) Think carefully before selecting your answer

(3) Record your answer in the correct column on the answer sheet provided e.g. Answer/Reason

A

(4). Read the set of possible reasons provided for your answer

(5) Carefully choose the reason which best matches your thinking after working out the answer

(6) Record your reason in the right column on the answer sheet e.g.

Answer	Reason
A	2

7. If you change your mind about the answer cross out the old answer and record the new choice e.g. Answer

A ~~B~~ 2, ~~4~~

8. Record your name and personal data on your answer sheet.

Now read and answer the following questions

Attempt all questions.

ECOLOGY

I. Occurrence of air pollution started prior to the industrial revolution period. Although many people tend to regard air pollution as one of the dividends of industrialization, the causes of air pollution in Ikoyi town could be traced to:

(1) Natural contaminants

(2) Burning of carbon

(3) Burning of sulphur and sulphur containing compounds.

(4) Oxides of Nitrogen in the air

(5) Emissions from industries

(6) Automobile exhaust emission

(7) Microscopic organisms such as bacteria, fungi parts of insects

(8) Chlorofluorocarbon (CFC).

(9) Dust and smoke

Question 1:

Defining the Problem

Question 1: What concept in Biology does this analogy represent?

a) Nitrogen cycle
b) Air pollution
c) Destructive measures
d) Natural occurrences
e) Over population

REASONS

1. Emission of air pollutants
2. Disposal of waste
3. Effects of industrialization
4. Effects of Human activities on natural habitats
5. Conservation of resources

Selecting appropriate information

Question 2: What are the likely general effects of this air pollution to Ikoyi transporters?

(a) Reduction in visibility of the atmosphere

(b) Fishes are produced in abundance

(c) The soil becomes fertile

(d) Acute illness possibly leading to death

(e) Destruction of the ozone layer

REASON

1. The dust particles in the atmosphere reduce the amount of light reaching the earth thereby leading to accidents on the roads
2. Dust particles cause diseases such as asthma, cancer, bronchitis etc.
3. Sulphur dioxide can damage leaves, fruits, flowers
4. The sulphuric and nitric acids affect fertility of the soil.
5. More ultraviolet rays reach the earth's surface

Combining the pieces of information:-

Question 3: What will be the most economic implication of air pollution to Ikoyi community?

The same problem occurred at Mushin Area, what is the likely effect and remedy to these problem.

(a) Many people will suffer from malaria

(b) Many will suffer from bronchitis and other lung diseases

(c) Many companies will close down

(d) Less number of workers will be in the offices

(e) There will be reduction in standard of living

REASON

1. The hospital will be congested
2. More government revenue will be spent on drugs
3. Many companies will not get raw materials
4. Government will build more schools
5. More money will be spent on food

Evaluation:-

1. What are the preventive measures to these problems?

a) Laws on conservation of plants and animals should be implemented

b) Proper disposal of waste gases

c) Reduction of burning activities

d) Separating residential areas from industrial areas

e) Educating masses on the effects of the problem

REASONS

1. Proper circulation of oxygen
2. To stop contamination of air
3. Prevention of exposure to dangerous gases
4. Reduction of human activities against the surrounding residential areas

APPENDIX 1B

STUDENTS PROBLEM – SOLVING IN BIOLOGY (SPSB) GENETICS

NAME OF SCHOOL……………………CLASS…………………...

SEX……………………

TIME: 1 Hour

INSTRUCTION: The purpose of the question is to find out how logically and accurately you think. Your reason for choosing an answer is as very important as the answer elected.

Please record your answer to each of the question on the specified answer sheet provided. Use the following steps in answering each question.

1. Read the question thoroughly and carefully
2. Think carefully before selecting your answer
3. Record your answer in the correct s column on the answer sheet provided e.g answer/Reason.
4. Read the set of possible reason provide for your answer
5. Carefully choose the reason which best matches your thinking after working out the answer
6. Record your answer in the right column on the answer sheet. E.g

Answer	Reason
A	2

7. If you change your mind about the answer, cross out the old answer andrecord the new choice e.g.

Answer	Reason
~~A~~ B	~~2~~ 4

8. Record your name and personal data on your answer sheet.

   Now read and answer the following questions:-

INSTRUCTION: Read the following passages carefully and answer the question that follow:

ATTEMPT ALL QUESTIONS

Mr bode, his wife Lola, and their two boys, Jide and Kola went out, for lunch on a Saturday afternoon. They had a good time enjoying their meal of Amala and fresh fish soup. They were on their way out of the restaurant when they met an old school friend of Mr Bode, Lekan. Both men were very excited to see each other after a very long time. Mr Bode introduce the wife and children to Lekan. Lekan was quite surprised and he did not hesitate to ask why the boys are fair in complexion when the parents are dark in complexion. Mr Bode quickly reminded him that the boys paternal parents are very fair skinned.

Defining the problem

Question 1: What concept in Biology does this analogy represent?

a) Organization of life
b) Microorganisms and life
c) Ecological management
d) Science of heredity genetics
e) Development of new organism

REASONS:

1) Micro organisms are responsible for the difference in complexion
2) There are different stages in life
3) New organisms evolve from a pre-existing one
4) There is variation in Heredity
5) environment pressure is the cause of natural selection

Selecting appropriate information

Question 2: The parents, Bode and his wife are dark in complexion. The children, Jide and Kola are fair in complexion, what expect of inheritance explain this.

1) Dominant form of expression
2) Recessive form of expression
3) Co-ordinance of expression
4) Transmittable characters
5) Non-transmittable characters

REASONS

1) presence of an allele whose phenotypic expression is visible the offspring
2) the traits of fairness in the parents cannot be transmitted to the offspring.
3) The presence of an allele whose phenotypic expression is not visible in the offspring

4) The presence of a pair of allele whose phenotypic expression are both fully expressed in the children
5) The children rejected the tracts for fairness

2b) In a situation where the parents are dark in complxtion and the offsprings are also dark, what aspect of inheritance explain this?

a) Heredity
b) Variation
c) Dihybridization
d) Dominance
e) Recession

REASONS

1) differences occurrence within individuals of a species
2) presence of allele whose expression is masked or hidden
3) manifestation of two characters, determined by two alleles of a gene
4) characters are transferred from parents to offsprings
5) presence of allele that completely dictates the appearance of heterozygotes

Combining the pieces of information

3. Which of the scientific laws/theories supports your answers to questions 2a and 2b?

a) Law of inheritance
b) Law of independent assortment of genes
c) Theory of evolution
d) Darwin's theory
e) Law of variations

REASONS

1. Acquired traits can be passed from parents to offspring
2. Environmental pressure is the driving force behind evolutionary change
3. In diploid organism, one allele may be dictating the expression of the character to the complete exclusion of the other
4. Alleles on different chromosomes assort independently during genete formation
5. The heredity characters of an organism are determined by genes

4) Evaluation

Later in life, if Jide and Kola who are fair in complexion give birth to dark children, how would you convince the public that they are legal children?

a) The drugs given to the children as infants is responsible for the dark skin
b) The weather condition in their town is responsible for the dark skin
c) The children's body cream makes them dark skinned
d) The dark skin (Jide and Kola's parents) i.e. Bode and his wife manifests in their grandchildren.
e) The Children's dark skin will eventually turn fair

REASONS

1) A gene for a character may have the same forms (alleles) which exress the character in different ways
2) The weather condition is too harsh on the skin
3) Each trait has two forms of expression, one dominant one recessive
4) Two alternative alleles separate from each other during all division
5) The drugs is made up of a chemical substance that makes skin dark.

APPENDIX 1C

STUDENT PROBLEM-SOLVING IN BIOLOGY (SPSB)

MARKING GUIDE FOR PART I

1(i) State dilemma based on facts contained in the story (5 mks)

(ii) State dilemma partly on facts from the story, partly by conjecture (3 mks)

(iii) Cannot state dilemma (1 mk)

2(i) State position relevant to the situation in the story (5 mks)

(ii) State a position not relevant to the situation in the story (3 mks)

(iii) Cannot give reasons (1mk)

3 (i) Give reason related to facts in the story (5 mks)

(ii) Give reason unrelated to the facts in the story (personal reasons, perhaps subjective) (3 mks).

(iii) Cannot give reasons (1 mk)

4(i) State consequences relating to facts in the story (5 mks)

(ii) State consequences relating to reasons for acting (3 mks)

(iii) State consequences unrelated to facts and reasons for acting (1 mk).

APPENDIX 1D

STUDENT PROBLEM-SOLVING IN BIOLOGY (SPSB)

ANSWER SHEET FOR PART II

SECTION A

i. Name of Student:---

ii. Sex: (a) Male ( ) (b) Female ( )

iii. Type of School: (a) Boys only ( )

(b) Girls only ( )

(c) Coeducational ( )

iv. Science subject studied: Tick as appropriate (a) Biology

(b) Chemistry ( ) (c) Physics

v. (a) Science Major ( ) (b) Non Science ( )

Section B

S/N	Question	Answer	Reason
1			
2			
3			
4			
5			
6			
7			
8			

UNIVERSITY OF IBADAN
DEPARTMENT OF TEACHER EDUCATION
FACULTY OF EDUCATION

APPENDIX 2

Students Attitude to Ecology and Genetics (SAEG)

INSTRUCTION: Answer all question

SECTION A: Personal Data

Name of School:……………………………………………………………

Name of Student:…………………………………………………………

Local Government:………………………………………………………

SECTION B

The following statements are developed to measure student's attitude to biological science. Rate them, using SD, D, and SA as the case may be. Each of the items means

SD = Strongly disagree

D = Disagree

A = Agree

SA = Strongly Agree

S/N		SD	D	SA	A
	ATTITUDE TO BIOLOGY				
1	I think the knowledge of Biology makes me understand my life				
2	I prefer to tell everyone the advantages one could get from Biology.				
3	I believe the knowledge of Biology will keep our health stable				
4	I think the rate at which the knowledge of Biology is growing in our country will bring about increase in population				

	ATTITUDE TO GENETICS				
5	I think farmers in Oyo state will enjoy bumper harvest if they continue to use liable seeds form Original source				
6	I do not believe that all traits characters from parents will be inherited by the offspring’s				
7	I believe the union between a sickler and a normal person will produce a normal offspring’s				
8	I do not believe that albinism is an inheritable character				
9	I prefer to teach that men are responsible for the sex of a child				
10	I prefer to live in temperate country where the temperature is low				
11	I think the study of probability will help in the determination of sexes of living organisms				
12	I believe recycling will help convert waste to wealth				
13	I dislike the producefrom early maturing animals because the chemical used for their fattening is detrimental to human health				
14	I dislike discouraging future couples from marriage due to their sickle cell status				
	ATTITUDE TO ECOLOGY				
15	I like lessons on land pollution because of its effect on environment.				
16	I dislike lessons on conservation techniques because it cannot supply all the answers to our question about useful living.				
17	I feel there could be misconception of conservation ideas hence it may not be necessary.				
18	I will like boys and girls to learn conservation of resources in Biology.				
19	It is enjoyable see groups and corporate bodies participating in conservation of resources.				
20	I hate field work exercise used for conversation of our natural resources.				

UNIVERSITY OF IBADAN
DEPARTMENT OF TEACHER EDUCATION
FACULTY OF EDUCATION

APPENDIX 3
STUDENTS' ACHIEVEMENT TEST IN ECOLOGY AND GENETICS (SATEG)

SECTION A

Name of the School

Name of Student

Local Government:…………………………………………………………

SECTION B: Circle the correct option

1. In an ecosystem the organism which changes light energy into stored chemical energy is the (a) consumer (b) decomposer (c) producer (d) carnivore
2. Trees in savannah habitats usually have heavy thick bark which mainly (a) reduces the rate of transpiration (b) protect them from the scorching sun (c) protect them from heavy winds (d) resist bush fires
3. In the marine food web, the source of energy to the producer comes from (a) sea waves (b) sea water (c) sun (d) air
4. A population is best described as (a) a group of the same species of organisms living together (b) a group of animals and plants living together (c) a group of insects and grasses (d) different species of wild animals
5. A stable self sustaining environment produced by an interaction between the biotic and abiotic components is best described as (a) a niche (b) a community (c) an ecosystem (d) a habitat
6. The density-dependent factors that operate to regulate a population size may include the following except (a) shortage of food supply (b) fire outbreak (c) spread of diseases (d) increased competition
7. The group of several populations that interact and share a habitat form (a) a species (b) a community (c) an ecotype (d) a tribe

8. Air pollution can be reduced by the following methods except (a) building tall factory chimneys (b) passing waste gases through filters and absorbers (c) using lead-free petrol in cars (d) recycling tins, cans and bottles
9. The following practices can contribute towards the conservation of natural resources except (a) afforestation, (b) deforestation (c) contour ploughing (d) establishment of Game Reserves
10. The blood group in humans referred to as a universal recipient is (a) O (b) A (c) B (d) AB
11. The haploid number of chromosomes in humans is (a0 48 (b) 46 (c) 24 (d) 23
12. If a pure breeding white cat (hormozygous dominant) mates with a pure breeding black cat (recessive), what would be the fur colour of the F, generation? (a) Homozygous white (b) Homozygous black (c) heterozygous white (d) Heterozygous black
13. Which of the following is not a means of conservation? (a) controlling excessive deforestation (b) prevention of poaching (c) replacing harvested mature trees with seedlings (d) buring of vegetation before cropping
14. One of these following statements about mutation is true, which one? (a) the genotype is not affected (b) the genotype is affected (c) the phenotype is not affected (d) it cannot be induced by artificial means
15. Variation which exhibits a wide range from one extreme to the other with very little difference between the intermediates is described as (a) phenotypic (b) discontinuous (c) continuous (d) genotypic
16. Which of the following is an example of physiological variation? (a) blood groups (b) skin colour (c) finger prints (d) human height
17. A person with blood group B can only donate blood to individuals with blood groups (a) A and B (b) B and AB (c) O only (d) B only
18. If the pink colour of a petal is dominant over white what would be the colour of the flower of the F_1 generation when a pure pink flowered plant is crossed with a white flowered plant? (a) a purple (b) pink (c) white (d) yellow
19. If two parents are sickle cell carriers then their genotypes would be (a) Hb^AHb^A and Hb^SHb^S (b) Hb^SHb^S and Hb^SHb^S (c) Hb^AHb^S and Hb^AHb^S (d) Hb^AHb^A and Hb^AHb^A

20. What is the probability of producing a child of blood group O by a woman of blood group O and a man of blood group A? (a) 25% (b) 50% (c) 75% (d) 100%

ANSWER TO STUDENTS' ACHIEVEMENT TEST IN ECOLOGY AND GENETICS (SATEG)

1. C
2. A
3. C
4. A
5. C
6. B
7. B
8. D
9. B
10. D
11. D
12. C
13. D
14. B
15. B
16. A
17. B
18. B
19. C
20. B

APPENDIX III

ANSWER SHEET

STUDENT ACHIEVEMENT TEST IN ECOLOGY AND GENETICS (SATEG)

Personal Information (Biodata)

Name of School:

Sex: Male (   ) Female (   )

Class: __________________

INSTRUCTION: Tick the correct option from A – D.

S/N	A	B	C	D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

FACULTY OF EDUCATION

APPENDIX 4

STUDENT SELF EFFICACY SCALE (SSES)

This questionnaire seeks to investigate your self-efficacy in Biology

SECTION A: Personal data

Name: --

Gender.: --

Mental Ability: --------------------------------

: ---

SECTION B

The following statements are based on some aspects of your Biology efficacy. Please read each statement very carefully and indicate your honest opinion with a tick (√) in the appropriate column,

Strongly Agree (SA) - A statement you agree with completely

Agree (A) - A statement you agree with but not completely

Disagree (D) - A statement you disagree with partially.

Strongly Disagree (SD) - A statement you disagree with completely.

Thanks for your sincere cooperation.

S/N	ITEM	SA	A	D	SD
1	I can always solve difficult problems in biology.				
2	I get excited when I am challenged in Biology				
3	It is easy for me to stick to my objectives and achieve my objectives in Biology.				
4	I am confident when I handle practicals in Biology.				
5	I cannot apply situation in Biology to my real life situation.				
6	I can solve most problems in biology if I invest the necessary efforts and patience.				

7	I cope well in team work in biology.				
8	I am confident in my ability to find solutions to whatever problems I am confronted with in Biology				
9	I am always afraid of Biology classes.				
10	I cannot do well in Biology.				
11	I can express my opinions when other classmates disagree with me				
12	I succeed well in cheering myself up when an unpleasant event has happened				
13	I can study a chapter well for a test in Biology				
14	I believe I can work well in harmony with my classmates in Biology classes				
15	I pay attention well during every Biology class				
16	I believe I can succeed well in passing a test in Biology				
17	I believe I can guide students in constructing their knowledge during Biology classes.				
18	I believe I am self-efficient in ensuring students' participation in Biology classes				
19	I believe I am self-efficient about providing daily life examples that suit students' previous experiences during Biology classes.				
20	I am confident in my ability to be the best in Biology in spite of any difficulties				

UNIVERSITY OF IBADAN

DEPARTMENT OF TEACHER EDUCATION

FACULTY OF EDUCATION

APPENDIX 5

STUDENTS MENTAL ABILITY TEST

This test intends to find out your mental ability. It has section A and B. Section A contains your demographic data and section B contains twenty (20) questions with options A-E. Choose the option that correctly corresponds to the questions

SECTION A

INSTRUCTION: Supply the required information in the given space. You have twenty (20)minutes to complete it.

Name of School:

Class:

SECTION B

INSTRUCTION: Read the following items and pick the correct answer from the given options

1. The opposite of reluctant is__________________ (a) eager(b)hesitant (b) fast (c) opposed (d)skilled.
2. In June of 1945 a school had forty (40) students. If the number of the students doubled every five (5) years, how many students were there in June 1960? (a)160 (b)240 (c)320 (d)640 (e) none of these
3. Which number should come next in this series 13 6 10 15 21 28__(a)32 (b)35 (c)36 (d)42 (e)54.
4. A carpenter has a 12 foot board, how many cuts must be made to cut it into three (3) equal parts? (a) 3 (b)1 (c)2 (d)4 (e)none of these
5. It is necessarily found in game_______________ (a) referee (b)defeat (c) spectators (d)players
6. The opposite of extravagant is _____________ (a) humble (b)economical (c)inexpensive (d) poor (e) wasteful
7. Which number is missing in this series? 11 17 ?26 29 31(a) 20 (b) 21 (c) 22 (d) 23 (e) 24

8. Weeks is to seven (7) as score is to ___________ (a) count (b) fourteen (c) goal (d) grade (e) twenty

9. How many 6's are there in the following number series which is preceded by5 but not followed by 7?5 6 7 6 5 6 4 9 2 7 6 7 4 3 5 6 8 6 4 9 5 6 7 (a) one (b) two (c) three (d) four (e) none of these

10. How many B's are there in the following letter series, which are followed byG but G is not followed by S? B G S Q B R N O B G N S Q L T B G Q T D B G U W X B G F (a) 4 (b) 3 (c) 2 (d) 5 (e) none of these

11. Kunle and Adetutu are twins whose age together are half of their mother, their father who is three (3) years older than their mother is 51. How old is Adetutu? (a) 15yrs (b) 9yrs (c) 12yrs (d) 6yrs (e) 8yrs

12. The sum of two numbers is 21. One fifth of the smaller is equal to one tenth of the larger. Find the smaller number? (a) 3 (b) 2 (c) 4 (d) 6 (e) 7

13. When George and Athena were married,120 of the guests were Athena's family or friends. This was 60 per cent of the total number of guests. How many guests were there altogether? **(a)**180 **(b)** 192 **(c)** 200 **(d)** 720

14. The number pattern in triangle **P** is repeated in triangle **Q**. What is the value of **X**?**(a)** ½ **(b)** 2 **(c)** 3 **(d)** 20

Q

P

0.25□□So, 10 □□□□□□□□□□□□□15. Note that 100 =**(a)** 0.40 **(b)** 4.0 **(c)** 40

(d) 400

16. Which one does not belong? SCISSORS PIN KNIFE AXE **(a)** AXE**(b)**KNIFE **(c)** PIN **(d)** SCISSORS

17. Trevor is taller than Daniela, and Nadine is taller than Hamish. If Samira and Nadine are both shorter than Daniela, who is second-tallest? **(a)** Trevor **(b)**Nadine**(c)** Samira **(d)** Daniela

18. In a certain code, VEDCXJKISWTO means EXIT. In the same code, what does PHSLOTYWY mean? **(a)** HOW **(b)** LOT **(c)** PLY **(d)** STY

19. If 10 hens can lay 100 eggs in 10 days, how long would it take 4 hens to lay 28 eggs?**(a)** 1 day **(b)**7 days **(c)**14 days **(d)**28 days

20. Which one does not belong? HEAT TEPID COLD FREEZING **(a)**TEPID **(b)** HEAT **(c)** FREEZING **(d)** COLD

21. If you arrange the words below to make the best sentence, what letter doesthe LAST word begin with? the below roof the carpet leaked onto the through rain **(a)** b **(b)** c **(c)** l **(d)** t

22. The numbers in each of the three brackets follow the same rule. Find the missing number. [19, 25, 3] [4, 26, 11] [?, 51, 9] **(a)** 20 **(b)**31**(c)** 33 **(d)** 34

23. SHOUT is to TALK as TALK is to **(a)** SPEAK **(b)** CRY **(c)** LAUGH **(d)** WHISPER

24. These words run in pairs. Insert the missing word to complete the third pair.MEMORY – MEMORISE

    FAMILIAR – FAMILIARISE

    DEFIANT – _____________

    (a) DEFIANCE **(b)** DEFENCE **(c)** DEFY **(d)** DEFEND

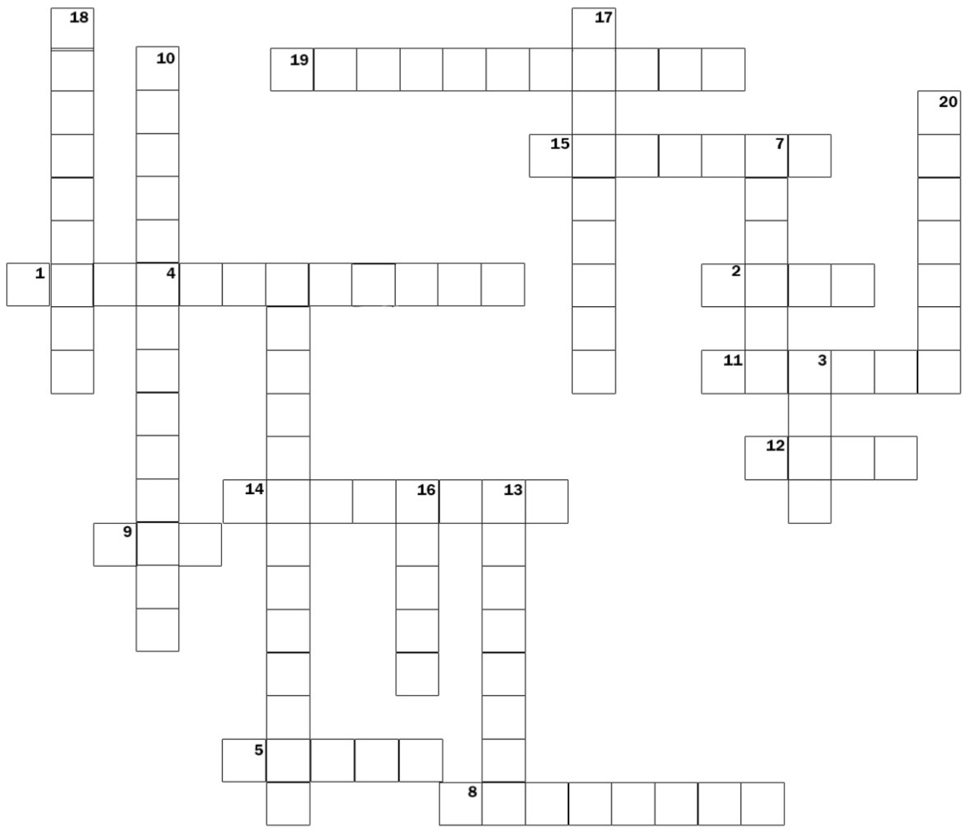
25. MOTHER is to SISTER as GRANDMOTHER is to **(a)** AUNT **(b)** NIECE **(c)** UNCLE **(d)** DAUGHTER

APPENDIX 7A :

ECOLOGY AND GENETICS PUZZLE KEY

Please complete the puzzle below

Name__________________________



Adapted from www.TheTeacherscorner.net

ACROSS CLUE (NUMBER OF ALPHABETS IN WORDS)

1)Release of harmful substances to the air which lead to increase in the quantity of the substance(12)

3) Tree material that burns to produce smoke causing Release of harmful substances to atmosphere(4)

5) Illness caused as a result of harmful substance released to the air.(5)

8) Transference of traits from parents to offspring(8)

9) Container used to control and prevent the spread of solid waste on land(3)

11) One of the Source of harmful substance release to the water(6)

12) What could be done to the unclean water in order to purify it to be good for drinking by human(4)

14) Process of conserving forest living and non living material(8)

DOWN CLUE (NUMBER OF ALPHABETS IN WORDS)

2) One of the Source of harmful substance release to the air(4)

4) The release of harmful substance into the environment causing biological damage to man and his resources.(9)

6) Release of harmful substance on land which lead to increase in the quantity of the substance (13)

7)) Source of harmful substance release to the Land (6).

10) Release of harmful substance to water which lead to increase in the quantity of the substance (14)

13) General name for material used by human necessary for conservation(8).

16) The location of a gene on a chromosome(5).

18) An importance of conservation whereby natural assets used are renewed and obtained easily(9)

15) Method of keeping fish and assets found in water (7)

17) An allele that absolutely determines the physique or phenotype of heterozygotes (9).

19) The dark shaded structure in a cell's nucleus on which an organism's genes are set. (11)

20)The weather condition of a place which create problem for the conservation techniques that may be employed(7)

Rules governing the Environmental and Genetics Puzzle

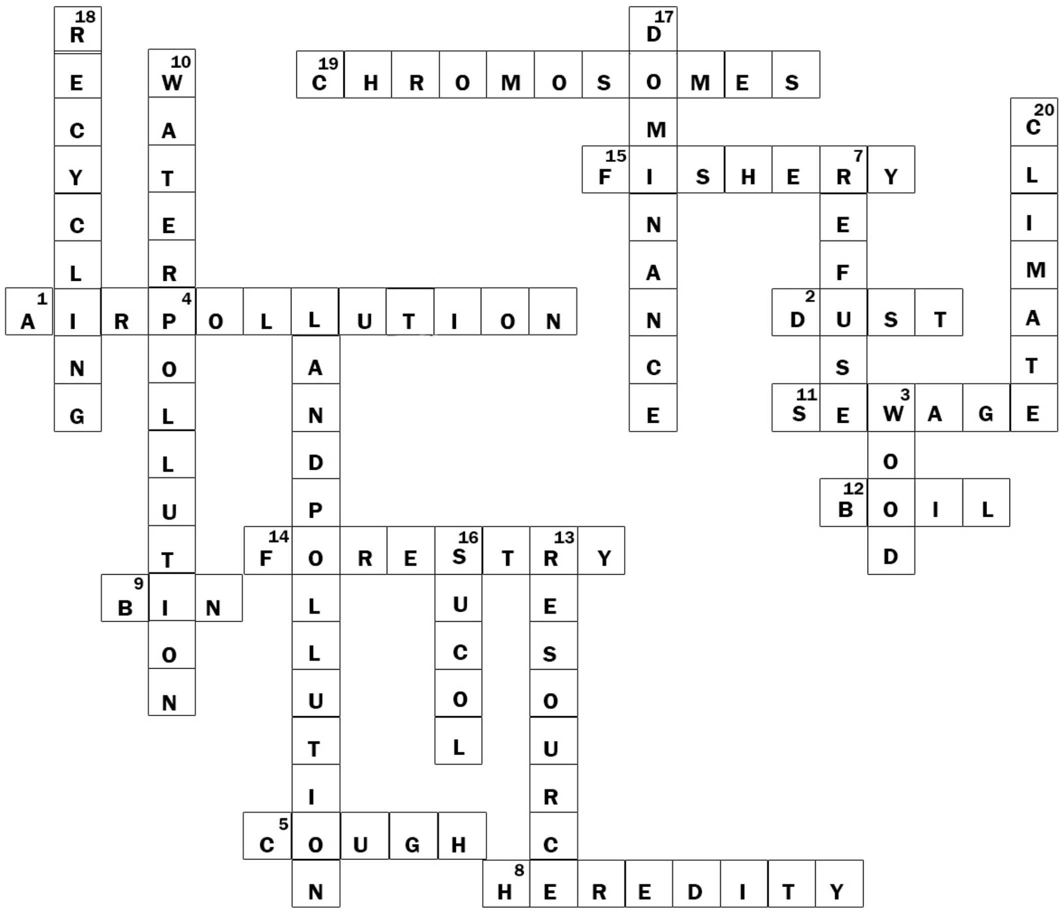
- Every word must have a clue.
- Minimum of 2 words in aclue(as question) is required
- Maximum of 30 words in a clue (as question).
- NO DUPLICATE WORDS ALLOWED AS ANSWER. .
- Words (as answer) can have up to 20 letters;
- Clues (as question) may be up to 200 letters.
- Lots of long words (as answers)   may cause the resulting crossword to be larger than your printed page will allow. This will require some experimentation.
- If our crossword generator cannot find a place for a word (as answers), it may be dropped, or you may get an error.
- **ONLY ALPHANUMERIC CHARACTERS** may be used for the 'words'(as answers).

APPENDIX 7B

ENVIRONMENTAL AND GENETICAL PUZZLECOMPLETED

Please complete the puzzle below

Name__________________________



Adapted from www.TheTeacherscorner.net(2010)

APPENDIX 7C

ACROSS CLUE (NUMBER OF ALPHABETS IN WORDS)

1)Release of harmful substances to the air which lead to increase in the quantity of the substance(AIR POLLUTION)

3) Tree material that burns to produce smoke causing Release of harmful substances to atmosphere(WOOD)

5) Illness caused as a result of harmful substance released to the air.(COUGH)

8) Transference of traits from parents to offspring(HEREDITY)

9) Container used to control and prevent the spread of solid waste on land(BIN)

11) One of the Source of harmful substance release to the water(SEWAGE)

12) What could be done to the unclean water in order to purify it to be good for drinking by human(BOIL)

14) Process of conserving forest living and non livingmaterial(FORESTRY)

15) Method of keeping fish and assets found in water (FISHERY)

DOWN CLUE (NUMBER OF ALPHABETS IN WORDS)

2) One of the Source of harmful substance release to the air
(DUST)

4) The release of harmful substance into the environment causing biological damage to man and his resources. (POLLUTION).

6) Release of harmful substance on land which lead to increase in the quantity of the substance (LAND POLLUTION)

7)) Source of harmful substance release to the Land (REFUSE)

10) Release of harmful substance to water which lead to increase in the quantity of the substance (WATER POLLUTION)

13) General name for material used by human necessary for conservation(RESOURCES).

16) The location of a gene on a chromosome(LOCUS)..

18) An importance process of conservation whereby natural assets used are renewed and obtained easily (RECYCLING)

20)The weather condition of a place which create problem for the conservation techniques that may be employed(CLIMATE)

17) An allele that completely dictates the appearance or phenotype of heterozygotes (DOMINANCE).

19) The dark staining structure in a cell's nucleus on which the organism's genes are arranged. (CHROMOSOMES)

Rules governing the Environmental and Genetical Puzzle

- Every word must have a clue.
- Minimum of 2 words in a clue(as question) is required
- Maximum of 30 words in a clue (as question).
- NO DUPLICATE WORDS ALLOWED AS ANSWER. .
- Words (as answer) can have up to 20 letters;
- Clues (as question) may be up to 200 letters.
- Lots of long words (as answers) may cause the resulting crossword to be larger than your printed page will allow. This will require some experimentation.
- If our crossword generator cannot find a place for a word (as answers), it may be dropped, or you may get an error.
- **ONLY ALPHANUMERIC CHARACTERS** may be used for the 'words'(as answers).

APPENDIX 8

INSTRUCTIONAL GUIDE FOR COMPUTER SIMULATION PACKAGE ON ECOLOGY AND GENETICS

Preparation Phase

1. The teacher orients the students on the, objectives and expected performance, implementation and evaluation.
2. Students are allowed to put theoretical knowledge already gained into action – mount the disc on the system already connected to the projector.

Teaching Phase

3. The teacher executes the lesson based on the prepared plan and the time allotted for him/her to teach the lesson. Usually, it is presented in 10-15 minutes only depending on the length of the topic in the PowerPoint or Prezi or any other multi-media materials. The appropriate graphic organizer is encouraged to be used as a guide in the discussion
4. The Students identify, watch and listen to the simulation.

Evaluation Phase

5. Students ask questions on their observations or part of the simulation presentation that is not clear.

Reflection Phase

6. The teacher explains, models, illustrates, clarifies, supplies missing information
7. Students generate important notes

Modification Phase

8. Students give insights, feedback and comments gained during the teaching,when the teacher was answering the questions and supplying the missing information.
9. Students evaluate the solution and make modification

APPENDIX 9

INSTRUCTIONAL GUIDE FOR DIGITAL PUZZLE PACKAGE ON ECOLOGY AND GENETICS

Preparation phase

Step

1. The students are positioned by the computer they are to work with

2.Studentsare given the package to work with

3. Students are instructed on how to work with the package.

4. The teacher moves round the classroom to monitor the participants.

Introduction phase of the content involves

5. Teacher attracts students' attention to activate their background knowledge on the topic to be considered.

Presentation phase:

6. Students identify the key words and sub-concepts using ecology and genetics puzzles clues.

7. Teacher prodstudents with more questions using the environmental puzzle clues to generate additional information on topic.

8. Students' view on the concept are clarified using the ecology and genetics puzzle.

Evaluation phase:

9. Teacher assesses students for more critical analysis on the content using the ecology and genetics puzzle clues.

10. Students practice individually

11. Students develop a deep understanding of the topics they study and improve their thinking abilities.

12. Students are given homework or assignment to further practicethe skill developed.

APPENDIX 10

TEACHER'S INSTRUCTIONAL GUIDE ON COMPUTER SIMULATION – DIGITAL PUZZLE PACKAGE

Preparation phase:-

5) Teacher asks the students some questions to test their previous knowledge on the sub-concept being considered.
6) Students are instructed on how to use the package.

Teaching Phase:-

5) Teacher presents computer simulation package for 10-15 minutes depending on the scope of the topic.
6) Students identify, watch and listen to the computer simulation presentation.

Evaluation phase:-

5) Teacher gives the clues on different topics under Ecology and Genetics to task the students critical
6) Students supplies the answers (keywords) and type then on the cross-word puzzle sheet as across clue or down clue. (column and rows).

Reflection phase

5) Teacher approves or corrects the students answers. He/she clarifies and supplies the missing answers if there is any.
6) Students writes notes based on the correction given by the teacher.

Modification phase:-

5) Teacher asks related questions that can generate correct, logical response, insight and feedback
6) Students modifies knowledge on the topic.

APPENDIX 11

LESSON NOTES ON INSTRUCTIONAL GUIDE FOR COMPUTER SIMULATION PACKAGE ON ECOLOGY AND GENETICS

Class: SS II

Subject: Biology

Topic: Introduction to Ecology

Duration: 1 hour 20 minutes

Preparation: Phase:

Teacher introduces the topic – Introduction to Ecology" to the students and state the objectives:-

By the time the lesson finishes, students should be able to

1. Explain the term Ecology
2. Mention the branches of Ecology
3. Define some ecological concepts.

Students listen and answer questions posed at them to test their prior knowledge on the concept

1. What is habitat?
2. What do you understand by the word environment?
3. Living things are divided into two groups, what are they?

Teacher instructs students on how to operate the gadgets:- students are to put on the gadgets and insert the CD containing content of the topic into the system.

Teaching Phase:

Students observe the PowerPoint presentation on the topic Ecology on the screen for 10-15 minutes.

Evaluation phase:-

Students ask questions on the part of the simulation presentation that is not clear

Reflection phase:-

Teacher answers the questions and supplies the missing information.

Students writes important notes as the concept is made clearer by the teacher.

Modification phase:-

Students gives their comments or feedback as the teacher prods them with questions on what they have leant e.g. (1) What is Ecology?

(2) Name the two branches of Ecology?

Class: SS II

Subject: Biology

Topic: Components of an Ecosystem

Duration: 1 hour 20 minutes

Preparation: Phase:

Teacher introduces the topic – Components of an Ecosystem" to the students and state the objectives:-

By the time the lesson finishes, students should be able to

1. Define community
2. State the components of an ecosystem
3. Explain the interaction among the components of an ecosystem

Students listen and answer questions posed at them to test their prior knowledge on the concept

1. Mention some of the things in your environment that affects you.
2. How does each of these things affect you?

Teacher instructs students on how to operate the gadgets:- students are to put on the gadgets and insert the CD containing content of the topic into the system.

Teaching Phase:

Students observe the PowerPoint presentation on the topic Components of an Ecosystem on the screen for 10-15 minutes.

Evaluation phase:-

Students ask questions on the part of the simulation presentation that is not clear

Reflection phase:-

Teacher answers the questions and supplies the missing information.

Students writes important notes as the concept is made clearer by the teacher.

Modification phase:-

Students gives their comments or feedback as the teacher prods them with questions on what they have leant e.g. (1) What are the Biotic factors of an Ecosystem?

(2) List the Abiotic factors of an Ecosystem?

Class: SS II

Subject: Biology

Topic: Local Biomes and World Biomes

Duration: 1 hour 20 minutes

Preparation Phase:

Teacher introduces the topic – Local Biomes and World Biomes" to the students and state the objectives:-

By the time the lesson finishes, students should be able to

1. List the local biomes
2. List the world Biomes
3. State the characteristics of each

Students listen and answer questions posed at them to test their prior knowledge on the concept

1. What is a Biome?
2. Describe the types of biomes that can be found in Nigeria?

Teacher instructs students on how to operate the gadgets:- students are to put on the gadgets and insert the CD containing content of the topic into the system.

Teaching Phase:

Students observe the PowerPoint presentation on the topic Local biomes on the screen for 10-15 minutes.

Evaluation phase:-

Students ask questions on the part of the simulation presentation that is not clear

Reflection phase:-

Teacher answers the questions and supplies the missing information.

Students writes important notes as the concept is made clearer by the teacher.

Modification phase:-

Students gives their comments or feedback as the teacher prods them with questions on what they have leant e.g. (1) What is a forest?

(2) Describe a savanna and a desert?

GENETICS

Class: SS II

Subject: Biology

Topic: Introduction to Genetics

Duration: 1 hour 20 minutes

Preparation Phase:

Teacher introduces the topic – Introduction to Genetics" to the students and state the objectives:-

At the end of the lesson, students should be able to

1. Define Genetics
2. Mention 2 sub topics under genetics
3. List some transmittable traits in plants and animals

Students listen and answer questions posed at them to test their prior knowledge on the concept

1. Mention some noticeable features amongst members of family
2. What are the difference between you and your siblings?

Instructs students on how to operate the gadgets:- students are to put on the gadgets and insert the CD containing content of the topic into the system.

Teaching Phase:

Students observe the PowerPoint presentation on the topic Introduction to Genetics on the screen for 10-15 minutes.

Evaluation phase:-

Students ask questions on the part of the simulation presentation that is not clear

Reflection phase:-

Teacher answers the questions and supplies the missing information.

Students writes important notes as the concept is made clearer by the teacher.

Modification phase:-

Students gives their comments or feedback as the teacher prods them with questions on what they have leant e.g. (1) Define Heredity and vaccination

(2) List two transmittable traits in animals and plants

Class: SS II

Subject: Biology

Topic: Common terms in Genetics

Duration: 1 hour 20 minutes

Preparation Phase:

Teacher introduces the topic – Common terms in Genetics" to the students and state the objectives:-

At the end of the lesson, students should be able to

1. List the common terms in Genetics
2. Explain the terms

Students listen and answer questions posed at them to test their prior knowledge on the concept

1. What can be found in the nucleus of a cell?
2. What is a Zygote?

Instructs students on how to operate the gadgets:- students are to put on the gadgets and insert the CD containing content of the topic into the system.

Teaching Phase:

Students observe the PowerPoint presentation on the topic Common terms in Genetics on the screen for 10-15 minutes.

Evaluation phase:-

Students ask questions on the part of the simulation presentation that is not clear

Reflection phase:-

Teacher answers the questions and supplies the missing information.

Students writes important notes as the concept is made clearer by the teacher.

Modification phase:-

Students gives their comments or feedback as the teacher prods them with questions on what they have leant e.g.

(1) List 5 common terms used in Genetics?

(2) Explain 3 of the common terms

Class: SS II

Subject: Biology

Topic: Gregor Mendel's experiment

Duration: 1 hour 20 minutes

Preparation Phase:

Teacher introduces the topic – Mendel's experiment" to the students and state the objectives:-

At the end of the lesson, students should be able to

1. Short note on Gregor Mendel
2. Describe Gregor Mendel's experiment
3. State why he was successful

Students listen and answer questions posed at them to test their prior knowledge on the concept

1. What do you call scientists who study Genetics?
2. Name some of them
3. Who is the father of Genetics?

Instructs students on how to operate the gadgets:- students are to put on the gadgets and insert the CD containing content of the topic into the system.

Teaching Phase:

Students observe the PowerPoint presentation on the topic Gregor Mendel's experiment on the screen for 10-15 minutes.

Evaluation phase:-

Students ask questions on the part of the simulation presentation that is not clear

Reflection phase:-

Teacher answers the questions and supplies the missing information.

Students writes important notes as the concept is made clearer by the teacher.

Modification phase:-

Students gives their comments or feedback as the teacher prods them with questions on what they have leant e.g. (1) Who is Gregor Mendel?

(2) Why is he called the father of Genetics?

LESSON NOTES ON INSTRUCTIONAL GUIDE FOR DIGITAL PUZZLE PACKAGE ON ECOLOGY AND GENETICS

Class: S.S. II

Subject: Biology

Topic: Introduction to Ecology

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Define ecology
2. Mention the branches of ecology

Preparation Phase:

Students sit by the computer they are to work with

Students are given the package (CD) containing the topic to be treated

Students are to insert the CD in the system

The teacher ensures that the students are doing the right things

Students are to answer the following questions to achieve their background knowledge on Introduction to Ecology

1. What does the word environment mean to you?
2. Define atmosphere

Presentation stage:

Students click on each diagram in the box on the screen. The name of the object and short notes on it will be shown on the screen e.g. students click on diagram of a plant or animal in his environment. The notes on their environment is shown on the screen, teacher further gives explanation:- Two branches of Ecology are synecology and autecology.

Students are allowed to ask question to clarify their doubts on each diagram.

Evaluation

Teacher asks students the following questions to assess their assimilation rate on the topics:-

1. Define Ecology
2. Mention the branches of Ecology

Class: S.S. II

Subject: Biology

Topic: Some Ecological concepts

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. List some ecological concepts
2. Define some ecological concepts

Preparation Phase:

Students sit by the computer they are to work with

Students are given the package (CD) containing the topic to be treated

Students are to insert the CD in the system

The teacher ensures that the students are doing the right things

Students are to answer the following questions to achieve their background knowledge on Ecological concepts

1. Define habitat
2. What do you understand by the word population?

Presentation stage:

Students click on each diagram in the box on the screen. The name of the object and short notes on it will be shown on the screen e.g. students click on diagram showing some of the ecological concept like hydrosphere. The notes on hydrosphere is shown on the screen, teacher gives further explanation on each term.

Students are allowed to ask question to clarify their doubts on each diagram.

Evaluation

Teacher asks students the following questions to assess their assimilation rate on the topics:-

1. Define these terms:- Environment, Habitat, Community, Biomes, Pollution etc.

Class: S.S. II

Subject: Biology

Topic: Local Biomes and World Biomes

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. List the local biome
2. List the world biome
3. State the characteristics of each biome

Preparation Phase:

Students sit by the computer they are to work with

Students are given the package (CD) containing the topic to be treated

Students are to insert the CD in the system

The teacher ensures that the students are doing the right things

Students are to answer the following questions to achieve their background knowledge on Ecological concepts

1. What is a biome?
2. Give an example of a biome

Presentation stage:

Students click on each diagram in the box on the screen. The name of the object and short notes on it will be shown on the screen e.g. students click on diagram showing a dense forest and a grass land for local biome then students click on diagram showing a desert, swamp, afro-alpine then short note on the concepts appear on the screen, teacher gives further explanation on the biomes.

Students are allowed to ask question to clarify their doubts on each diagram.

Evaluation

Teacher asks students the following questions to assess their assimilation rate on the topics:-

1. Where can each of these zones in local biome be found in Nigeria?

Class: S.S. II

Subject: Biology

Topic: Introduction to Genetics

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Define genetics
2. Mention sub-topics under genetics
3. List some transmittable characters

Preparation Phase:

Students sit by the computer they are to work with

Students are given the package (CD) containing the topic to be treated

Students are to insert the CD in the system

The teacher ensures that the students are doing the right things

Students are to answer the following questions to achieve their background knowledge on Introduction to Genetics

1. How do people recognize a child from a particular family?
2. Who do you resemble in your family?

Presentation stage:

Students click on each diagram in the box on the screen. The name of the object and short notes on it will be shown on the screen e.g. students click on the picture of a man and his child, note on genetics as a study of heredity and variation will be shown on the screen, teacher gives further explanation on heredity and variation

Students are allowed to ask question to clarify their doubts on each diagram.

Evaluation

Teacher asks students the following questions to assess their assimilation rate on the topics:-

1. What are the two sub-topics under genetics?
2. Define each of them

Class: S.S. II

Subject: Biology

Topic: Common terms in genetics

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. List the common terms in genetics
2. Explain the terms

Preparation Phase:

Students sit by the computer they are to work with

Students are given the package (CD) containing the topic to be treated

Students are to insert the CD in the system

The teacher ensures that the students are doing the right things

Students are to answer the following questions to achieve their background knowledge on Common terms in genetics

1. What is a cell?
2. What can be found in the nucleus of a cell?

Presentation stage:

Students click on each diagram in the box on the screen. The name of the object and short notes on it will be shown on the screen e.g. students click on the diagram of a chromosome and a gene, note on each would be display on the screen. Same with other terms like locus, haploid etc.

Teacher gives further explanation on each of the plant.

Students are allowed to ask question to clarify their doubts on each diagram.

Evaluation

Teacher asks students the following questions to assess their assimilation rate on the topics:-

1. What do you understand by the terms Locus, transmittable characters, allele , chromosome etc.

Class: S.S. II

Subject: Biology

Topic: Gregor Mendel's Experiments

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Write short note on Gregor Mendel's?
2. Describe Gregor Mendel's Experiment
3. State why he was successful

Preparation Phase:

Students sit by the computer they are to work with

Students are given the package (CD) containing the topic to be treated

Students are to insert the CD in the system

The teacher ensures that the students are doing the right things

Students are to answer the following questions to achieve their background knowledge on Gregor Mendel's Experiments

1. What do you call scientists working on genetics?
2. Can you mention the names of some of them?

Presentation stage:

Students click on each diagram in the box on the screen. The name of the object and short notes on it will be shown on the screen e.g. students click on the picture of a man, Gregor Mendel appears and his contribution to genetics will be read on the screen.

Teacher gives further explanation on diagram shown on the screen.

Students are allowed to ask question to clarify their doubts on each diagram.

Evaluation

Teacher asks students the following questions to assess their assimilation rate on the topics:-

1. How did Gregor Mendel contribute to genetics?
2. What made him successful?

LESSON NOTE ON INSTRUCTIONAL GUIDE FOR COMPUTER SIMULATION – DIGITAL PUZZLE PACKAGES ON ECOLOGY AND GENETICS

Class: S.S. II

Subject: Biology

Topic: Introduction to Ecology

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Define Ecology
3. Mention the branches of ecology

Preparation Phase:

Students are instructed to listen and watch the simulation presentation on introduction to Ecology for 10 minutes. Then the clues from the puzzle package on the topic will be displayed on the screen, students are to read the clue and type the answer on the crossword puzzle sheet that will be displayed on the screen.

Teaching phase:

Teacher present the simulation PowerPoint on introduction to Ecology for 10 minutes

Students identify, watch and listen to the presentation

Evaluation phase

Teacher display clues to the key words in the topics on the screen. E.g. a place where plant and animal lives

Students type the answer on the crossword answer sheet on the screen to fit into the columns or rows.

Reflection Phase

1. Teacher approves or correct the answer given by the student by displaying the right answer on the screen, and supplies the missing information if there is any. (i.e. habitat)
2. Student writes important note

Modification phase:

Teacher asks related questions that can further stimulate right response from the students e.g.

1. How many types of habitats are there?
2. What do you call the habitat?

Class: S.S. II

Subject: Biology

Topic: Components of an Ecosystem

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Mention the component of an ecosystem?
2. Explain how each affects human being

Preparation Phase:

Students are instructed to listen and watch the simulation presentation on Components of an ecosystem for 10 minutes. Then the clues from the puzzle package on the topic will be displayed on the screen, students are to read the clue and type the answer on the crossword puzzle sheet that will be displayed on the screen.

Teaching phase:

Teacher present the simulation PowerPoint on components of an ecosystem for 10 minutes

Students identify, watch and listen to the presentation

Evaluation phase

Teacher display clues to the key words in the topics on the screen. e.g. the weather condition of a place over a period of time

Students type the answer on the crossword answer sheet on the screen to fit into the columns or rows.

Reflection Phase

1. Teacher approves or correct the answer given by the student by displaying the right answer on the screen, and supplies the missing information if there is any. (i.e. climate)
2. Student writes important note

Modification phase:

Teacher asks related questions that can further stimulate right response from the students e.g.

2. Is climate a biotic factor of an ecosystem or abiotic factor?
3. Mention one biotic factor of an ecosystem

Class: S.S. II

Subject: Biology

Topic: Local biomes and world biomes

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. List the local biome
2. List the world biome
3. State the characteristics of each

Preparation Phase:

Students are instructed to listen and watch the simulation presentation on Local biome and world biomes for 10 minutes. Then the clues from the puzzle package on the topic will be displayed on the screen, students are to read the clue and type the answer on the crossword puzzle sheet that will be displayed on the screen.

Teaching phase:

Teacher present the simulation PowerPoint on Local biomes and world biomes for 10 minutes

Students identify, watch and listen to the presentation

Evaluation phase

Teacher display clues to the key words in the topics on the screen. e.g. the study of a zones that is common to both local biomes and world biomes

Students type the answer on the crossword answer sheet on the screen to fit into the columns or rows.

Reflection Phase

1. Teacher approves or correct the answer given by the student by displaying the right answer on the screen, and supplies the missing information if there is any. (i.e. forestry)
2. Student writes important note

Modification phase:

Teacher asks related questions that can further stimulate right response from the students e.g.

1. List other zones in the local biome and world biomes

Class: S.S. II

Subject: Biology

Topic: Introduction to Genetics

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Define genetics
2. Mention the sub-topics under genetics
3. List some transmittable characters

Preparation Phase:

Students are instructed to listen and watch the simulation presentation on introduction to Genetics for 10 minutes. Then the clues from the puzzle package on the topic will be displayed on the screen, students are to read the clue and type the answer on the crossword puzzle sheet that will be displayed on the screen.

Teaching phase:

Teacher present the simulation PowerPoint on introduction to Genetics for 10 minutes

Students identify, watch and listen to the presentation

Evaluation phase

Teacher display clues to the key words in the topics on the screen. e.g. the transference of traits from parents to offspring.

Students type the answer on the crossword answer sheet on the screen to fit into the columns or rows.

Reflection Phase

1. Teacher approves or correct the answer given by the student by displaying the right answer on the screen, and supplies the missing information if there is any. (i.e. heredity)
2. Student writes important note

Modification phase:

Teacher asks related questions that can further stimulate right response from the students e.g.

1. Mention the sub-topics under genetics?
2. List some transmittable characters

Class: S.S. II

Subject: Biology

Topic: Common terms in Genetics

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. List the common terms in genetics
2. Explain some of the terms

Preparation Phase:

Students are instructed to listen and watch the simulation presentation on common terms in genetics for 10 minutes. Then the clues from the puzzle package on the topic will be displayed on the screen, students are to read the clue and type the answer on the crossword puzzle sheet that will be displayed on the screen.

Teaching phase:

Teacher present the simulation PowerPoint on Common terms in Genetics for 10 minutes

Students identify, watch and listen to the presentation

Evaluation phase

Teacher display clues to the key words in the topics on the screen. e.g. the dark staining structure in a cell's nucleus on which the organisms genes are arranged

Students type the answer on the crossword answer sheet on the screen to fit into the columns or rows.

Reflection Phase

1. Teacher approves or correct the answer given by the student by displaying the right answer on the screen, and supplies the missing information if there is any. (i.e. chromosomes)
2. Student writes important note

Modification phase:

Teacher asks related questions that can further stimulate right response from the students e.g.

1. Where are genes found?
2. What is the location of a gene on a chromosome called?

Class: S.S. II

Subject: Biology

Topic: Greogor Mendel's Experiment

Duration: 1 hour 20 minutes

Objectives: At the end of the lesson, students should be able to

1. Write short note on Gregor Mendel
2. Describe Gregor Mendel's experiment
3. State why he was successful

Preparation Phase:

Students are instructed to listen and watch the simulation presentation on Gregor Mendel's experiment for 10 minutes. Then the clues from the puzzle package on the topic will be displayed on the screen, students are to read the clue and type the answer on the crossword puzzle sheet that will be displayed on the screen.

Teaching phase:

Teacher present the simulation PowerPoint on Gregor Mendel's Experiment for 10 minutes

Students identify, watch and listen to the presentation

Evaluation phase

Teacher display clues to the key words in the topics on the screen. e.g. An allele of gene that completely dictates the appearance or phenotype of heterozygotes.

Students type the answer on the crossword answer sheet on the screen to fit into the columns or rows.

Reflection Phase

1. Teacher approves or correct the answer given by the student by displaying the right answer on the screen, and supplies the missing information if there is any. (i.e. Dominant gene)
2. Student writes important note

Modification phase:

Teacher asks related questions that can further stimulate right response from the students e.g.

1. What is the allele in a heterozygote that is passive called?
2. What is the condition where both allele in a heterozygotes are fully expressed called?

INSTRUCTIONAL GUIDE FOR CONVENTIONAL TEACHING METHOD ON ECOLOGY AND GENETICS

CLASS:- SS2

LESSON 3

CLASS:- SS2

SUBJECT:- BIOLOGY

TOPIC:- MENDEL'S EXPERIMENT.

DURATION:- 40 MINUTES.

PREVIOUS KNOWLEDGE:- Students are familiar with some terms used in Genetics

INTRODUCTION:- Teacher reminds the students of the Geneticists who worked on Genetics (Thomas Morgan, Johnson). Notable amongst these is Gregor Mendel (1822-1884) who laid down the basic laws of genetics. He carried out the first qualitative studies on inheritance.

STEP 1:- Teacher explains the experiment basic laws on pea plant:- (i) He got true breeding stocks of pea plant for a given expression of a trait. He did this by allowing the plants to self pollinate for several generation.

2) He then crossed two true breeding sets of plants showing the alternative forms of a trait. i.e. He crossed a pure stock of plants showing green pod colour with that showing yellow pod colour.

STEP II:- Teacher continues – He was able to remove the immature another from the flower of a plant with green pods, then he pollinated this flower by dusting its stigma with pollen from the mature another of a flower from a plant with yellow pods. He covered the pollinated flower with a paper bag to prevent pollen from another sources from falling on its stigma. He also reversed this process (reciprocal cross).

STEP III:- Teacher proceeds (3) He finally allowed the hybrid offspring (fi generation) he obtained from the crosses to self- pollinate and produce offspring. (f2 generation). He then counted the numbers of offspring of each type in the f1 and f2 generations.

CONCLUSION:- He was able to collect a quantitative data which helped him understand the principles of heredity.

LESSON 4

CLASS:- SS2

SUBJECT:- BIOLOGY

TOPIC:- MENDEL'S LAWS OF INHERITANCES

DURATION:- 40 MINUTES.

PREVIOUS KNOWLEDGE:- Students are aware that the first quantitative studies on inheritance helped Mendel lay down the basic law of genetics

INTRODUCTION:- Teacher explains: Mendel was able to come to certain conclusion due to his experiments. He termed these as principles of Mendelian inheritance or Mendel's laws of Heredity. There are two of such laws:-

i The law of segregation of genes (ii) The law of independent assortment of genes.

STEP I:- Teacher continues:- The law of segregation states that:- (i) the hereditary characters of an organism are determined by genes factor which are discrete unchanging units of inheritance.

2) A gene for a character may have alternative form (allied) which express the character in
different ways.
3) Each character is controlled by two copies of each gene which may be identical alleles (homozygous) or different alleles (heterozygous) in a diploid organism.
4) If a diploid organism has two different alleles (heterozygous) for a character, one allele may be dominant, and the other recessive.
5) In a diploid organism that is heterozygous for a character, the two alternative alleles separate from each other meiosis, each going randomly to a different gamete.

STEP II:- Law of independent assortment:- This states that alleles on different chromosomes assort independently during meiosis. i.e. during gamete formation, the way one pair of alleles for a given character distributes itself in the gametes does not affect the way other allelic pairs distribute themselves. This applies only to allelic pairs on different homologous chromosomes.

STEP III:-Mendelian Traits:- Mendel was able to select seven discontinuous traits from the garden pea he used for his studies. Each trait had a dominant and a recessive form of expression. He termed them seven pairs of contrasting traits. Mendelian trait is now used for characters that:-

a) are controlled only by one pair of alleles

b) show dominant and recessive form

c) lie on separate chromosomes.

CONCLUSION:- Teacher concludes – The basic laws of heredity are the laws of separation of genes and the law of independent assortment.

ECOLOGY

Topic: Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Air pollution

State the examples of air pollutants

Mention the causes and sources of Air pollution

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you think can bring about dirt and germs in Air?

(2) What do these dirt and germs do to our bodies?

(3)Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

Presentation:

Step I: The teacher explains the meaning of pollution and defines Air pollution.

Step II: The teacher states examples of Air pollution

b: The teacher explains the sources and causes of Air pollution

Evaluations: The teacher assesses students' knowledge of the subject matter,the following question were asked.

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.

Assignment: The students are asked to read Effects, prevention and control of Air pollution against next lesson.

Topic: Water pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Water pollution.

State the examples of Water pollutants.

Mention the causes and sources of Water pollution.

Previous Knowledge: Students has been taught Effects, prevention and control of Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

State five effects of air pollutants

Mention five control measures for the following Air pollutants Smoke and Carbonmonoxide.

How do we prevent the occurrence of these substances?

Presentation:

Step I: The teacher defines Water pollution and explains it.

Step II: The teacher mention some example of Water pollution and its effect on living organisms.

Step III: The teacher explains the sources and Water pollution and its effects on living organisms.

Evaluations: The teacher assesses students' knowledge of the subject matter, asking the following questions;

1. Define the term 'Water pollution'
2. Give examples of Water pollutants
3. Mention the cause and sources of the following water pollutants on living organisms
4. Sewage
5. Detergent

Assignment: The students should read Effects, prevention and control of water pollution against next lesson.

Topic: Conservation of Natural Resources

Time: 80 minutes

ReferenceBook

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define and explain conservation of natural resources

Enumerate method of conservation of natural resources

List importance of conservation

Previous Knowledge: Students has been taught has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of Conservation techniques..

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you understand by Good Environment?

(2) What do you expect to see in a good Environment?

(3)Is it possible to maintain Good Environment? Give reason to support your answer.

Presentation:

Step I: The teacher defines and explains conservation

Step II: The teacher defines and states the methods of water conservation.

Step III: The teacher also defines and states the methods and importance of wildlife and fisheries conservation.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

Assignment: Students should read Conservation agencies and problems encountered in conservation.

APPENDIX 12A

EVALUATION SHEET FOR ASSESSING TEACHERS PERFORMANCE ON THE USE OF COMPUTER SIMULATION PACKAGE(ESATPCP)

Section A

Name of the teacher ………………………………………………..

Name of the school:…………………………………………………

Topic taught:…………………………………………………………

Class taught:…………………………………………………………

Section B

S/N	Performance assessed	V. good 5	Good 4	Average 3	Poor 2	V. poor 1
1	Placing students' in groups of five					
2	Teaching students' using computer stimulation package strategy					
3	Monitoring students' interactions in the groups					
4	Showing of the Computer Simulation Package to SSS TWO students by the teacher					
5	Topics are assigned in line with the Senior secondary 2 Biology curriculum by the teacher.					
6	Reflection through the Computer Simulation Package					
7	Taking turns to teach in form of microteaching.					

APPENDIX 12B

EVALUATINGSHEET FOR ASSESSING TEACHERS' PERFORMANCE ON THE USE OF PUZZLE-BASED DIGITALISED (ESATPB)

Name of Teacher: --

School: --

Date: -----------------

Guidelines Involved	V. Good 5	Good 4	Average 3	Poor 2	V. Poor 1
Teacher introduction of the lesson whether it is based on students previous Knowledge.					
Teacher's ability to give students the opportunity to answer the questions using their intuition and the Environmental puzzle as guides.					
Teacher's ability to use the clues inside the Environmental puzzle as guides in order to make students to both identify the concept and leading to the behavioural objective.					
Ability of the teacher to make students to respond by allowing students to present their ideas with the aid of the Environmental Puzzle.					
Teacher clarification of students views on the concept using the Environmental puzzle as basis for clarification.					
Teacher's ability to assess students for more critical analysis on the content using the Environmental puzzle.					

APPENDIX 12C

EVALUATING SHEET FOR ASSESSING TEACHERS' PERFORMANCE ON THE USE OF MODIFIED CONVENTIONAL INSTRUCTIONAL METHOD(ESATPMCIM)

Name of Teacher: ---

School: ---

Date: --

Guidelines Involved	**V. Good 5**	**Good 4**	**Average 3**	**Poor 2**	**V. Poor 1**
Teacher's introduction of the lesson.					
Ability of the Teacher to discuss the content of the concepts.					
Ability of the Teacher to allow students to write the note.					
Teacher's ability to give an overview of the lesson.					
Teacher's oral questions in conformity with the concept.					
Teacher conclusion of the lesson.					
Teacher gives homework or assignment.					

Appendix 13

Rubrics for the Simulation Package

The following tool was used to assess the simulated teaching performance of the teachers:

	SIMULATED TEACHING RATING SCALE (STRS)				
Name of Teacher:			Subject:		
Name of Mentor:			Date:		
Class:	Term:				
Direction: Check the appropriate column that best describes the competencies of the student-teacher.					

COMPETENCIES	Description				
	Excellent 5	Very Satisfactory 4	Satisfactory 3	Fair 2	Poor 1
A. DELIVERY OF THE LESSON					
1. The teacher is well-prepared with the lesson					
	Excellent 5	Very Satisfactory 4	Satisfactory 3	Fair 2	Poor 1
2. The teacher is neat, well-groomed and wears appropriate attire.					
3. The teacher is free from mannerisms that tend to disturb the learner's attention					
4. The teacher uses appropriate English / Filipino in teaching					
5. The teacher shows dynamism and enthusiasm					
6. The teacher maintains a pleasing eye contact with the students.					
7. The teacher possesses a well-modulated voice.					
8. The teacher displays a pleasant disposition, emotional stability and discipline.					

9. The teacher acknowledges responses from students by giving immediate feedback for questions and answers.					
10. The teacher is open to suggestions and constructive criticism.					
SUB TOTAL	50				
B. MASTERY OF CONTENT					
11. The teacher demonstrates in- depth knowledge of the subject matter					
12. The teacher gives sufficient and concrete examples to create meaningful learning experiences					
SUB TOTAL	10				
C. METHODS and MATERIALS					
13. Method/s used is/are suited to the needs and capabilities of Learners					
	Excellent 5	Very Satisfactory 4	Satisfactory 3	Fair 2	Poor 1
14. The teacher uses varied instructional materials which adhere to the principles of audio-visual designs.					
SUB TOTAL	10				

D. CLASSROOM MANAGEMENT					
The teacher uses a systematic way of doing the following:					
15. practice exercises					
16. group works /activities					
17. correcting, distributing and collecting papers					
18. Order and discipline are present in the classroom					
19. Instructional materials are within easy reach of the teacher during his/her teaching					
SUB TOTAL	25				
E. INTERACTIVE SKILLS					
The teacher's interactive skills stimulate discussion in different ways such as:					
20. appreciating student participation in the discussion					
21. probing for learner's Understanding					
22. helping learners articulate their ideas					
23. promote risk-taking and problem solving to facilitate factual recall					
24. encourage convergent and divergent thinking					
25. stimulate curiosity					
26. help learners to ask questions					
SUB TOTAL	35				
OVERALL SCORES	130/26				
FINAL RATING	5				

Procedures in computing the final rating of the student:

1. Add the scores of every competency to get the subtotal.
2. Add the subtotal of every column to get the overall scores.
3. Divide the overall scores by the total number of competencies.

Example:

OVERALL SCORES	115/23				
FINAL SCORE	5				
FINAL RATING	1.0				

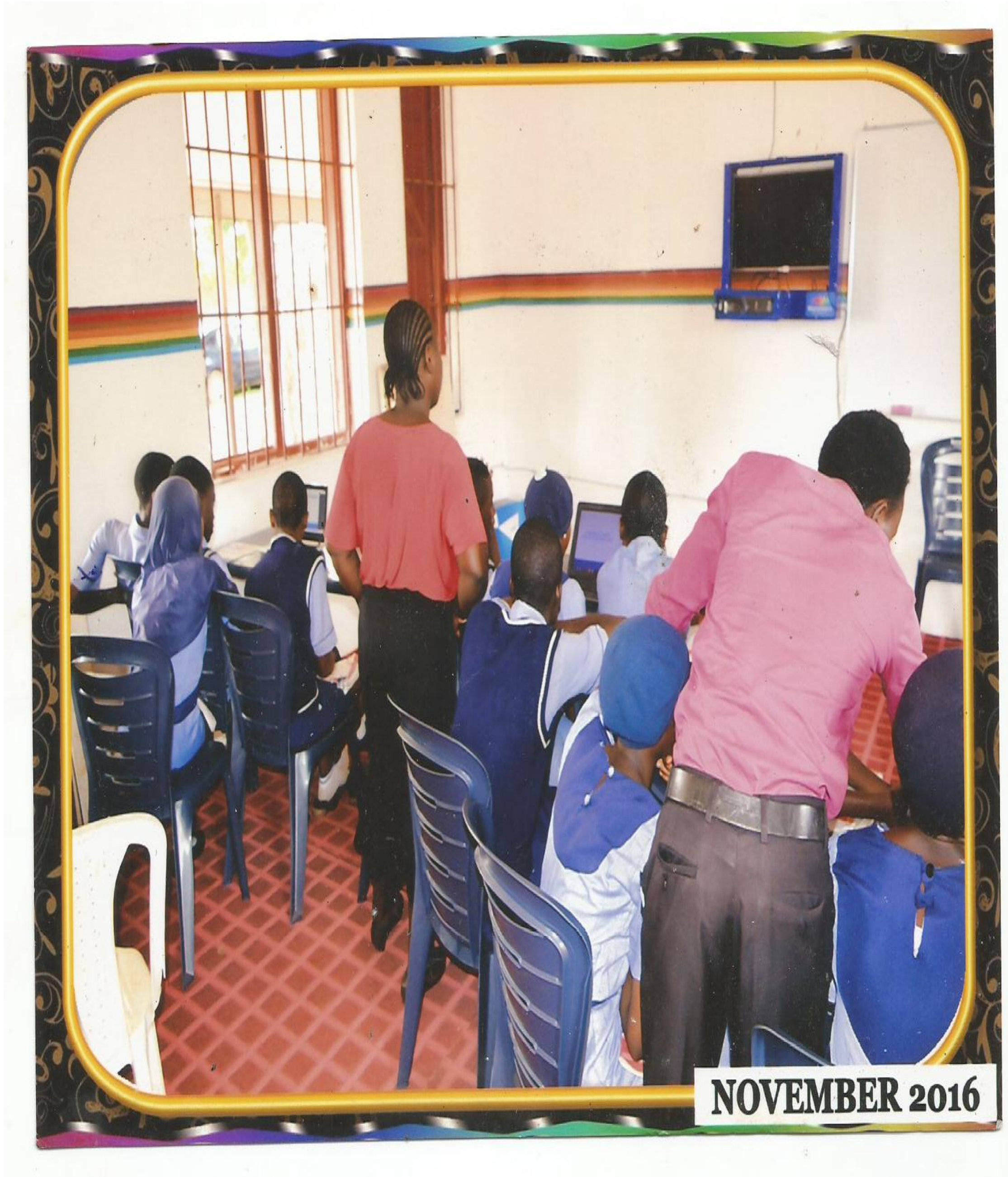
FINAL SCORE	EQUIVALENT RATING	INTERPRETATION
5	1.0	Excellent
4	1.5	Very Satisfactory
3	2.0	Satisfactory
2	2.5	Fair
1	3.0	Poor

Note: When the decimal point is 5 and above, round off to the nearest whole number. Example: 123/25= 4.92; round it off to 5.0. The instrument was validated using the Pi's inter-rater measure, and the reliability index was determined as 0.86.

APPENDIX 14

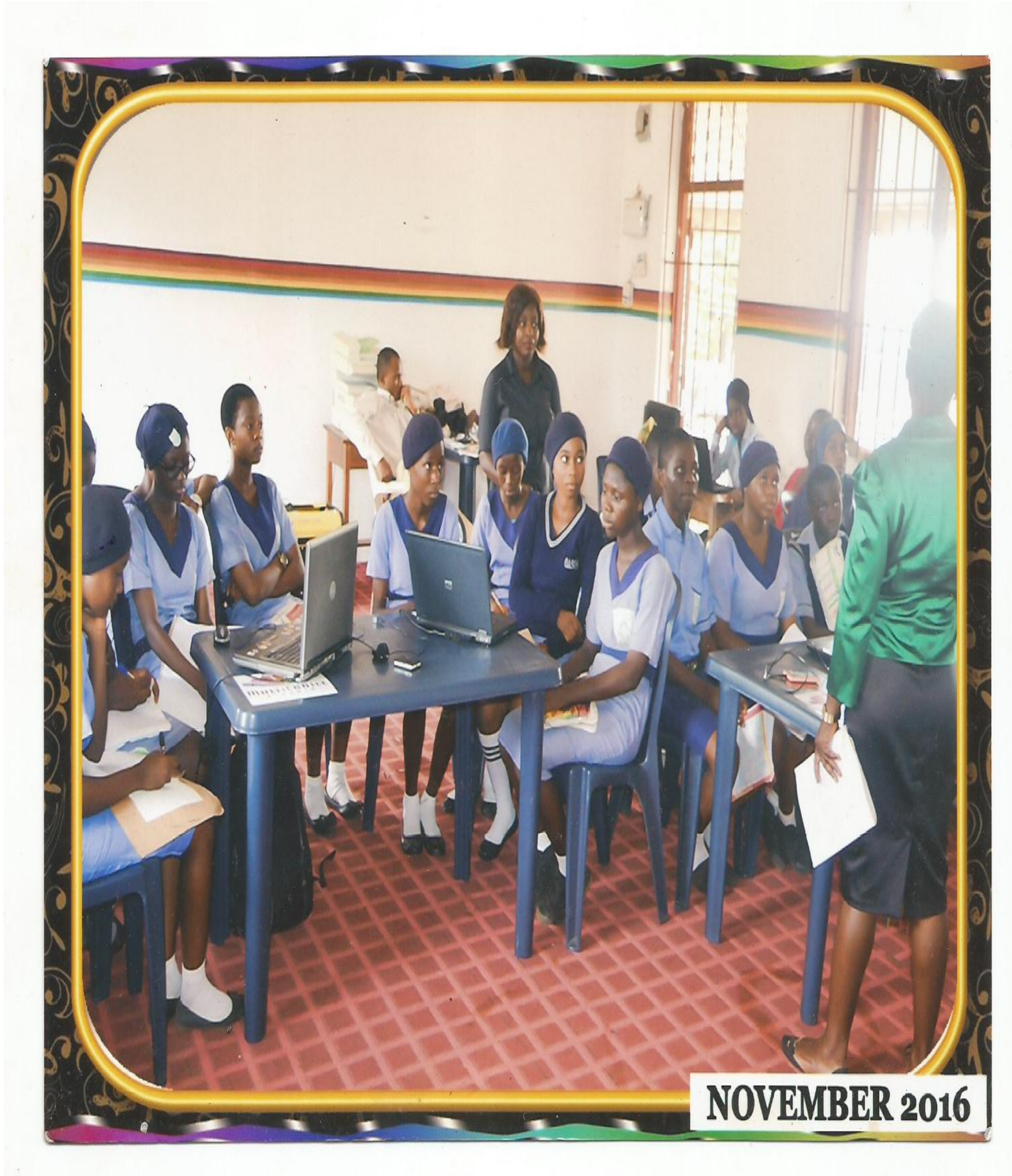
PICTURE FROM THE FIELD

Loyola College Students Learning Genetics Using Computer Simulation Package



Emmanuel Alayande Science School Students Solving Puzzles Onecology using Gigital Puzzle

Students Observing First Stage of Meiosis using Computer Simulation



Researcher Guiding Students on how to use Computer Simulation Package


NOVEMBER 2016