EFFECTS OF PROBLEM-SOLVING AND GUIDED INQUIRY STRATEGIES ON SENIOR SECONDARY STUDENTS' LEARNING OUTCOMES IN BIOLOGY IN IBADAN.

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ABSTRACT

Biology is a very important science subject offered by students in senior secondary schools. Students' performance in the subject has been reported as poor. Various instructional strategies have been used without much improvement in students' achievement and demonstration of practical skills. Studies have shown that teacher-centred techniques employed over the years did not yield desired result. This study examined the effects of problem-solving and guided inquiry instructional strategies on students' achievement and practical skills in Biology. The study also examined the moderating effects of career aspiration and gender.

The study was guided by the theory of constructivism. The pretest-posttest control group quasi-experimental design using a 3x2x2 factorial matrix was adopted. Multistage sampling procedure was employed. Two Local Government Areas were randomly selected from the existing two clusters of Ibadan educational zones. Three schools were purposively selected from each Local Government area with consideration for type of school and functional laboratory. Two schools were randomly assigned to each of experimental and control groups. Two hundred and forty students participated in the study. Instruments used were Biology Achievement Test (r = 0.78), Test of Practical Skills (r = 0.82), Career Aspiration Interest Scale (r = 0.78) and Instructional Guides. Data were analysed using descriptive statistics, Analysis of Covariance and Sidak post-hoc test at 0.05 level of significance.

The results showed that there was a significant main effect of treatment on students' achievement ($F_{(2,228)} = 9.69$; partial $\eta^2 = .07$) and students' practical skills ($F_{(2,228)} = 66.38$; partial $\eta^2 = .36$) in Biology. Students in the guided inquiry group had the highest mean score ($\bar{X} = 15.09$) followed by those in problem-solving ($\bar{X} = 12.78$) and demonstration ($\bar{X} = 11.62$). The highest mean scores in practical skills was obtained by those in guided inquiry ($\bar{X} = 53.25$) followed by those in problem-solving ($\bar{X} = 52.48$) and demonstration ($\bar{X} = 33.31$) groups. There was a significant effect of career aspiration on students' practical skills ($F_{(2,228)} = 4.33$; partial $\eta^2 = .02$) but not on achievement. Students in the biological science had higher mean score ($\bar{X} = 48.49$) than their counterparts in physical science ($\bar{X} = 42.27$). There was interaction effect of treatments and career aspiration on students' achievement ($F_{(2,228)} = 3.43$; partial $\eta^2 = .03$) but not on practical skills. Participants in biological science had higher mean score ($\bar{X} = 16.76$) than their counterparts in physical science ($\bar{X} = 13.42$), when guided inquiry strategy was used. There was significant interaction effects of treatment, career aspiration and gender on students achievement ($F_{(2,228)} = 4.27$; p partial $\eta^2 = .02$) but not on practical skills. Male biological science students in guided inquiry group had higher mean score ($\bar{X} = 16.85$) than their female counterparts ($\bar{X} = 16.66$).

Guided inquiry strategy was the most effective in improving female students' achievement and practical skills demonstration in biological science. Teachers should be encouraged to use guided inquiry strategy in teaching biology among female students.

Keywords: Problem-solving, Guided inquiry, Career aspiration, Gender, Students' achievement in Biology.

Word count: 495

DEDICATION

This study is dedicated to Almighty Allah (SWT) the author of all goodness, who is the owner of my soul, my strength, the source of my wisdom, my success as well as my guiding light; and my mother, late Alhaja Musimat Abeke Olalekan. May her soul test in peace. Amen.

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CERTIFICATION

I certify that this study was carried out by Modinat Dasola Rufai at the International Centre for Educational Evaluation (ICEE), Institute of Education, University of Ibadan, Ibadan, Nigeria.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The need for science to provide citizens with a functional knowledge of their environment and the tools they needed to manage it effectively has ascended the priority ladder globally. This is hinged on the belief that having a basic knowledge of science, its skills and processes can improve the quality of life of people and increase survival of the human race in their environment. In Nigeria, a systematic exposure to science education seems to be the prerogative of the formal school system. Starting from the primary to the secondary school level, science is presented to the students as specific subjects. These include basic science, chemistry, biology, agricultural science, physics and health sciences among others. Of these subjects, Biology is unique. Biology has multidisciplinary nature as evident in its contribution to knowledge in areas like agriculture, medicine, health and disease control, industry and research, as well as in the areas of training of specialists to man these areas. Also, Biology possesses unifying concepts on science; it may be well suited for developing scientific literacy.

Biology is a science subject important to life and life processes as reported by Ezeazor (2003). She remarked that Biology exposes students to the world of self-knowledge and knowledge of the immediate and distant environment. This implies that, if students are equipped with adequate knowledge of their environment, this may make them to be aware of the benefits they could derive from it. Consequently, they will make efforts to protect, improve, sustain and explore their environment. Some of the achievements made through biological sciences include application of genetics in agriculture; production of hybrid crops and farm animals with desirable qualities and early maturing varieties of plants and animals, and the use of biological method instead of chemical method in the control of agricultural pest as well as the use of naturally occurring bacteria to clean up oil spills and toxic chemicals. Also, in medicine, application of biology helps in the production of single cell protein by micro-organisms to help people with protein deficiency. Equally, geneticallyengineered microbes were used for manufacturing substances difficult to produce, such as insulin and interferon developed through the knowledge of Biology. Again, the use of hybridism technology to produce antibiotics and in-vitro fertilization that helps infertile couples to have children is an achievement of biology (Ramalingam, 2010).

In spite of the importance of Biology, studies have shown continuous under-achievement in the subject at the secondary school level over the years. Many researchers in and outside of Nigeria have been concerned with this problem of under achievement in Biology (Okebukola, 1997; ijaiya, 2000; Olatoye, 2002 and Wetzel, 2008). West African Examination Council (WAEC) chief examiners' report (2009) affirmed the state of poor performance especially in practical Biology and highlighted the observed weakness of candidates, as:

- poor knowledge of practical procedures;
- inability to properly identify organisms and their label parts;
- inability to relate structure of specimen to its function;
- inability to make logical reference from experimental results;
- inability to interpret tabulated results; and
- unruled and crossing of guidelines in labelling diagrams. (WAEC Chief Examiners' report Nigeria, 2009).

It was concluded that students' performance in Biology is poor due to their inadequate exposure to practical work and non-acquisition of relevant skills. This state of poor performance is shown when cognisance is taken of students' results of ten years (2004-2013) in Biology examinations in West African Senior School Certificate WASCE (Table 1.1).

Table 1.1 Trend of Performance in Biology in May/June WASSCE from 2004-2013

YEAR	TOTAL SAT	TOTAL CREDIT A1- C6	TOTAL PASS D7 and E8	FAIL (F9)
2006	1, 137181 (97.86%)	559, 854 (49.23%)	292, 317 (25.70%)	261, 200 (22.96%)
2007	1, 238163 (98.11%)	413, 211 (33.37%)	397, 353 (32.09%)	402, 148 (32.48%)
2008	1, 259965 (98.05%)	427, 644 (33.94%)	329, 961 (26.19%)	484, 071 (38.42%)
2009	1, 340206 (98.21%)	383, 112 (28.59%)	413, 014 (30.82%)	471, 312 (35.17%)
2010	1, 300418 (98.11%)	645633 (49.65%)	318486 (24.41%)	297228 (22.86%)
2011	1, 505199 (98.20%)	579432 (38.56%)	458338 (30.45%)	441720 (29.35%)
2012	1,6461540 (97.53%)	587044 (35.66%)	465139 (28.26%)	555827 (33.77%
2013	1, 647823 (98.12%)	851416 (51.66%)	442687 (26.86%)	313104 (19.00%)
2014	137716 (98.31%)	663951 (45.47%)	438135 (34.55%)	237476 (18.24%
2015	1180369 (98.22%)	626622 (53.08%)	305168 (25.35%)	219267 (18.57%)

Source: WAEC Research and Statistics Unit, Lagos.

Examining Table 1.1shows that from 2006 to 2015, the number of students who passed Biology at credit level in WASSCE was below 50% except in 2013and 2015 when the number rose to 51.66% and 53.08. Using this as a standard, it is evident that majority of students did not get admitted into higher institutions to pursue Biology based courses. A constant flux of under-achievement of students in science based subjects like Biology could have adverse implications on the level of scientific research and technological development in Nigeria. This necessitates that the teaching-learning of the subject be given a serious attention.

Available literature reveals that some variables have been identified to be responsible for the students' consistent low performance in senior secondary school Biology. Among these are inadequate qualified teachers (Animasahun, 2011), insufficient practical work and ineffectiveness of science teachers (Berk, 2005 and Fasasi, 2013); use of traditional teaching method which encourages rote learning (Nwagbo &Chikelu, 2012 and Omole & Tekoma, 2014); students' poor attitude and poor self-esteem (Ogundipe, 2004); poor teaching methodology (Adeyemi, 2002; Isa, 2007); poor funding of school/laboratory and deficient assessment (Ugwu, 2007; Akinbobola, 2008) and inadequate laboratory facilities and exposure (Ganiyu, 2000; Adeyegbe,2005 and Isaac, 2012) among others. Thus, scientific process and attitude are not emphasised and acquired, meaning, there is a need to improve science teaching and learning in the secondary schools.

Several moves were made to improve the quality of science teaching in secondary schools through the development of radical science curricula and teaching methodology. These moves led to the development of a suitable curriculum, which was called activity-oriented curriculum. This curriculum emphasises pupil-centred activities as the right approach to learning science. The Federal Government of Nigeria also, in its National Policy on Education (FG,2004), de-emphasised the memorisation and regurgitation of facts (common in our schools today), but instead emphasised practical, exploratory and experimental methods of teaching which can lead to sustainable development of the country. For instance, Basic Science (primary and junior secondary) students are to be taught "what science is and how a scientist works'' (STAN) as quoted by Ajeyalemi (2011). Also, up till date, the examination syllabi of the West African Examinations Council (WAEC) and the National

Examinations Council (NECO) indicate that 'practical work' should form the basis of achievement for Biology, Chemistry and Physics in the Senior Secondary Certificate Examinations (SSCE). To implement this laudable objective, the strategy to be adopted should be appropriately chosen.

Examination of the teaching strategy most likely used in some schools Biology classroom show that practical instructions are carried out using traditional lecture method. This does not actively involve the learners and encourages rote learning. The learner thus, acquires an unstable level of knowledge not transferable to problem solving situations. Meanwhile, researches have shown that in an attempt to invoke students' ability to think critically and reason logically, it is possible to teach students "strategies for learning''. This can be done while instruction is focused on practical activity content, a process called 'Reciprocal Teaching' Brown and Campione in Ige (2003). The idea is that strategies learning improves content learning. Akuche (2008) posited that most practicing science teachers do not devote enough time to practical work, probably because of:

- time constraint
- equipment constraint
- very large class size
- extensive scheme of work
- lack of interest of the teacher

The scheme of work in biology is very enormous and filled with lots of activities and experiments meant to help students understand the theory more and also provide continuous experience in process skill development. The teacher is expected to cover the whole syllabus before the SSCE examination. To meet these demands, many teachers shift all the practical work towards the tail end of the students' final year in senior secondary school, just before WAEC examination. Consequently, students are faced with the task of memorizing to pass the examinations. They are unable to identify most apparatus and understand most of the biology concepts. The resultant effect likely being that the students would not cultivate the required practical skills, vital for doing science.

There are three major dimensions to science; its content (scientific knowledge), method (scientific process) and application (which may result in tangible products). Scientists apply scientific method to conduct inquiry into nature to obtain scientific knowledge using processes such as, observing, classifying, hypothesising designing experiments, measuring and interpreting data. Scientific method and knowledge are applied to obtain the products, which usually change as new knowledge unfolds. These three dimensions, particularly the method distinguish science from all other disciplines and they should form the basis of any education programme in science (Ajeyalemi, 2011). Science educators generally agree that involvement of students in practical work is essential to science teaching. Among others, it is believed that practical work contributes to the understanding and learning of science (Millar, 2004) as well as encouraging students to gain science process skill, sand cientific attitudes (Johnstone & Al-Suaili, 2001).

Current global trend have raised the need to have access to high quality and effective science education which is the product of improved teaching and learning in school. Fasasi (2013) affirmed that any reform in science education must be practical driven to meet day-to- day work requirements which underlines the importance of practical work in the curriculum. Further, literature has revealed that science educators have called for a new direction in improving science teaching, (Osokoya, 2002; Akinbuilo, 2004; Adeyegbe 2005; and Ajeyalemi, 2011). They all suggested that for science teaching to be meaningful and relevant, the nature of science must be adequately reflected. This calls for a shift of emphasis from the traditional content and factual acquisition of scientific knowledge to those that will actively involve the learner in promoting learning by doing

Schmid and Telaro (1990) identified the cause of discrepancy between what students were able to learn in biology and what they should be learning as a neglect of the learning processes underlying biology instruction. Therefore, the issue of 'how to teach' needs to be fully addressed. It then follows that if students are to benefit from teaching and learning process, it is necessary to identify ways of improving students' performance in the subject and to search for new strategies or alternative methods of instruction that can boost achievement. In developing such strategies, existing strategies of teaching science must be taken into consideration. Examples of these include the use of Advanced Organiser (Egbugara, 1983 & Novak, 1977), Problem solving (Smith, 1991; Ikitide, 1994; Ige, 1999; Ishola, 2000 and Raimi, 2002), Concept mapping (Olagunju, 2001 and Osinubi, 2004), as well as Scientific Inquiry (Akuche, 2008). The findings of these works have provided further empirical support for the usefulness of these strategies over and above conventional method. Though, some of these strategies have been used in science classrooms, very few actually have been used to teach biology but not practical biology. This study aimed at exploring teaching strategies that can be used to present biology practicals to students to promote better achievement and improve the skills acquisition in the field.

In the teaching of any science subjects, it is important to include practicals as stipulated in the syllabus to supplement lecture method. Akinbobola (2008) traced the poor performance, interest and skill acquisition of students in practical science subjects such as biology, to teachers' inability to take candidate through practical sessions. Practical work is any teaching and learning activity which involves at some point, the students in observing or manipulating real objects and materials (Isa, 2007). Practical work as a matter of fact is important in the learning of natural sciences. The opportunity to interact with real objects and get involved in necessary physical and mental activities reinforces the knowledge of the learners and leads to the development of necessary basic practical skills. Biology, a natural science, needs a lot of practicals for its understanding, development and application. Practicals can only flourish when teachers are confident in its use, schools and colleges are sufficiently resourced, and the practical skills gained by students are applied. Practical work occupies a prominent and distinctive place in science education which made it generate enough research (Abraham & Millar, 2008).

Deltan (2009) stated that engaging learners in practicals bring about excitement science, helping them discover the value of evidence-based reasoning, higher order cognitive skills and teaching those who will become creative problem-solver. These have been the goals of science educator reformers. The means to achieve these goals especially method is to promote creative thinking in science. It is the contention of the researcher that perhaps the use of teaching strategies based on problem-solving and guided inquiry would significantly improve practical skills acquisition and achievement (learning outcomes) in Biology. The curriculum provides Biology students with ample opportunities of performing practical works which consist of a range of activities such as actual experiment, formal investigation and confirmatory exercise. This therefore offers students the opportunity to acquire desired competence in process skills.

Skill, according to Baiyelo (2000) denotes the mastery of logically linked series of activities that can be easily learnt. It is therefore a quality of performance which does not depend solely upon a person's fundamental innate capabilities but must be developed through training, practice and experience. Skills particularly required in practicals are psychomotor. Skills forming are closely associated and any omission of performance skills in a chain can be fatal to development of the complex skills (Adeyemi, 2003). In science teaching classroom, there is the need for strong relationship between the hand, the brain and the heart in a highly coordinated fashion to do useful tasks (West, Farmer & Wolf, 1999; Adipere & Leghemo, 2011). Learners are expected to possess the ability to carry out a whole range of useful physical tasks through a variety of mental activities as they begin with the basic rudiments of motor skill to the perfection of complex skill. Learning motor skill involves repetition and skills are perfected by doing.

Acquiring skills in modern technology, a thorough knowledge and understanding of related sciences is essential. Science teaching (Biology in particular), should be organised in such a way that students "study" science instead of merely "learn" science. Studying science implies going into the science laboratory to carry out scientific investigations. In so doing, first-hand experience of scientific inquiry and personal skills can be developed in students (Ajeyalemi, 2011). Students can actively appreciate inquiry only by becoming actively involved in it and this can be done effectively by getting involved in practical work (Keban & Erol, 2011).

Biology practical skills are science process skills and students need to acquire and develop them effectively for sustainable development of science and technology today. This demands that students must exhibit some degree of independence in learning, must take an active part in the learning process and must understand the technicalities involved in problem-solving. These attributes cannot be acquired in a Biology classroom, where students are taught using conventional teaching method as this produces rote learning. Because of the need to match teaching strategies with the demands of specific subject area, various innovative teaching strategies have been developed. These include; problem-solving, guided inquiry and cooperative learning.

These strategies are in line with the thinking of cognitive scientists who encourage teachers to help students take charge of their own learning and so become independent learners. This study established the extent to which problem-solving and guided inquiry strategies influenced students' learning outcomes in Biology.

Several terms such as analytical, critical reflective thinking, discovery and others have been used simultaneously with problem-solving (Ishola, 2000; Raimi, 2002; Orimogunje, 2008 and Apara, 2014). Many researchers had offered several definitions for problem-solving, for example, it referred to as effort needed in achieving a goal or finding a solution, when no automatic solution is available (Schunk, 2000). Raimi (2002) defines it as the application of already acquired knowledge of ordered science process skills (by the solver) to arrive at solution to novel and related chemical problems. Orimogunje (2008), views problem-solving as improvement of students' ability to reason logically, think critically and at the end solve problems that come their way in the environment.

Problem-solving is considered as the process of investigation where the solution is not obvious to the investigator at the onset of the activity. It is an integral part of science and one of the highest form of human thinking activities hence, the highest form of learning (Reid & Yang, 2002). It has been found to be dependent on the adequacy of specific relevant concepts in the students' cognitive structure, as well as the accessibility to such knowledge (Novak, 1977 in Ige, 2001)

In Problem-solving, students are encouraged to solve an identified problem either from the textbooks or from everyday experiences of the teacher, students and or community. Whatever the source of problem, the solution process will require the use of scientific method. It involves conscious and systematic application of acquired information or knowledge and reasoning to overcome an event perceived by an individual as problem. The problem solver (student) is assisted during the experiment with varying degrees of hints, cues and clues. Problem-solving depends on what the solver knows and what he possesses as at the time of solving the problem. Students must develop the ability to conduct science investigations using prior knowledge and experiences along with treating science investigations as problem-solving (Wetzel, 2008).

To enhance Biology students' comprehension of how scientists (Biologists) work and scientific knowledge evolves, experimental Biology curricula must be provided in which selected concepts and associated processes of problem-solving approaches are stated in a specific manner or steps. Acquisition of effective problem-solving behaviour depends not only on the conceptual knowledge but on the strategies learned by the problem solver (Bello cited in Apara, 2014).

The methodological implication is that, if experimental Biology concepts are broken down and presented in a logical sequence, following the algorithmic fashion to the students, experimental skills will likely emerge with time, if the frequency and intensity of practice is maintained. Such skills are likely to be sustained as students become more proficient, thus leading to meaningful and successful laboratory experiences (Obeka, 2010). As a teaching strategy, it entails training students on how to solve problems by proceeding in a logical "step by step" sequence from a problem state to solution state. The notion of problem-solving which is sometimes described as a core skill has received much attention in the literature of science education (Reid, 2002). There are several approaches to problem-solving, these include; simulation, using computer, introspection, modelling and experiment. Modelling and experiment were used in this study.

Modelling involves use of diagrams, graphs, pictures, concept mapping, physical models and other means to explain the findings of an investigations (Wetzel, 2008). Theorists in problem-solving, have identified basic strategies involved in problem-solving processes (Ashmore, Frazer and Casey (1979), Egbugara, 1983; Onwioduokit, 1989 and Smith, 1991). The various models suggest that problem-solving involves defining a problem, collecting information related to the solution process, reasoning through the problem state to the solution, checking and evaluating the solution. Existing models on problem-solving were designed principally for and applied mostly in theoretical contexts (Ikitide, 1994). These were mainly in the areas of mathematics, chemistry, engineering, physics and few in biology. These are; Egbugara (1983) Ibadan seven-step physics problem-solving model, Onwioduokit (1989) Laboratory Problem-Solving Model (LAPSOM) model, Ikitide (1994) Researcher Experimental Problem-Solving (REPSOM) model among others. Perhaps the earlier introduction of problem-solving model into other subject areas may not be unconnected with the more intrinsic relationship they have with mathematics. This may account for a few problem-solving models in Biology.

Other than problem-solving approach to practical teaching, various other strategies have also been suggested. These include guided inquiry strategy (Akuche, 2008). Literature have shown that guided inquiry is an efficient way to learn science practicals. Process of inquiry in science is often associated with laboratory, especially at the secondary school levels (Onwioduokit, 1989). This is because the laboratory is looked upon as the workshop of scientists. Inquiry is a teaching strategy which takes different forms and understanding. Scientific inquiry according to Kyles, in Akuche (2008), is a systematic and investigative performance ability which incorporates unrestrained inductive thinking capabilities after a person has acquired a broad and critical knowledge of the particular subject matter through formal learning. Implicit in each definition however, is the fact that inquiry is an intellectual endeavour. Achievement of one objective merely opens up new avenue, to be inquired into, even greater understanding of the phenomena. The basic need of the society calls for acquisition of practical skills and understanding of modern technologies.

Guided inquiry requires students to engage in relatively sophisticated mental processes including; formulating problems for investigation, formulating hypotheses to guide the investigation, designing experiment to collect data, synthesising knowledge in form of generalising or finding solution to a problem and possessing certain scientific attitudes such as objectivity, curiosity and open mindedness (Fasasi, 2013). Guided inquiry in science education can be defined as using series of structure, sequenced, scientific investigations that integrate appropriate processes and information, chosen through research to fashion meaningful learning experiences for students.

Guided inquiry equips the student with means to gain knowledge on his own through active participation and develops his mind by using it to solve problems. It also challenges students to find information for themselves, thus making instruction student centred. Since students find information by themselves, retention of knowledge is better facilitated. This strategy encourages analytical thought and promotes intuitive development. Moreover, it may help in realising one of the fundamental objectives of science education; to develop manipulative skills by personal contact with materials and apparatus.

Demonstration is used as control in this study. It is a method of teaching practicals by presenting or establishing facts or principles. It is a procedure of doing or performing something in the presence of others either as a means of showing them how to do it or illustrate a principle (Omosewo, 2008). It is also a method of instruction that employs sight and hearing as a means of communication. In demonstration, the teacher acts as dispenser of knowledge, with no room for student to participate actively in the conduct of the experiment or practical. At best, in the teacher demonstration, experiment is conducted for the students to report on. It is this approach that is normally referred to as the "cookbook", and teacher-centred. The students are placed in a passive role which they may find frustrating or boring unless the teacher makes it a point of involving them in the thinking behind the experiment and perhaps in the manipulations as well. In order not to encourage rote learning, students are allowed to participate in this demonstration by feeling, touching and recording data. This method provides scope for a good display of objects, specimens and apparatus to the students. Most often improvisation is employed in the science class to demonstrate a concept or a technique (Antadoga, 2013).

Having highlighted the teaching methods on practical work, there are some psychological constructs other than teaching strategies capable of determining the learning outcomes in Biology. These constructs are concepts used to describe psychological activities or patterns of activities believed to occur or exist but cannot be directly observed or measured. Career aspiration and gender were psychological constructs that served as moderator variables in this study. There are several reasons people choose certain career, such as interest, one's aptitude or values attached to the career or people in such a career. Making a good career choice is a major concern of students, parents and governments. Biology though, popular among science students, seems to have witnessed low-rate of interest by students that preferred physical sciences than biological sciences. Studies have shown that students were influenced by their peers, perceptions, talents, environments or home background (Tshabal, 2000 in Adesisi, 2012). Whatever influenced students, it is necessary that they take proper care and get adequate help/hints early enough before making decision on the career choice.

Exposing students to career possibilities enable students see the connections between what they are learning in school and what people are doing in "real world". This will increase students' awareness of the types of skills needed for potential jobs; thereby guiding them towards a course of study in the tertiary institutions and this will make their learning purposeful. This will also help students realise the future applicability of academic topics they are exposed to in early educational experiences. Notably, many students choose careers without considering their ability and capability that connect academic work to a chosen career, this may cause many students go into unstable career due to ignorance, inexperience, poor advice from parents, teachers, and friends or as a result of prestige attached to a certain profession.

Career aspiration can be defined as a cluster of needs, motives and behavioural intentions which individual articulates with respect to different career field options (Singaram, 2007 cited by Adebisi, 2012). It refers to individuals' occupational self-concept, beliefs and values about themselves in the workplace regarding their capability, significance and worth in their occupations (Adebisi, (2012). Also, according to Silva (2001) career aspirations refer to individuals expressed career-related goals or intentions and also include motivational components not presented in mere interests. Career aspiration represents an individual's orientation towards a desired career goal under ideal condition. Based on the meaning of career aspiration, the choice of students to study any course at post-secondary institutions could be shaped by the related career goals which could also be influenced by the aspiration. Career aspiration could be biological sciences, which are Biology-related disciplines like medicine, microbiology, nursing and agriculture or physical sciences such as engineering, computer science and mathematics-related disciplines. It is assumed that career aspirations may rely on other factors. Meanwhile aspirations do not exist in a vacuum, but rather occur within a social context. Therefore, career aspiration has a relative relationship with students' performance. Abe and Junaid (2012) find family size, family psychological environment and parental education have significant relationship with pupils' career aspirations.

Different subjects to which students were exposed to, during the course of study is usually the knowledge students need to acquire from the school. From the above view, one can easily deduce the role of a teacher with respect to subject selection in the students' chosen course of study. Price (2003) cited by Adeyemo and Daodu, (2006) identified a range of factors influencing course preference including: graduate employment rates from the course among employers, graduate satisfaction from the course, the quality of teaching in the course, approaches to teaching, learning and assessment from the course, including opportunities for flexible study, which are all school made. The consideration of student's choice in early career preparation programmes will help engage and empower the child throughout the later stages of career decision- making. This attention towards career preparation can help ensure that career aspirations are realised; therefore interventions should be consistent with the needs and preferences fo the student's course of study, which ultimately determines the achievement of the target career choice (Citera &Combs, 2002).

Gender as a strong predictor of human behaviour has been a central focus in classroom research. Efforts made through research to link sex difference to learning outcomes in science and mathematics have been inconclusive, as there has been conflicting results in attempting to find gender-related differences in science and mathematics abilities. Studies have shown that boys are better at more logical and theoretical subjects such as mathematics and science, while girls have been consideredto dominate and perform better in creative subjects like art and reading (Oboh, 2005; Ariyibi, 2010). They assert that gender-roles, level and type of encouragement expectation, different learning opportunities, career aspiration and values placed on the subjects among others are possible reasons for differences in achievement.

Okogie (2001) find that male students performed better than their female counterparts in theoretical tasks but female students performed significantly better than their male counterparts in tackling practical task in science. Also, Nwagbo and Chikelu (2012) and Omole and Takema (2014) find no significant difference between male and female students' achievement and practical skills in science. This opposes the findings of Gorman, (2006) and Taiwo (2013), who observed significant difference in favour of male students. In the same vein, certain gender preferred to pursue a particular career. For instance, male are seen more in the physical sciences (mathematics, engineer, and so on) than the female counterparts. It appears that Biology is not gender bias subject as claimed by some people, provided both sexes are subjected to the same teaching and learning condition. It is worthwhile to examine the effect of gender on learning outcome using problem-solving and guided inquiry strategies. It is therefore imperative that a study to verify the above variables on learning outcome in Biology practical be undertaken.

1.2 Statement of the Problem

The performance of students in science at secondary school level, particularly in Biology has not been encouraging as being revealed by candidates' results in public examinations. Literature reveals that several factors determine students' achievement, students factor, enabling school environment, shortage of qualified teachers, lack of functional laboratory, poor teaching methodology and inadequate teaching aid.

A closer look at the case of under-achievement of students in Biology shows that, to a large extent, it is as a result of their inability to answer questions in the practical section satisfactorily. This section accounts for about 40% of the overall score in the subject. Biology teachers have not been paying attention to practical teaching. The West African Examination council Chief examiners' report reveals that Biology students avoid physiology-related practical questions and few who attempted questions in this section hardly obtained a good score to enhance their chances of making a pass grade. Teaching of Biology is becoming more of theory than practical in many senior secondary schools today. Many teachers of Biology tend towards teaching theoretical aspect of the subject neglecting the practical aspect. Quality Biology teaching is supposed to be one that is meaningful and academically enhancing goal of students. Biology is one of the core science subjects in the senior secondary school in Nigeria, and the teaching of the subject deserves proper presentation to the learners. Therefore, the need arose for the use of strategies that can engage students in the process of science that will develop in them required skills, creative thinking and ability to ask logical questions, ability to seek appropriate answers and solve problems. Problem-solving and guided inquiry strategies are student-centred and capable of developing these skills. Previous studies on problem-solving and guided inquiry concentrated on mathematically oriented subjects like mathematics, physics and chemistry. In addition, previous studies have investigated either of both strategies with other moderating variables other than career aspiration and gender. Therefore, this study investigated the effects of problem-solving and guided inquiry strategies on senior secondary school students' Biology learning outcomes (achievement and practical skills) in Ibadan. The study also examined moderating effects of students' career aspiration and gender on achievement and practical skills.

1.3 Hypotheses

In order to give direction to this study, seven hypotheses were tested at 0.05 level.

H_{01}; There is no significant main effect of treatment (problem-solving, guided inquiry) on students':

I. Achievement in Biology

II. Practical skills in Biology

H_{02}; There is no significant main effect of career aspiration on students':

I. Achievement in Biology.

II. Practical skills in Biology.

H_{03}: There is no significant main effect of gender on students':

I. Achievement in Biology

II. Practical skills in Biology

H_{04}: There is no significant interaction effect of treatment (problem-solving and guided inquiry) and career aspiration on students':

I. Achievement in Biology

II. Practical skills in Biology

H_{05}: There is no significant interaction effect of treatment (problem-solving and guided inquiry) and gender on students':

I. Achievement in Biology

II. Practical skills in Biology

H_{06}: There is no significant interaction effect of career aspiration and gender on students':

I. Achievement in Biology

II. Practical skills in Biology

H_{07}: There is no significant interaction effect of treatment (problem-solving and guided inquiry), career aspiration and gender on students':

I. Achievement in Biology

II. Practical skills in Biology.

1.4 Scope of the Study

This study was interested in determining the effects of problem-solving, guided inquiry and demonstration strategies in Biology among senior secondary school students in Ibadan. The participants were limited to senior secondary schools class two students from Ibadan educational zones 1 and 2. The experimental topics considered for the study among all the participants were nutrition, physical processes and tissue as well as supporting system

1.5 Significance of the Study

The results of this study revealed relative effectiveness of problem-solving and guided inquiry strategies for helping students acquire conceptual knowledge and practical skills required to achieve better academic performance. Also, it would provide information required for curriculum planning and science educators on interplay between practical methods and students' variables such as career aspiration and gender as well as how these can affect learning outcomes. It would also provide some reference materials for teachers in handling instructional approaches in biology practical. The outcome of this study could contribute significantly towards curriculum planning, development and training of Biology teachers for better classroom effectiveness which could culminate in improved learners' academic achievement and acquisition of required skills in Biology.

The findings could encourage the government to organise seminars, conferences and workshops on which the best learning strategies would be discussed and taught in order to improve the teaching and learning of Biology.

Finally the results of this study will provide a basis for taking into consideration the importance of students' life chosen career, as the skills needed for lifelong learning will be greatly enhanced. It would also give direction to other research work based on limitations highlighted in this study

1.6 Definition of Terms

Operational Definition

Problem-solving: This refers to the use of conceptual and procedural knowledge to solve Biology questions. It involves application of an organised method of reasoning in the process of bridging the gap between problem and its solution.

Guided inquiry: This refers to the approach of teaching in which the students are left to perform practical works using practical manual with limited guidance, but the teacher guides the students by asking thought provoking questions with the use of researcher instructional guide as used in this study (manual for guided inquiry).

Learning outcomes: This refers to Biology achievement performance in Biology achievement test and performance in practical skills (TPSB) in Biology.

Achievement: This refers to scores earned by students in pre-test and post-test derived from Biology Achievement test (BAT Scale; 50% & above; pass mark, 0 - 49%; failed).

Practical skill: Refers to competence required in performing a learning task as measured in identification, manipulative, observation and communicative skills. This refers to scores earned by students in pre-test and post-test derived from test of knowledge of practical (TPSB Scale; 50% and above; pass mark, 0 - 49% failed)

Problem-solving Model: This refers to model showing various stages which a student is likely to pass through in order to progress from a problem state to solution state while solving biological problem of a practical nature, Researcher Experimental Problem-Solving Model (REPSOM),

Career Aspiration: This is a measure of desire for future employment in biological science or physical science (CIS Scale). Those in biological science are students that score 28 - 48 marks in biological scale, while those in physical science are students that score 28 – 48 in physical science scale.

Demonstration: This refers to the demonstration method of teaching in which the teacher demonstrates the practical lesson and the students observe. The students do not have the set of apparatus. Only the teacher has a set of apparatus which he/she shows to students while the students listen (laboratory manual for demonstration). This serves as a control.

Manipulative skill: Refers to outward competence required in handling equipment and materials, the setting up and connecting the apparatus.

Communicative skill: Refers to clear and concise competence in reporting the physical significance and relevance of practical work in Biology.

Identification: Refers to outward competence in recognising, naming and stating the functions of apparatus.

Observation: Refers to outward competence required to notice changes that might have occurred in the process of performing practical such as colour change and odour perception

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Background

2.2 Aims and Objectives of Biology teaching.

2.3 Antecedent and Goal of Practical work.

2.4 Instructional Strategies and Learning Outcomes

2.5 Problem-solving Approach

2.6 Models in Problem-solving

2.7 Studies in Problem-solving and Learning Outcomes

2.8 Inquiry Strategy Approach

2.9 Studies in Guided Inquiry and Learning Outcomes

2.10 Demonstration Approach and learning Outcomes

2.11 Practical skills.

2.12 Career aspiration and learning Outcomes.

2.13 Gender and Learning outcomes.

2.14 Conceptual framework

2.15 Appraisal of Literature

2.1 Theoretical Background

The present study is conceived on the learning theory of constructivism. The concept of constructivism has roots in classical antiquity, going back to Socratic dialogues with his followers, in which he asked direct questions that led his students to realise for themselves the weakness in their thinking. The Socrates's dialogues is still an important tool in the way constructivist educators assess their students' learning and plan new learning experiences. Constructivism emphasises the importance of the active involvement of learners in constructing knowledge for themselves, and building new ideas or concepts based on current knowledge and past experience. The learner selects and transforms information, constructs hypotheses and makes decisions relying on cognitive structure to do so. One feature of constructivist paradigm explains that individual constructs their own meaning and knowledge by actively engaging in the learning process. The theorists acknowledge the learner's active role in the personal creation of knowledge and the importance of experience in this knowledge creation process. It is known that the quality of acquired knowledge through active construction is better than passively gained knowledge.

This learning theory is built on three cognitive theorists who have been highly influential in understanding the process of human learning. They are Jean Piaget (1896-1980), David Ausubel, (1918-2008) and Lee Vygotsky (1896-1934). Jean Piaget developed theories of childhood development and education, now known as Progressive Education that led to the evolution of constructivism. Piaget (1960)believed that human learn through the construction of one logical structure after another. He concluded that logic of children and their mode of thinking are initially entirely different from those of adults. The implication of this theory and how he applied them have shaped the foundation for constructivists education. He argues that human generate knowledge and meaning from an interaction between their experience and ideas, use mental patterns (schemes) to guide behaviour or cognition and interpret new experiences or materials in relation to existing schemes. However, for new material to be assimilated, it must first fit an existing scheme.

To Ausubel (1960), meaningful information is stored in the network of connected facts or concept referred to as schemata. New information which fits into existing schemata is more understood, learned, and retained than information that does fit into an existing schema (Cakir, 2008). For both theorist, new concepts that are well anchored by or attached to existing schemata will be more readily learned and assimilated than the new information relating to less established schemata. The same holds for the information not attached to any schemata at all for example, the case of compartmentalised or rote learning. Ausubel (1960) postulated that meaningful learning occurs when new information subsumed is by existing relevant concepts and these concepts undergo further change and growth (Novak, 1988 in Cakir, 2008). He identified rote learning as arbitrary, verbatim, non-substantive incorporation of new ideas into cognitive structure. Information does not enter cognitive structure, but with no specific relevance to existing concept/propositional framework. Because of this, rote learning may involve interference with previous similar learning and exhibit some of the difficulties in pattern of recall, including fail to notice associations. Ausubel (1960) further suggested that effective instruction requires the teacher to choose important or relevant information to teach, and to provide the means to help students relate this to concepts they already possess existing schemata.

When a learner encounters situations in which his/her existing schemes cannot explain new information, existing schemes must be changed or new ones made. Piaget termed this as accommodation. The condition leading to accommodation is known as disequilibration. To restore balance in the cognitive system, new scheme are developed or old ones are modified until equilibration is reached and the new information accommodates into the learner's view of the world. Seen in this light, one may agree that prior cognitive structures are important part of Piaget and Ausubel theory of cognitive development as prior knowledge or existing schemata are of central importance if the learner is to meaningfully acquire new information or concepts.

Vygotsky is a social constructivist who believed that cognitive development is studied by examining the process that one participates in when engaged in shared activities and how this engagement influence engagement in other activities. Because of this, development occurs as children learn general concepts and principles that can be applied to new task and problems (Palinscar, 1998 in Amao 2015). Vygotsky, (1978) in support of his theories introduce the zone of proximal development (ZPD), stating that learning should be matched in some manner within the child's development. Full development of the ZPD depends on social interaction within the student's peer group. The level of skill that a student may achieve with peer collaboration exceeds what can be attained from individual endeavour. That is students' developmental capabilities in the classroom need to be looked at as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers".

The teaching of Biology have undergone a paradigm shift from a passive process to an active construction and interpretation of observations. Learning is a treasure within, and scientific knowledge is been actively developed and designed by the learner. This is the constructivists' view of learning science. The constructivists view learning as an interaction between the learner and his environment (Ada, 2006). Constructivism in education means the novel knowledge is linked to the existing one and new knowledge block is created by the learner. Keban & Erol (2011) reviewed that during the interaction between the learner and his environment the learners' prior knowledge becomes the basis for him to interpret and developed new knowledge. This is so because learning is a process of conceptual change and knowledge navigation. Learning is designed to be self-centered (learner-centered), which makes the learner an active participant in learning environment. Learning in this case involves the redesigning, readjusting, restructuring of student conceptions nd misconceptions. The challenge in teaching is to create experiences that involve the student and support his thinking, explanation, evaluation, communication and application of the scientific models needed to make sense of these experiences which are associated with pedagogical approaches that promote learning by doing or active learning. Akinbobola, (2009), opined that constructivists' teaching focus on an independent learning, creativity, critical thinking and problem solving. Constructivists' teaching is based on the fact that skills and knowledge acquisition are not by passive receiving of information and rote learning but it involves active participation of the learners through knowledge construction, hands-on and activities (Akinbobola & Ado, 2007).

In constructivist classroom, the teacher facilitates and provides students with experiences that allow them to use the science processes and skills such as observing, measuring, classifying, , communicating, inferring, using number, using space/time relationship, questioning, controlling and manipulating variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data. It has been reported by Bello (2011) that strategy instruction is considered as one of the sub-topics of constructivist learning model. Keban & Erol (2011) further stressed that one of the most important key elements of the strategy usage in education is to guide the students to enter the actual process. The actual content and the types of competencies sought for within biology as a science subject contribute to students' perceptions of biology as well as in achievement.

What makes biology learning truly meaningful and achievable is when students consciously and explicitly link new knowledge to relevant concepts already possessed. In a classroom setting where constructivism prevails, the teacher acts as a facilitator and motivator to guide the learning of students to help them overcome learning difficulties, to achieve a greater academic performances. Here, learning and knowledge are interactive and dynamic as propanded by Vygotsky (1978). This explains why these approaches (problem-solving and guided inquiry) most suitable for Biology because scientific knowledge is dynamic and not static. In guided inquiry learning strategy, the teacher provides illustrative materials for students to study on their own. Nwagbo (1999) noted that if the learner is allowed to discover relationships and methods of solution by himself or herself, make his or her own generalisations and draw conclusions from them, he or she may planned better to make wider coverage and applications of the materials learned.

Students are allowed to sort out the relevant or irrelevant questions or variables, to search out the required information (data), be completely responsible for organizing and interpreting the data and finally offer a possible solution to the observed problem. Students are offered an opportunity to engage in mental activities that are much more sophisticated than in the discovery method. Inquiry strategy of learning employs all the mental activities used in discovery learning and many more. The learner has to ask insightful questions. By doing so, problems have to be recognized and in searching for solutions to such problems, the learner has to formulate hypotheses. Having formulated hypotheses, investigative exercises through experiments have to be designed. The experiments have to be carried out and knowledge has to be synthesised from the analysis of the gathered data. Gradually, the learner develops in self-certain attitudes that are very much like attitudes of real scientists. In essence, therefore, these methods are teacher-designed opportunity for the students to behave very much like mature scientists. Thus, this kind of learning situation is more suitable for adolescents (11-15 years) in the Piagetan stage of formal operations. It can be observed that the problem-solving and guided inquiry learning situations stress the importance of students using their cognitive mental ability to work out meanings to what they observe around them. This approach could be described as "investigative" strategy of learning

2.2 Aims and Objectives of Biology Teaching In Senior Secondary Schools

Harmonious development of child's personality and social efficiency, etc. are the general aims of education. If science teaching is to be made effective, its aims should be in consonance with the general aims of education. Biology instruction is supposed to be utilised not only to learn about plants and animals, but it should contribute to the general objectives of education and living organisms, generally. Sometimes the aims are more or less general viz: to teach students how to observe accurately and thoroughly, describe their observations clearly and systematically, promote detailed knowledge of the living nature through observation and apply these observations to everyday life.

The aims of secondary education are to:

- Impart factual knowledge which may be a means but not an end, and which is necessary to obtain insight and understanding.
- Teach the students to detect and analyse problems, to train their intellect and to make them cultured members of the society

2.2.1 Knowledge.

This aim has received the topmost priority as compared to other aims. Pupils studying Biology should acquire the knowledge of:

- Fundamental principles and concepts useful in daily life.
- Facts for science study.
- Inter-dependence and relationship of different branches of science.
- Knowledge of plants and animals.
- Natural phenomena going on.
- Knowledge of general rules of health and human body, etc.

2.2.2 Skills

Science students should acquire skills in experimentation, construction, observation, drawing, etc. Experimentation and construction skills include handling, arranging, preserving, and repairing scientific instruments.

2.2.3 Abilities

The biology teaching should develop certain abilities such as ability to

- Sense a problem, organise and interpret;
- Analyse and ;eneralise
- Predict
- Organise exhibitions, excursions and fairs; and
- Discuss, argue and express scientific terminology
- Improvise and manipulate instruments using his acquired knowledge.

2.2.4 Attitudes

Science teaching directly inculcates the scientific attitudes among the students. Biology is not an exception, so the students should be taught directly and systematically and every individual ascertain that he develops the desired attitudes and practices them. A man with the scientific attitude is expected to be:

- Critical in observation and thought
- Open-minded
- Respectful of others' view points and is ready to discuss his problems with others and accepts what appears correct.
- In search of the answers to 'What's' and 'Whys' and 'How's' of the things he observes and accepts the natural things as such.
- Objective in his approach to problems
- Not a believer of superstitions and misbelieves.
- Follower of cause and effect relationship.
- Truthful in his experimentation and conclusions.
- Impartial and unbiased in his judgments.
- Adopts planned procedure in solving a problem.

2.2.5 Reflective Thinking.

With the above attitudes developed, a science student will handle a problem scientifically. He will sense a problem, define it, collect evidence, organise and interpret the data, formulate the hypothesis, test its validity and finally draw conclusions impartially. The training in the scientific method should be one of the important aims of teaching science.

2.2.6 Habits

Certain socially desirable habits like honesty, truth, tolerance, self-confidence, self-reliance, etc. should be inculcated through the science teaching.

2.2.7 Interests

The teaching of science should also aim at developing some interests in reading scientific literature, in scientific hobbies, in activities of clubs, excursions, in natural phenomena; in drawing, in leadership, etc. The motivational techniques like rewards and punishments, praise and blame, rivalry and emulation, etc. should be implied by the teacher.

2.2.8 Appreciation

The appreciation of natural beauty, scientific inventions, scientists endeavour is the outcome of science teaching. For this purpose the teacher should arrange outings, should relate the life histories of scientists and should keep the students in touch with the new inventions in science.

2.2.9 Providing Work for Leisure

As the empty mind is devil's workshop, a science student should not while away his/her leisure. He/she can prepare inks, soaps, boot polishes and other daily useful things or he/she can keep hobbies of stamp collecting, coin collecting, photography, drawing, gardening, study of plants and animals or of minerals, etc. He/she can learn to improvise certain instruments, learn to play with musical instruments along with its construction knowledge.

2.2.10 Training for Better Living

A science student should know the ways and means of prevention as well asd eradication of diseases to maintain good health, as well as should also be able to adjust himself within his domestic, social environment and economic as well as cultural conditions.

2.2.11 Forming Basis for Career

The attitudes and interests of the students should well be adjudged by the science teachers and they should impart them the knowledge accordingly so that they may pursue the desired professions. Participating in the training for professional careers in Biology, especially to give the necessary basis for the understanding of the application of Biology in its various areas; agriculture, medicine etc. and in all circumstances of life where the action of the isolated individual is dominant (hygiene, community health, nutrition e.t.c.) and leading the student to a certain understanding of nature. An artist can never be a doctor. So nothing should be forced on students. Acceleration should be provided in his own direction to get a suitable vocation and fit himself/herself well in society and prove an asset to it.

2.3 Antecedent and Goals of Practical Work

The ever increasing role of science and vocational education today has brought about rapid changes in their philosophies, methods, and teaching strategies. These changes aim at producing the required manpower in these fields to sustain the present and future generations. Many of the new programme in science education emphasised self-paced individual work on the part of students. Behaviours which are concentrated and practicalised are now the expected outcome in modern science courses (Abah in Fasasi 2003).

The use of laboratory method in science teaching originated from the idea of the early scientists. It was in the 17^{th} century that scientists paid the greatest attention to the scientific method that led to the revolution in science. The sheer number of persons that paid attention to the method then indicated the need for an acceptable method of conducting science. Francis Bacon (1561-1626) was perhaps the first in the 17th century to formulate a series of steps to account for the scientific method in his book Novum organum (the new instruments 1620)

Practical works involve activity based learning process confined to the four walls of a room and in which close-to-true type interactions with materials take place. Such activities include identification, experimentation, observation, use of farm tools etc. Busari (1996) defines practical work as learning experience in which there are interactions with the apparatus which improves students' power of observation. Practical work allows science education to become something that learners participate in rather than something they are subjected to. Experimental work serves primarily to demonstrate techniques and to verify theory. Students develop an understanding to the process of science (i.e. skills used in doing experiment) if they learn about how science works. The most important aim of scientific education is the improvement of students' performance whose indicators are those of knowledge, manipulative skills and attitude which manifest after being exposed to various learning experiences in sciences. Practical work represents diverse range of purpose and expectations in science teaching. Some science educators emphasised students development of technical skills (Adipere & Leghemo, 2011; Achimugu, 2014) others emphasised development of processes of scientific inquiry (Millar, 2004) yet others emphasised the enhancement of scientific attitude and enjoyment of science (Agbo &Nyam, 2007).

For students, laboratory work presents varied experiences with structured activities, school science equipment and science topics.

Practical works are designed mainly to complement classroom teaching, learning process. Such practical works are examined in this study, using problem-solving, guided inquiry and demonstration approaches. In the literature, the work of many researchers have been focused on the aim of practical work (Watson ,2000 and Bob, 2011).Though there are variations in the level of details, the specification contains common element of content, procedure and affective aims. According to Ajeyalemi (2011) those aims can be divided into eight categories. These are to:

- Develop manipulative skills and techniques
- Encourage accurate observation and description
- Discover or illustrate a concept, law or principle
- Experience scientific phenomena
- Motivate by stimulating interest and enjoyment
- Develop certain scientific attitudes such as open-mindedness and objectivity.
- Develop an understanding of experimental procedure and evidences (experimental design, data collection representation and interpretation,) and
- Get a 'feel' for what it is like to be a problem solving scientist

Kerr in Hodson (1998) identified ten motives for developing practical work in school science. These are to:

- Encourage accurate observation and careful recording;
- Promote, simple, commonsense scientific method of thought;
- Develop manipulative skills;
- Give training in problem solving;
- Fit the requirements of practical examination regulations;
- Elucidate theoretical work to aid competence;
- Verify facts and principles already taught;
- Be an Integral part of the process of finding facts by investigating and arriving at principles;
- Arouse and maintain interest in the subject; and
- Make biological, chemical and physical phenomena more real through actual experience.

Although priorities may have shifted somewhat, these motives have remained largely unchanged. Hodson (1998) argued that although the educational goals for practical work are common across many schools, the practice employed to achieve them is not. Some widely differing activities coexist under the umbrella term practical work. So research findings on the efficacy of practical work are confusing and generally inconclusive (Baiyelo, 2000).

According to Isa (2007) the role of biology experiments in developing an interest in biology, a better understanding of subject, scientific skills, open- mindedness e.t.c. have remained controversial. She stated that practical work in science is intended to develop scientific skills, conceptual understanding, cognitive abilities, creative thinking, scientific attitude etc. But how far these expectations are met is controversial. Hodson (1990) concluded that practical works help only some students in developing some of these abilities. Madu (2004) posited that students find laboratory lessons boring, yet practical work is supposed to stimulate interest in science. James (1995) and Hodson (1998) concluded that laboratory work does little to improve understanding of science at least as measured by pencil and paper test. Later studies by Adejoh (2011) did not challenge this view.

Owolabi,Ogunleye and Adeyemo (2007) concluded that reviews of meta-analysis indicate that laboratory work promotes competence in skills of gathering information, organizing, communicating and interpreting observations. It has little effect on capacity to ask appropriate questions in science and to recognize what is involved in answering such questions through experiments or ability to draw conclusions. Hodson (1998) suspected a way out of this confusion and educationally unproductive situation by re-conceptualising practical work in terms of three associated purposes. These purposes are to:

- Develop students learning science, acquire and develop conceptual and theoretical knowledge;
- Help students learn about science -- develop an understanding of the nature and methods of science and an awareness of the complex interactions among science technology, society and the environment; and
- Enable students to study science – engage in and develop expertise in scientific inquiry and problem solving.

These can be regarded as different goals each of which has a range sub goals for which different approaches are necessary. Teachers need to be clear about sub goals they have for a particular lesson and to design learning activities so as to ensure effective teaching.

Practical work in some countries has a long history and is now part of a well-established tradition of science teaching. In Britain, for example it was established quite clearly that science education should be taught in laboratories (Layton, 1990 and Hodson 1996). In some other countries, including Nigeria practical work is frequently neglected by teachers and curriculum developers (Hodson 1996: Owolabi, Ogunleye & Adeyemo, 2007; Bilesanmi-Awoderu, 2006). Kirkley (2003), posit more valid motives for practical in science education which include:

- Teaching or learning the academic approaches to work especially as a scientist
- Helping students develop specific skills
- Allowing students to experience phenomena and to achieve some tacit knowledge of them.

They further stated that the skills include: discrimination, observation, measurement, estimation, manipulation, planning, execution and interpretation and that the attainment of these skills is based on practice and feedback. They further highlighted the most common motives for employing practical which are: illustrating theory, achieving meaningful learning and gaining theoretical insight into the national phenomena. Millar (2004) in his contribution also, identified three major reasons for practical work

- To develop ,understanding of concepts
- To develop practical/manipulative skills
- To train the students in inquiry skills

Millar (2004) proposed that every science teacher must aspire to achieve these in his interaction with students.

Laboratory according to Isa (2007) and Isaac (2012) is that school building block specifically designed for carrying out experiments, a place where ideas are tested and where scientific generaliation are validated orreuted. This means that laboratory is seen as important structural components in science teaching. Laboratories are so embedded in the practice of science teaching that it is difficult to imagine studying it without them. Yet, their purpose is not universally agreed and evidence of their effects is not equivocal (Isaac, 2012).

If practical work has not been achieving many of its aims, even in educational advanced countries where the needed human and material resources have been provided in abundance, how much more would it be a problem in under-served learning environment? Ajayalemi (2011) concluded that the salient aims and objectives of practical are not being achieved in the Nigeria school system due to a lot of factors such as the in enabling learning environment and inflexible methods of teaching adopted by the teachers. What curriculum recommends, teachers seem comfortable with the lecture-recitation and easy pattern of instruction what methodology courses teach.

2.4 Instructional Strategies and Academic Achievement

If standard based education is to become a reality in any nation, the instructional strategy of learning ideas and skills should play important role. In any teaching-learning situation, there is a complex interaction between the instructor (teacher), the student, the media via the method used and other subsystems including the outcome. This interaction between the presage, context, process and product variables is the main concern of teaching. The ability to effectively manage and utilise these variables and skills required to obtain an outcome is termed instructional strategies (Ibeagha in Ishola, 2000). Teaching is a process of imparting knowledge, skills and attitude to learners (Abdullahi 1982). All students can learn but students learn in different ways and at different rates (Joyce Weil & Calhoun 2004). Methods are the tools of the teacher for reaching the set goals and objectives. The effective teacher has multiplicity of methods at his disposal and must be prepared to select the one which will be most effective for leading the learner to desired goal.

Teaching methods sometimes called strategies are ways and means adopted by teachers to direct the learners' activities towards an objective. It is therefore a process of cognitive, affective and psychomotor development whose aim is to mould the learner towards a total contribution to the development of the learner and the community (Akinbobola, 2009). Teachers must not only be knowledgeable about the content they teach but should know and be committed to making decisions that involve the use of varieties of instructional strategies and approaches appropriate to the students diverse learning needs (Joyce et al, 2004). It is therefore a challenge to science teachers to discover new ways of motivating and stimulating the different abilities of science students (Ogunleye, 2005)

Studies have shown that teaching of science in Nigeria secondary schools fall short of standard expected of it (Nwosu & Ebere 2012), also the present method used in teaching science in secondary school does not help in the acquisition of science process skills by students Madu, 2004). Ali as quoted by Ibe and Nwosu (2003) asserted that there is no best method but that effective teaching should be laboratory centred and activity oriented rather than text book or lecture-method.

Van-Secker and Lissitz (1999) conducted a study on the effects of some instructional techniques on students science achievement .The techniques which are recommended in the national science education standard are

- Student centred –instructions;
- Teaching of critical thinking skills; and
- Use of hand –on laboratory activities.

The use of laboratory activities was found to exhibit positive effects on the science achievement of 10^{th} grade student. The effect size for student centred instruction was 1.07, the effect size of critical thinking was 12 and the effect size for use of hand on laboratory was 85. They found out that an emphasis on student-centred instruction actually increased the differences in science achievement between boys and girls. Emphasis on critical thinking increased the differences in achievement between the majority and the minority students and between students with high socio-economic status (SES) and students with low (SES). Their study illustrates the need to study the effect of instructional strategy on specific type of students in specific situation.

Akpachafo (2001) and Agbogboroma (2005) reported that the use of instructional modes/strategies significantly enhanced the performance of students in secondary school. Their findings show that the use of instructional strategy has positive effect on students' academic achievement. Similarly, the results of Omole and Takema (2014) in which various strategies were developed and empirically tested showed that physics teacher plays a key role in improving students' attitude and achievement.

2.5 Problem-solving Approach to Teaching

The first attempt to cite problem-solving as a useful teaching approach was made by John Dewey in 1909 in his book "How we think" (UNESCO, 1986). In his view, reflective thinking was the aim of education. It would incite activities with a deliberate and conscious goal which could be planned procedures and possible invention. The five phases of his reflective thinking, heuristicly expressed in instructional term reveal the rudiment of the present conception of problem-solving stages. Literature shows that of various problem-solving models, the five steps model of John Dewey serve as benchmark, because all present models are predicated on this plan with either one or two steps plus or minus the five-step model he enunciated.

However, current emphasis on problem-solving has its roots in Gestalt psychology, although the pioneering work in cognitive science is often considered to have begun in1972 when it received the greatest boost with the emergency of Newell and Simeon's Human problem-solving publication, (Stewart & Alkin, 1982 cited in Raimi, 2002). The appearance of this book served as a guide and stimulus to the more recent work design to learn how novices and experts proceed in attempting to solve well-defined problems in science and particularly physic. The importance of their work has not only been felt in several other areas of science but have served as a breakthrough in providing sufficient baseline information on knowledge (conceptual and procedural) and has led to the revolution of models for instructional purposes in these areas of science (Ikitide, 1994).

Problem-solving has its origin in cognitive psychology and most findings arising from research in problem-solving are based on constructivists or information processing model of learning (Ige, 2001). In spite of the progress made by various researchers in problem-solving areas, there is still need for studies to examine cognitive pathways that connect procedural and declarative knowledge for specific skills, problem types and subject matter domains in science. Results from such researches will form basis for developing dynamic teaching strategies to help learners successfully solve problems.

The definition of problem-solving has generated controversy over the years, it can only be effectively understood if the nature of problems are made explicit. Numerous definitions of the terms 'problem' and 'problem-solving' was documented in the literature, and there has been much disagreement on what constitutes a problem. Some researchers define a problem with respect to the nature of the task involved; of exercises or 'real problems'.Mcmillen (2012) proposed that the difference between the two depends on an individual student's ability and prior knowledge. Others look at the distance between the problem and the solver (gap definition). Thus, these definitions have been suggested;

A problem is bridging the gap between the problem state and a solution state Jackson, in Ige, (1999). A conscious attempt to fill the gap between the given and the goal (Ashmore, 1977). A problem exists when a person perceives a gap between where he/she is and where he/she wants to be but does not know how to cross the gap (Hayes, 1980).

Gagne (1977) views problem- solving as a process by which the learner discovers a combination of previously learned rules which definition he can apply to achieve a solution for a novel problem situation. Gagne's model classifies problem- solving as the highest form of learning in his hierarchy. In discussing problem-solving, he states the more complex form of learning depends upon processes which have been previously acquired in the simpler forms in a hierarchical fashion

Gagne's definition of problem- solving can be illustrated with the following examples:

- **Problem:** Grasshopper dies when kept under water for some time.

The rules to be used to find a solution are: grasshoppers require air for breathing; water contains dissolved air; grasshoppers possess organ to breathe atmospheric air.

- **New Rule:** organs used in breathing atmospheric air are not useful in breathing dissolve in water. Thus, problem- solving involves "thinking out" a new rule, combining the previously learned rules. The above example typifies problem-solving as a process that involves pupils in problem related to practical life of immediate relevance.
- **Problem-solving**, according to Bloom (1956) model, corresponds to application level of thinking in his taxonomy. As described by Bloom, students operate at the application level when they select an abstraction (principle, law or theory) from their learned repertoire and use it to solve problems. This description of application level learning is similar to Gagne's explanation of problem- solving; whereby Bloom's abstraction corresponds to Gagne's higher

application order rule. In both models, there is an emphasis on transfer of higher order rule learning to new and different situations rather than repetition and drill using closely related problems.

Smith (1991) suggested a continuum definition for a problem, which embraces all tasks that fall along the continuum exercise, to 'real' problems, from simple to complex and from familiar to unfamiliar. Based on this line of thought, Smith (1991) defines problem as ;

> *A task that requires analysis and reasoning towards a goal(solution); must be based on an understanding of the domain from which the task is drawn; cannot be solve by recall, recognition, reproduction or application of an algorithm alone and is not determined by how difficult or by how perplex the task is for the intended solver algorithm*

The process of problem-solving can be viewed in this context, as ''the process by which a system generates an acceptable solution to such a problem. Based on various definitions and viewpoints of problems certain facts emerged from literature about the nature of problems according to Smith (1991). These fact are:

- The solution of a problem must require more than simple recognition or recall
- Problem cannot be solved algorithmically with little or no understanding of what has been done or why it is correct. Landa (1972) cited, in Ige (1999) define algorithms as "completely determined readymade prescription on how to act". It could be concluded that algorithms are part of the procedural repertoire of a skill problem solve, while the ability to select an appropriate algorithm and modify it for use in solving unique problem is an essential ingredient of the problem –solving process.
- The ability to understand and apply underlying science concepts is crucial to the solution of any type of problem (Niaz, 1995; Orimigunje, 2008).

The crux of a problem definition issue lies in what the goal of instruction is perceived to be. Science teachers should aim at helping students become good problem solvers. Therefore, the primary goal of involving students in problem-solving tasks is to foster on them a great depth of understanding of the content area and its relevance to their personal lives. Thus, in biological problem-solving, students have to be trained to solve a variety of ill-defined, non-routine, perplexing, complex and real world problems for which they may not know to do. This will be made possible when students are helped to acquire a good conceptual understanding of content areas, as well as the procedural knowledge they will need to solve problems.

One way of achieving success in any instructional endeavour is to identify those factors that enhance performance and to see how these can be manipulated to maximize learning gains. Many factors have been mentioned in various researches as affecting positively or negatively problem-solving performance. Smith (1991) lists external and internal factors which could enhance problem-solving performance. These are:

External factors affecting problem-solving performance include;

- The nature of the problem in terms of its being from a familiar domain and being presented in a familiar/well understood context.
- Problem structure i.e. semantics, vocabulary, novelty, complexity e.t.c
- Social factors e.g. peer pressure, peer cooperation, teacher and parental expectations.

Internal factors affecting problem-solving performance include;

Internal factors affecting problem-solving performance identified include;

- Affective variables such as self-confidence, perseverance, enjoyment, motivation, beliefs and values.
- Experience: the length of period of successful problem-solving experience can enhance good problem-solving ability.
- Knowledge of domain: specific knowledge include; factual, conceptual/schematic and procedural
- Knowledge of general problem-solving procedures such as means-end analysis, trial and error e.t.c
- Personal characteristics such as solver level of cognitive development, relative field independence and personality.

Any discussion on problem-solving approach would be incomplete without touching on the opposing schools of thought that prevail with regards to problem-solving instructions. One group favours teaching set pattern of solving problems, arguing that student's ability to develop analytically a pattern of support reasoning from simple to complex is the major hurdle in problem. The opposing group discouraged the use of a patterned and mechanical teaching method. They suggest the use of different paths against ways to attack and solve problem, they hold the view that both analytic and intuitive skills are required in problem-solving.

Proponents of the analytic group suggest using problem as a method in every aspect of the curriculum. This means in effect that students must be trained to deal with a wide variety of problems. Apparently, it is rather difficult as well as impracticable to organise the total experimental biology curriculum around problematic situations or problem-to-be-solved themes. It is also unwise to treat all learning as a form problem and start organizing subject matter content on potential learning situations around contrived problems. Teaching problem-solving in a step-by-step fashion may even defeat the primary objective of problem, namely, the development of originality and diversity in student's thinking. More so, it is difficult to visualize one procedure that would help solve a variety of problems. Therefore, in the interest of the learners, it is not a beneficial strategy to use problem as a general method. Besides, such an approach may turn out in the end to be a stereotyped and unattractive procedure.

The researcher is fully aware of the limitations of the problem-solving approach as proposed here, its numerous advantages and benefits notwithstanding, and has therefore selected a most fitting area of experimental biology that would meet the needs and complexity of the problem-solving approach. As earlier stated, no single teaching approach is sufficient for imparting knowledge, in this case, scientific knowledge, and the beauty of the problem-solving approach in doing this lies in its conceptual and procedural integration with resultant skills enhancement.

2.6 Problem-Solving Models in Science

Many studies have been reported dealing with how people solve problems in science education. The commonest approach has been to compare experts with novices to gain an understanding of the process needed to become a good problem solver (Steward and Van Kirt, 1990 quoted by Ishola, 2000 and Ige, 2003). However Smith (1991) holds the view that, though studying the performance of domain experts is a fruitful research tool, it may be necessary to understand the performance of successful problem solvers at a variety of levels. This is important in the light of the findings of Ikitide (1994) that some exceptional novices can successfully solve problems using problem solving techniques very similar to experts, especially when they are giving an adequate introduction to and practice in the domain. Since the goal of problem solving in science is to produce successful problem solver not "expert" in the domain it is important to identify what good/successful problem solvers do that contributes to their success and distinguishes their performance from that of unsuccessful subjects. The idea being that, designing classroom instruction to help students acquire these attributes will lead to increased percentage of successful problem solvers in different science domains.

Studies have shown that student's performance in problem-solving can be improved by explicitly helping students to develop the "expert" approach to problem-solving.

2.6.1. Ashmore, Cassey and Fraser's Problem-solving Models.

This model is a four logical stage for solving chemical problems. It is based on the philosophy that for successful problem solving a problem solver (student) must have a sound conceptual knowledge of the domain, and knowledge of problem-solving strategies and tactics (especially those used in science) and must also have self-confidence. The four stages of the model are:

1. Defining the problem
2. Selection of appropriate information.
3. Combining separate pieces of information.
4. Evaluating

These are indicated in the Figure 2.1

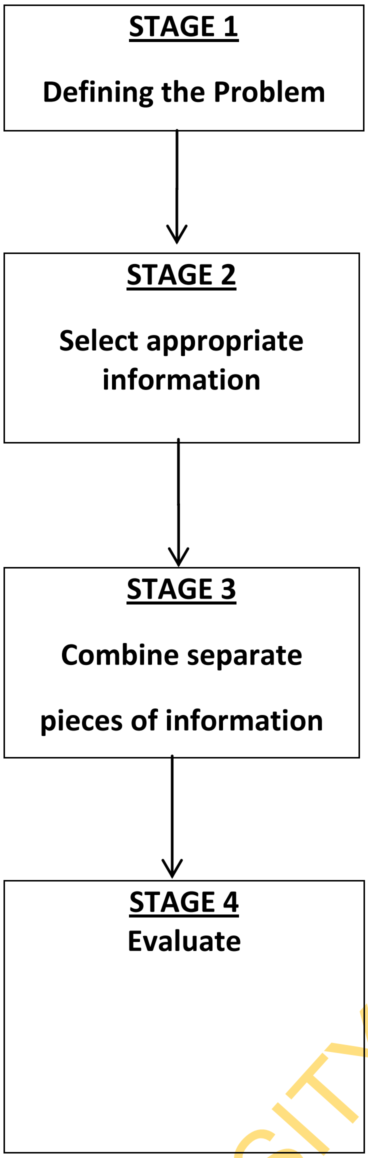


Figure 2.1: Problem solving model of Ashmore et al

Figure 2.1 is Ashmore, Cassey and Fraser's (1979) problem-Solving model. Stage 1 involves knowing the objectives of a given problem. Stage 2 involves selecting relevant information from the problem statement and recall of information from memory. Stage 3 requires problem solver to reason through the problem state to the solution, i.e the problem statement from memory. The last stage is to ensure that the solution of the problem is correct.

This model has been used with success by many researchers in chemical problem-solving. (Onwu and Moreme, 1986 and Ige, 1999). It has the advantage of using network as a means of analysing a students' attempt at problem solving. The demands of stage 2, which involves selection

n of appropriate information from the problem statement and from memory makes this model ideal for the incorporation of other teaching strategies which can help build up students' store of knowledge in memory. Previous research does not record much in models concerned with biological problem solving.

2.6.2 Laboratory Problem Solving Model (LAPSOM)

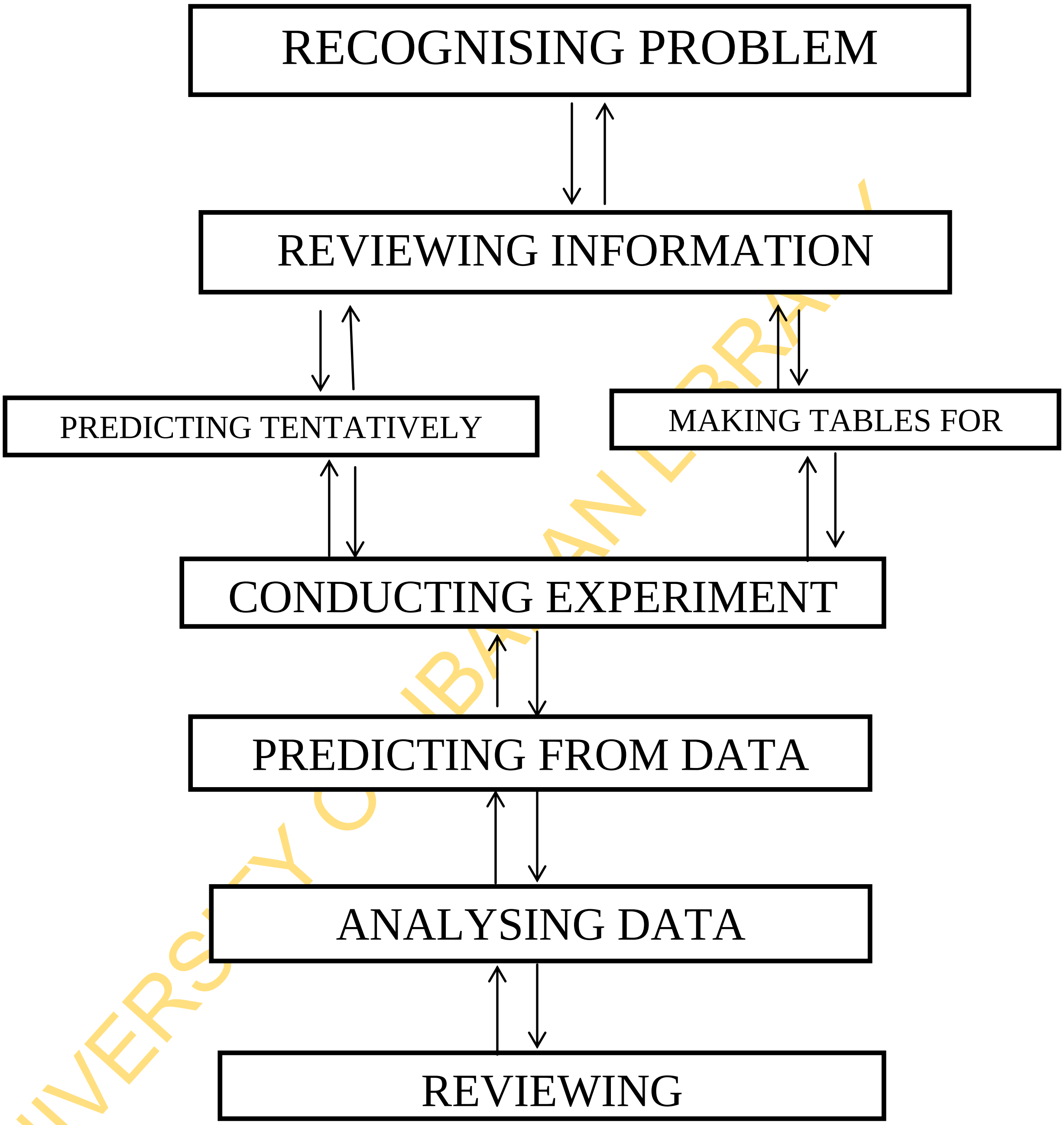


Figure 2.2: Laboratory Problem-Solving Model (LAPSOM)

Figure 2.2 was LAPSOM problem-solving model developed by Onwioduokit (1989) for school physics. The developer discovered that the existing problem solving models in science were principally design for and applied only in theoretical context. His literature search does not reveal any previous attempt to apply existing problem solving models in practical (laboratory) contexts. He undertook the construction of a Laboratory Problem Solving Models (LAPSOM) to facilitate students' development of skills in practical physics. It is in two parts. The first part shows a general strategy of solving practical problems, it specifies the systematic processes for laboratory problem solving. The second part concerns how students are taught to use this systematic approach (Instruction Guide). The first part of LAPSOM consists of five procedural stages which altogether comprises eight action steps (Figure 2.2). The reversible nature of the procedure ensures cognitive and process flexibilities which are required at each stage for arriving at the problem objective. It specifies the systematic processes for laboratory problem solving with the following stages

Stage 1: Recognise the problem and apparatus.

Stage 2(a): Recall Background Information

Stage 2 (b): Make prediction.

Stage 2(c): Drawing up a table for data.

Stage 3(a): Experiment.

Stage 3(b): Make a more reliable prediction from the data.

Stage 4: Analyze the data.

Stage 5: Evaluate solution and experiment.

In cases where solution is not obtained, the steps were reversed.

2.6.3 Gayford's Problem-solving Heuristics.

This involves a nine strategy/approach to problem solving in the biological setting. Each stage indicates questions or actions the problem solver should go through for example, what question if any, do you want to ask, is there anything that you have learnt in school or anywhere else which may help you with this problem. It is also indicates specific actions to be carried out. This approach is very wordy and cumbersome to use. It will also be difficult to assess students' on these numerous steps, thus the authors have summarised the approaches into five stages called "operational divisions" for purposes of assessment. These are:

1. Ability to state the problem
2. Ability to work cooperatively as a team.
3. Reason for choice of approach to solve the problem
4. Ability to modify the design as a result of experience.
5. Ability to evaluate their own success.

This approach is largely amendable to group/cooperative problem solving and can be very useful in ecological problem-solving especially in areas of fieldwork involving habitat relationships.

2.6.4 Stack and Stewart Problem-solving Heuristic

Stack and Stewart (1989) proposed a content independent strategy for solving problems in genetics. This entails the following steps:

1. Setting subgoals
2. Working backward
3. Working forward
4. Redescribing data
5. Generating hypothesis from redescription
6. Considering alternative hypothesis
7. Checking results
8. Consolidating knowledge gains

The advantage of this approach lies in his ability to encourage independent work for students. Students can proceed in the absence of the teacher. Also, the 8th step requires students to assess and take note of what he/she has gained/learned from solving the problem and think of how this can be applied in new situations.

2.6.5 Ikitde Experimental Problem Solving Model (REPSOM)

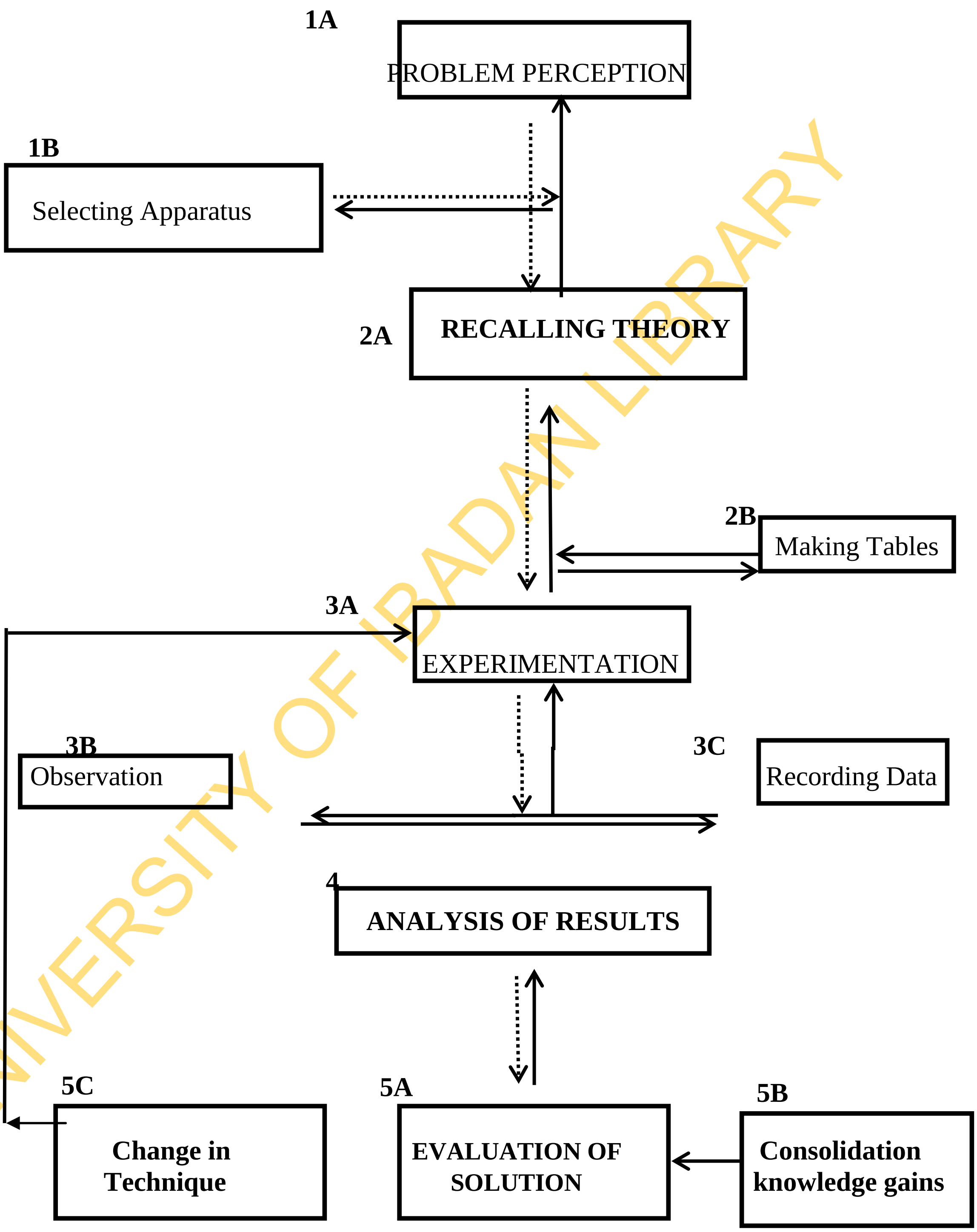


Figure.2.3: Ikitde Researcher's Experimental Problem-Solving Model (REPSOM)

Ikitde (1994) proposed a model for problem solving which fosters experimental proficiency in Biology. This model was made to meet the needs, demands and complexities of individual experimental problem solving in areas of Biology. The stages are indicated below:

1A& B	Problem perception and selecting of apparatus
2A&B	Recalling theory and making tables
3A,B&C	Experimentation, observation and recording of data.
4	Analysis of results
5A,B&C	Evaluation of solution, Consolidating knowledge gains and change in technique

This model further indicates specific action steps which students can be taught to use (Figure 2.3). The advantage of this model is that the stages are sequential, cyclical and hierarchical, thus the degree of success achieved in one stage determines the success achieved in subsequent steps. This makes for cognitive and process flexibility needed during the experiment until a solution is got. This model is adapted for the study. Previous researches do not record much on this model concerned with biological problem solving. This model could be useful in teaching students physiology problem solving.

REPSOM: Structure and General Strategy

The first part of this experimental problem-solving model consists of five procedural stages which are further broken down into eleven action-steps as shown in figure 14 .the beauty of the model is that the stages are not only sequential and cyclical but also hierarchical, in that the degree of success achieved at one stage determines the success achieved at the next and subsequent stages. This in turn ensures cognitive and process flexibilities needed during the experiment until solution is found. For example, errors made in the manipulative phase of an experiment are likely to lead to erroneous observations, which in turn will cause invalid or incomplete conclusions to be drawn.

Considered from the conventional perspective of teaching science, stages 1 and 2 can be referred to as pre laboratory session; stage 3 as the laboratory session and stages 4 and 5 as post laboratory session.

An elaboration of the various stages of the model now follows:

Stage 1A and B: Problem Perception and Selecting Apparatus

A correct identification of a problem should be the start of any worthwhile attempt at finding solution to any problem, a student should therefore read with understanding any practical question posed and be able to state the problem in a clear and unambiguous terms. Without a clear concept of the problem or what the experiment specifically demands, he cannot identify the apparatus/material, let alone imagine how the initial set up is going to be. This is a necessary first step to experimentation.

Stage 2A: Recalling Theory

Practical biology problems, like other basic science subjects, are always content referenced. Any students that is lacking in the theory of a particular experiment is bound to have problems with the interpretations discussion and conclusion of the experiment .therefore ,the information which a student needs for arriving at a solution of the problem are important factors'. The necessary first step here is for the problem – solver to try and recall the theory of the problem to mind as a guide to the next stage.

Stage 2: Making Tables

Being fully equipped with the theoretical background, the problem-solver would have a clear picture of the experiment and experimental process and can even predict tentatively what the result is likely to be if the experiment proceeds favourably .appropriate tables can now be drawn, knowing fully well the nature of results expected.

Stage 3A: Experimentation

The information acquired in stages 1 and 2 now launches the problem-solver into the crucial stage of the problem –solving process: finding out. This is the stage that lends itself to discovering the answer or solution which cannot be determined by merely looking it up in a science textbook. This act of mental and manipulative exercises can lead to discovering of knowledge and evaluating an original design, even if such information is not new to the biology teacher. This is what creativity at this stage means and should be encouraged by setting original and thought provoking problem-solving experiments or exercises.

Stage 3B and C: Observation and Recording Data

Systematic observation is the essential building block of a basic training in experimental biology. The problem solver is always expected to make accurate reporting of any observations made without recourse to theory. To forestall falsification of results, the assessor should always insist on seeing the result of any observation made before being recorded by the problem-solver (student).by so doing, the student will learn the art of trained and accurate use of senses to collect information.

Stage 4: Analysis of Results

Data collection and data analyzing form a continuous process in that the data collected determines the direction of the analysis and the analysis determined the data to be so selected as relevant. This is why this selection requires the problem-solver to explain the results collected by several observations as well as attempt a synthesis of the data accumulated during the investigation.

Such explanations as much as possible, is based on existing knowledge in the area." There is an attempt here to apply biological knowledge and understanding to the results that are obtained in the experimental process, even if they are not quite as expected". For even in failing to obtain results, the students have experienced the experimental process and its problems are in the best position to highlight sources of error and to suggest improvement to the design of the experiment.

Again, it is necessary at times allow students to design and try out experiments to test their own hypothesis, which may prove to be incorrect. "For the students will find it easier to reject his incorrect hypotheses which he proposed as a result of his experimentation and he is not made to feel stupid by being told that his hypotheses is wrong".

Stage 5 A, B &C: Evaluation of Solution, Consolidating Knowledge Gains and Change in Technique.

The problem solver having completed his investigation is asked to look back at his results and suggest new ideas and ways to conduct the investigation . If the result is considered sound, following a proper procedural appraisal, a solution is said to be at hand. When the solution are explained in the context of the real biological world, students can begin to see that biology is about people and society and is not value – free in its application .In fact, it is only by setting the problem in a social context that real meaning could be given to such solutions. This is why life experiment must be used throughout the experiment.

Sometimes, more in depth examination of the sources of error could lead to suggestions on the improvement on the design to yield better results. Also, "occasionally allowing students to go on with faulty design will give them opportunity for improvement, thus learning that experiments do not always have the right answers or think that teachers know the right answer".

In this study Ikitide (1994) was used. The choice based on suitability of the model for solving both practical problems and theoretical Biology problems. The use of problem-solving models in science education is important as they serve as a basis for developing dynamic instructional strategies for training students in successful problem solving behaviours; especially as problem-solving can only be effected by the use of teaching strategies which fully reflect the process and the nature of investigation

2.7 Studies on Problem-solving and Learning Outcomes

Many researches in science have looked into different aspect of problem-solving in science classroom. Such studies include; analysis of problem-solving behavior of learners, cognitive tasks involved in problem-solving and the effects of problem-solving approaches in promoting achievement in science classes. Some of these studies are indicated below.

In an attempt to explain problem solving behaviour, Ishola (2000)) identified source of limitation in problem solving performance as the inability of students to construct meaning from the problem statement or to link their constructed meaning to appropriate aspects of knowledge structures. This could be because of inadequate linkages or because the structures have not been generated in the earlier learning process. Ishola (2000) investigated relative effect of problem-solving strategies, Numerical ability and Gender on physics Achievement, Problem-solving attitude and Reasoning Ability using Egbugara Ibadan city seven steps model. The study adopted pre-test post-test and control design. 211 SS2 physics students from four co-educational selected from Sapele District of Delta state of Nigeria form the sample.

Four instruments were used to collect data. Analysis was done using descriptive statistics and ANCOVA at 0.05 level of significance. The results showed that there was a significant effect of treatment and Numerical ability on the dependent variables (physics achievement, Problem-Solving attitude and reasoning ability). There was significant main effect of gender on Physics achievement and reasoning ability.

The need for teachers to direct their teaching towards helping students develop a conceptual understanding of the underlying concept on which problems are based has been aptly described by Ikitde (1994) as having an important implication for teaching, in that problem-solving could be made more meaningful and students might become more successful if problems were presented in such a way that students could see the relationship between the problems, the phenomena on which the problem is based and the microscopic representation of those phenomena. In a study conducted by Ige (1999) on the relative effectiveness of Concept mapping and Problem-solving teaching strategies used (singly and in combination) on secondary School students' learning outcomes in Ecology. The study involves one hundred and seventy-seven (177) SS 2students from four secondary schools in Ibadan. Four validated instruments were used to collect the data. The data collected were analysed using ANCOVA. The students in treatment groups had higher cognitive achievement than the control group, with problem-solving group recorded highest mean among the three treatment groups. To this study, problem-solving strategy enhanced cognitive achievement than concept mapping even when combined the strategies.

Lee (1996) carried out a study using 279 pre-university students to find out the role of cognitive variables in problem solving performance in chemistry. The cognitive variables examined were, concept relatedness, idea association, problem translation skills, verbal knowledge, intelligence and prior problem-solving experience. Results show a consistent evidence of cognitive variables to problem-solving; problem recognition skills, linkage and prior knowledge were all important variable in solving chemistry problems. Problem translating skill was the most important predictor for solving electrochemistry problems. While the accuracy of translating the statement including the goal of the problem was important for solving all types of problems. This is opined by Ried and Yang (2002). Orji (1998) who has stressed that effective problem solving depends not only on the knowledge base but also on the appropriate solving procedure, which includes the redescription of the original problem in a way facilitating the subsequent search for its solution. This study also recorded that idea association i.e the linkage process that involve eliciting information from the existing cognitive structure was very important in problem solving experience. Prior knowledge was also found to be important in problem solving only if the prior problem has been meaningfully solved.

In another study, Ajueshi (1990) use Bloom's learning for mastering (LFM) model in conjunction with Ashmore et al problem-solving model to facilitate students' Problem-solving skill in chemistry. He involved a total of 119 form four students in a three experimental and one control group design. The result was that mastery of problem-solving heuristic and chemical content has a better facilitative effect in enhancing problem-solving skills than mastery of either problem-solving heuristics or chemical content. Raimi (2002) on chemical problem-solving of school students found that poor problem solvers were able to solve the entire separate step in the problem but did not form an integrated overall strategy that allowed them solve the whole problem. He explained that inability to solve a problem is caused by overload of the short term memory and recommended that students be trained to have an overall plan to solve a problem as this reduces the demand on short term memory. This correlation between problem solving ability and short term memory capacity corroborates earlier findings of Opendacker (1990).

Sule (2000) wrote reports of studies carried out in America on problem-solving attitude and achievement in mathematics revealed that certain elements of behaviour were manifested by the learners in the process of solving mathematical problem. He went further that the ability of individual to solve problem to a large extent depends on the attitude that individual leaner develops towards problem-solving. He also, reported that in Nigeria context the result of a research conducted on problem-solving attitude and students corresponding achievement in mathematics shows little evidence of correlation between students' attitudes and their ability to solve world problems in mathematics. Meanwhile he found that there is a significant relationship between problem solving attitudes of senior secondary school students and their level of achievement in the teacher made test in mathematics. In another way, in the area of arithmetic, Gok and Silay, (2010) used a 5-point strategy to instruct an experimenting group on solving a series of verbal problems. The control group was given the same set of problems but without a strategy. Results show an improved performance for the experimental group over the control group. Also, there was an improved performance on complex word problems over simple ones. Moreover, the low ability students in the experimental group showed an improved performance. This confirms that using systematic problems solving strategy to teach students enhances cognitive achievement.

Gok and Silay (2008), worked on the effect of directive and non-directive problem solving attitude and achievement of students in a developmental science course; the result was that attitude became more positive after instruction. Many researchers believe that if students are allowed to demonstrate higher cognitive abilities through problem solving , either through a teacher centered approach or student-centred approach, their attitude toward physics might be positively affected (Erdemir , 2009).

Watson (1994) carried out a study in which he observed in detail 13 students between ages 12 and 13 as they carried out a practical problem-solving activity in a normal classroom. He found that the strongest factor affecting the quality of education experience of the student was the extent to which they were involved in the problem and were able to see it in a holistic way. This study also exposes the need to relate problem situation to the prior knowledge of students; and state that two vital factors of importance in solving problems are:

- The foundation and presentation of the problem.
- How the learning experiences are structured.

He concludes that the structure of a lesson should explicitly give time for students to think about the problem, to reformulate it, for planning, for interpreting results, and evaluating them.

Berk (2005), in a related study on the effects of instructional methods and cognitive style on student' academic achievement in secondary junior social studies, examine three methods- Advance Organiser (ADO), problem-solving inquiry and Activity Discussion method and found that all the three had significant effects when compared to Expository Lecture Method . Students taught with the first three methods outperformed those taught with Expository Lecture Method.

Some researchers have attempted to shed light on how knowledge acquisition could affect problem solving ability. Cavallo (1996) explored the relationship among school students meaningful learning orientation, reasoning ability acquisition of meaningful understanding of genetics topics and the ability to solve genetic problems. The researcher first obtained measures of students meaningful learning orientation (meaningful or rote); reasoning ability (pre formal and formal) students were tested before and after laboratory based learning of genetics content. Assessment instruments were designed to measure students' interrelated understanding of genetics and their ability to solve problems using punnet square diagrams. Results showed that meaningful learning orientation best predicted student's performance on all except one of the open ended test questions while reasoning ability best predicted their achievement in solving genetics problem.

Lavoie (1993) tried to explain the relationship between student procedural and declarative student associated with the problem solving skill of prediction in Biology classes – his objectives are to:

- Identify and compare student's declarative and procedural knowledge associated with successful and unsuccessful prediction problem in biology.
- Identify sequential behavioural pattern associated with successful and unsuccessful prediction.
- Develop and describe a cognitive network model of the prediction problem solving process.

Results shows that successful prediction problem solving involves an intricate network of relevant declarative knowledge that is manipulated and transformed by appropriate procedural knowledge. He recommends the teaching of prediction as a problem solving skills in science classroom as it has the ability to reveal prior knowledge, to motivate and to establish mental readiness for conceptual change.

The findings reviewed reveal that teaching students models along with content can have a magnifying effect on their performance. Also, it is clearly established that students experimental skills can be greatly enhance through the use of appropriate problem-solving model. This study intends to address the basic experimental skills deficient of Biology students by involving them in appropriate and enriching problem-solving heuristic while conducting experiments in physiology.

2.8 Science Inquiry Strategy

Science educators have actively promoted science inquiry since1960 and continue to do so today (McBride, Bhatti, Hannan and Feinberg, 2004).They belief that science should not be taught to the children but that they should be left to discover it. In spite of this assertion little has changed in the way science is taught in our schools. Teachers talk and textbooks are still primary providers of science information for students (McBride et al, 2004).The US National Science Education Standard (NSES) as well as Nigeria National Policy on Education (NPE) recommended that science instruction and learning should be well grounded in inquiry. Modern science curricula emphasize students' involvement in science activities through discovery experience.

Discovery method involves an unstructured exploration in the laboratory in which students through their mental process such as observing ,measuring, classifying etc. can draw general conclusion from data which they have gathered (Abdulahi, 1982). There are two types of discovery method: guided inquiry and unguided inquiry.

Inquiry method of teaching was defined by Awodi in Akuche (2008) as a process which encourages students to solve problem in a logical and systematic manner, using the process of science. According to him, the process include inquiry skills such as observing, comparing, informing, hypothesizing, experimenting, data collection and interpretation of data. Horwitz cited in Gangoli (1995) defined open ended experiment as a style of teaching involving flexibility of space, students choice of activities, richness of learning materials, integration of curriculum and more of individual or small group activity than large group interaction.

Open-ended, pure discovery approach is defined by Ahmed in Gangoli and Gurunurthu (1995) as approach in which students:

- Do not know the answers at the beginning
- Are acquainted with the relevant apparatus
- Follow the procedure they think best
- Make their own observation and record them in the way they think best
- Interpret explain and generalize the result on their own way.
- Discuss their work with others
- Are provided with some limits on procedure.

For open ended experiments with guidelines (guided inquiry), suitable students sheet, reference book, necessary apparatus and material are given to the students. Some limits are also given to them for possible activities. Abdulahi (1982) stated that guided inquiry instructional mode can be inductive or deductive in nature. It is inductive when the solution to a scientific problem is given and the student is required to discover the general principle on which the solution is based. It is deductive when the general principle is given and the student is required to use the principle to discover the solution to a specific problem. Where neither the general principle nor the solution is given and the student is required to discover both the principle and solution unguided inquiry (pure discovery) is being employed.

Guided inquiry is defined in science education as "using a series of structured sequenced, scientific investigations that integrate appropriate processes and information chosen through research, to fashion meaningful learning experiences for students" (Thier & Daviss, 2002). They stated that those learning experiences are effective when

- Students are engaged at an emotional level by confronting them with problems that have meaning in their own lives ,that is by giving abstract concepts personal meaning
- They capitalize on students' engagement causing them to use the concepts, techniques and information of science to reason their way through a scientific or technological issue.
- Students are helped to master increasingly sophisticated scientific principles, concepts, methods, and information so as to retain the content beyond a final test. Thier and Daviss (2002) stated further that guided inquiry is different from conventional hand on science learning in that after students complete their assigned activities they are encouraged to design their own projects and investigations thereby exploring more into the topics

Further, Thier and Daviss (2002) opined that the principle of guided inquiry is based on two ideas proven by research:

- Students learn better when they experience something by doing it instead of by reading about it on a textbook or learning about it in a lecture. This principle expresses the essence of constructivism

- The level of learning (mastery) that our society and economy increasingly demand from each student is best achieved through engagement.

Studies have shown that true learning takes place only when students engage with information and processes deeply enough to weave that content into their personal views and understanding (Harlen, 2000). Teaching and learning based on guided inquiry are at the centre of the National Science Education Standard (Thier & Daviss, 2002). This calls for:

Table 2.1: Guided Inquiry Based Teaching and Learning

More emphasis on	Less emphasis on
Understanding scientific concepts and developing abilities of inquiry	Knowing scientific facts and information
Learning subject matter disciplines in the context of enquiry, technology and science; of personal and social perspectives; of the history and nature of science.	Studying subject disciplines for their own sake.
Integrating all aspects of science content.	Separating science knowledge and science processes.
Implementing inquiry as instructional strategies abilities, and ideas to be learned.	Implementing inquiry as a set of processes.

National Research Council 1996.

Guided inquiry concept does not slight science facts or processes. It gives equal weight to knowledge and skills. It emphasises learning science in a personal and social context instead of discrete sets of compartmentalised abstractions. Guided inquiry is also beneficial to students with learning disabilities. This is because it does not only make science content relevant to them, it also shows students that language empowers them to find and unlock meanings within ideas for themselves (Their & Daviss, 2002).

2.9 Studies on Guided Inquiry and Learning Outcomes

There are various studies on inquiry instruction. In the research carried out by Gangoli (1995), 92 students in the age 16-17 years in higher secondary school classes were involved. The analysis of the results showed that guided inquiry approach was superior to traditional laboratory approach in developing cognitive abilities (knowledge, comprehension and application) and laboratory skills. No definite conclusion was drawn regarding the superiority of one approach over the other in the development of creative abilities (fluency, flexibility and originality.

Omole and Takema (2014) in their study investigated effect of three innovative strategies (inquiry strategy, cooperative strategy and expository teaching strategy) on students' academic achievement in Nigeria senior secondary school physics. 267 students participated in the study the results showed that inquiry teaching strategy was the most preferable in enhancing students' achievement in physics while the expository was found to be the least effective among all the strategies.

In a research by ndioho and nbina, (2013) examined the effects of guided inquiry learning strategies on senior secondary school students' academic achievement and retention in biology. The study used pretest-posttest control design.. The sample size consisted of one hundred and eighty (180) SS2 biology students selected from three (3) senior secondary schools in the study Port Harcourt city local government area of River state by random sampling technique. Data were obtained through a validated 30 item multiple choice biology achievement tests (BAT). Study findings revealed that mean scores of the students in guided inquiry learning strategy enhances students' academic achievement and retention in biology more than the expository (lecture) method. Also, the posttest achievement means score was higher than retention posttest score. It was therefore concluded that active learning effective instructional strategies capable of stimulating students to and academic achievement and retention in biology.

James and Awodi (1997) in their study considered relative effect of inquiry and lecture methods on the performance of high and low achievers in senior secondary school biology. A total number of 110 first year senior secondary school students (SSI) were used for the study. The results show that inquiry method was better than conventional lecture method in improving the academic performance of the low achievers in biology in senior secondary school.

Also, in the research carried out by Akuche (2008), she considered guided inquiry, guided inquiry demonstration with, demonstration strategies on cognitive, attainment, attitude and performance in practical skills in physics. Conventional method was used as a control. The sample made up of 526 senior secondary school students 2 (SSII) drawn from eight secondary schools in Ibadan. Hypotheses were tested at 0.05 level of significance. The result showed that guided inquiry with demonstration and guided inquiry group were better than demonstration and conventional approaches and they tend to exert greater influence on the psychomotor outcomes of practical physics. Guided inquiry with demonstration however, exerts greater influence on performance of practical skill, than guided inquiry without demonstration.

Mao and Chang (1998) stated in their research findings that inquiry-oriented instructional method produce significantly greater cognitive attainment among ninth grade Earth science students than the conventional approach. Ajeyalemi (2011) also stated that students should be taught investigative techniques and the 'craft' of inquiry. they all concluded that students' participation in teaching and learning leads to more scientific and acceptable understanding of the concept and enhances the level of acquisition of skills.

In spite of all the fuss of teaching sciences as 'inquiry' the regular teachers have remained adamant. The laboratory is still more or less an extension of the theoretical class rather than a place to carry out investigation. The study is therefore important, since continuous emphasis on science inquiry can yield positive result, there is need sensitising teachers to start using it in their classroom.

2.10 Demonstration and Learning Outcomes

Demonstration simply means displaying something. A science teacher can demonstrate the dissection of a toad or rabbit to the students. Manipulation of equipment and materials could be done by the teacher to become familiar with the learning materials for students to observe a scientific phenomenon (Abdullahi, 1982). Science demonstration according to Abdullahi is used as an exhibition lesson or to show the correct use of science equipment. Ogunniyi (1996), sees demonstration as a process of establishing facts and principles. It is a procedure of doing or performing something in the presence of others either as a means of showing them how to do it themselves or illustrate a principle.

Demonstrations are normally done by the teachers, sometimes by the students in small groups or individually. The demonstration method requires the teacher to explain the complex processes that make up the skill in question while the learner watch.

Demonstration method, no matter the 'performer' does not allow individual student to develop manipulative skills. Sight alone cannot provide most of the scientific information needed by the students. Also, less scope is offered in demonstration for students to become familiar with equipment and materials talk less of seeing details of the objects being demonstrated and visibility is usually poor especially when the demonstration is done for the entire class.

Antadoka (2013) carried out a research on effect of demonstration and laboratory methods on students' achievement and retention in SS2 physics. The sample size comprises of forty six (46) SS2 physics student selected from Dekina educational zone in Kogi state of Nigeria. Lecture method was used as a control in the study. The physics achievement test and retention and interest scale physics were used to collect the data. The data was analysed using ANCOVA. The results was that group taught magnetism with laboratory method had highest achievement and retention, the group also showed greatest interest into the subject than those groups taught using demonstration and lecture methods. The lecture method recorded least achievement and interest.

From the foregoing, it is clear that demonstration, apart from illustrating facts and principle, also portrays techniques in the use of materials and specimens as well as create a problem situation that could stimulate students' interest if well-handled. The effectiveness of demonstration is consequences upon how it is used. A demonstration class whereby students are grouped and the teacher moves from group to group to demonstrate the lesson will be more effective than that done in front of the entire class. Engagement is what gives students' laboratory work an advantage over demonstration by the teacher. A demonstration may occur in front of students' eyes without them taking real notice of it. Setting up experiments and recording observations require at least some attention and these are lacking in most demonstration classes. Teacher should therefore, evaluate the efficiency of a method on how well it engages and encourages students in learning before using it.

In the study carried out by Buncick, Belts and Horgan (2001), series of standard demonstrations were presented as examples of activities that can be used to introduce multiple concepts and tie different sections of introductory biology courses together. The project underscores relationship connectivity, engagement and inclusivity and highlighted the role of well designed and implemented demonstration can play in the curriculum reform. Their findings illustrate a use of demonstration to enhance course connectivity. Buncick et al (2001) ascertain that demonstration provides a context for learning concepts strengthens course connectivity and promotes active engagement inclusiveness. Buncick et al (2001), also stated that though road map demonstration may not account for all of the change they observed in classroom dynamics, their observations led them to conclude that because students were invited to hypothesize, speculate, interpret, and apply what was being illustrated to the physical world, road map demonstration must have encouraged a more interactive style among faculty.

However, as advantageous as demonstration may appear to be, especially given the constraints of present day science teaching in the country, it can deprive the pupil of opportunity to become familiar with the learning materials as well as deprived scientific information since not all information can be grasped by sight and sound alone, as odour and texture require close observation and touch respectively. Demonstration can play an important role in enhancing learning outcomes if it is well designed and well implemented. From the study, though, demonstration enhances learning outcomes more than lecture method but it could be recommended that for demonstration to be effective it should not be staged by the teacher at the front of the class where only front row students may be involved; rather, demonstration should be done in groups.

2.11 Practical Skills

Skill simply means the ability to do something well or the competence to perform a task. It is the action or movement performed semi-automatically as a result of repeated practice. Skills are therefore best acquired in the course of activities and mastered with a varying degree of precision depending on the practice done. Ganiyu (2000) argues that the real use of the laboratory is to develop skills, to teach how to work as a scientist and to acquire a feel for the phenomena.

A learning outcome of practical work is to focus on skill acquisition. According to Woodley (2013), skills include activities such as identification, observation, measurement, manipulation, communication, graphing etc. Though some researchers concluded that practical work does little to improve understanding of science (Watson, Prieto and Dillian, 1995), others disagreed with this submission. Oriaifo (2005) opined that laboratory work promotes competence in skills of gathering information and organizing, communicating and interpreting observations but it has little effect on capacity to ask appropriate questions in science.

Ugwu, (2007) proposed five reasons for a science laboratory, namely-skills concepts, cognitive abilities, understanding the nature of science and attitude. The priorities given to the purpose of practical affect how teacher use the laboratory .Some of the purposes can only be achieved in science laboratory while for others laboratory is merely one among several means. Practice in the laboratory should advance skills in fine movements, in precision and care. The laboratory is the only means of acquisition of specific techniques such as learning to handle microscope, read thermometer, read meters accurately, etc.

Isaac (2012) stated that a number of factors are responsible for non-acquisition of skills in science, factors identified by him include teachers lack of professional competence not only in what to teach but how to teach the skills, teachers lack of time for preparing practical lessons as some of them view it as time consuming activity, lack of well-equipped laboratory. Teachers' wrong choice of teaching strategy may affect not only the acquisition of practical skills but also students' cognitive attainment and attitude toward science.

Jeffrey in Akuche (2008) suggested six skills associated with practical work as follows: communicative, observational, investigative, reporting, manipulative and discipline. This assertion was supported by Onwioduokit (1989) where he summarized the various aims and objectives of laboratory physics into two functions:

- To develop creative thinking, curiosity and analytical mind in learners under a problem solving solution
- To enable the inculcation of laboratory skills such as cognitive, manipulative, observational, computational and communicative skills.

One of the possible ways of achieving these aims is to make use of appropriate inquiry approach in the laboratory biology class that students can have a feel of the union between theory and practice thereby learn the processes involved in solving scientific problems.

Bates cited in Kalu (2001) concluded from review of studies involving laboratory works that though lecture, demonstration and laboratory teaching methods appear equally effective in transmitting science content, laboratory experiences are superior for providing students with skills in working with equipment and have a greater potential for nurturing positive students attitudes to science. Fasasi (2003) in his remarks found that laboratory work and field work when used individually and in combination as strategies in the teaching –learning process in Agricultural Science exposed students to necessary knowledge skills and attitude that help them in producing the requisite learning outcomes.

According to Kalu (2001) the aim of Practical work is to train students on how to follow instructions and manipulative apparatus. This is actually erroneous; practical work should develop in the students the skills in manipulation of apparatus. Appropriate laboratory activities should be effective in promoting the development of some inquiry and problem solving skills (Onwioduokit 1989). These activities can assist in the development of skills like identification, manipulation, observation, measurement, understanding scientific concepts, promoting positive attitude and providing opportunities for student success as suggested by various researchers.

Teaching effectively in practical context is not easy, it requires special skills, so there is need to provide adequate training and courses that focus more on the role of practical work in creating opportunities for students to learn science, learn about science and do science (Hodson, 1996; Isaac, 2012). Well-designed scientific investigations are needed for students to realize these goals. For the present study, the skills considered which also serve as dependent variables are: identification, manipulative, measurement and communicative skills.

2.12 Career Aspiration and Learning Outcomes

Aspirations represent a person's orientation towards particular goals (Domenico & Jones, 2007). According to Silvia (2001), career aspirations refer to an individual's career related goals or intentions and also include motivational components which are not present on mere interests. Traditional theories of career development propose that career aspirations develop in stages from childhood to adulthood. According to Ginzberg cited in Adebisi, (2012), young adolescents from 11 to 14 years of age have tentative choices based on interests but with little attention to realistic constraints. By the age of 14 to 24 adolescents are in the exploration stage with progressive narrowing of career options to make final decisions regarding career choices. Gotfredson's theory asserts that at the age of 14, students begin to adjust their career aspirations to factors of personal self and compromise their options to more realistic factors.

According to Gotfredson (2005), by the age of 14 to 24, adolescents are in the exploration stage with progressive narrowing of career options to make final decisions regarding career choices.. Gotfredson (2002) argued that adolescents start to eliminate occupational choices based on sex types and prestige levels. For example, female students might avoid choosing occupations that are perceived as too masculine such as mining and also might consider eliminating choices that are perceived as having low social prestige status such as a career as a house maid. Research shows that girls tend to aspire to a narrower range of occupations than boys because they believe many jobs are unsuitable for them whereas boys have a greater occupational understanding, focus and see more occupational opportunities than girls, and this is applicable to choice of study.

Current researches on occupational aspirations have been conceptualized within theories that more readily recognize the influence of contextual factors. The Social Cognitive theory in Adebisi (2012)for example holds that occupational aspirations are influenced by different socialization practices that adolescents are exposed to as well as adolescents' internalization of these different experiences. It focuses on the interaction between adolescents' cognitive personal variables and the contexts which may limit or encourage personal urgency in career or subject area.

Udoukpong, Bassey, Emah, Ime , Umoren and Shirley (2012) found that there is no significant relationship between students' Business Studies academic achievement and their career aspiration, and schools are in the most strategic positions to impact on career aspirations and expectations. This is mainly due to the existing school based resources such as vocational interest inventories and career seminars. According to Kniveton (2004), schools can provide career information or career guidance directly or indirectly to influence a students' career choice behavior. Schools and teachers can also identify aptitudes, abilities and encourage students to take certain subject combinations or take part in work experience. In a study conducted in Kenya by

Dondo (2006), the results indicate that school culture can influence one's career choice and aspirations since there are standards of performance which are set in each school leading to the choice of certain careers.

2.13 Gender and Learning Outcome

Another important learner characteristic that can influence student's achievement in science generally is gender. Early adolescence age is significant though, neglected period in the life cycle. This period can be broadly characterized as a time for experimentation and re-evaluation, in which dependence adult shifts to interdependence with adults, peers and young children. The onset of puberty during this period marks it as unique in the life cycle as it is accompanied by rapid growth and awakened sexual awareness. Welberg, (1980) cited in Ishola,(2000) ascertained average of two-year lag between the physical development of males and females during early adolescence and even larger individual variations, contribute to the great disparities in the need and capabilities of youth this age range. The main aim of gender equity in essence is that of facilitating equal opportunities in the participation of women and men in scientific and technology fields. For a child to be science inclined, the foundation has to be effectively laid at the basic education (Ekpunobi, 2005). Thus Universal Basic Education Programme with cardinals focused on the provision for free, universal basic education for every Nigerian child of school age is considered as having potential for achieving gender equality. Gender roles have been seen as the pattern of behaviors, attitudes and expectations associated with a particular sex with being either male or female.

Literature showed that sex is a strong prediction of human conduct and that many differences have been documented between the attitudes, behaviours and achievement of males and females. Abdu-Raheem (2010) attested to the fact that gender issues are currently the major focus of discuss and research all over the world, Nigeria inclusive. It has become a matter of national importance among the scholars and intellectuals are worried about pattern of women's role in the political, social, economic, cultural, religious, scientific and technological development of the nation.

There are many researches comparing performance of male and female students that have varied results. In their classic volume on gender differences (Maccoby & Jacklin, 1974) cited in Bakare, (2012) concluded that there are gender differences favouring girls in verbal abilities and performance, favouring boys in mathematics ability and performance (particularly in problem solving rather than computation, during adolescence) as well as spatial ability. In review of gender differences in these areas, Hyde and Linn, (2006) and Abubakar and Uboh, (2010) argued that many of these differences have decrease to the point where they are negligible.

Okeke, Alonge, Gyuse, Jegede, Pwol, Oriaifo, Ajisebutu (1992) carried out an extensive study of gender related issues in science participation and achievement; these scholars view sciences, technology and mathematics as being masculine and called for special privileges to encouraged girls to venture into such field. Supporting this view Olagunju, (2001) opined that there are tend to be more males than females in science related fields. Nda, (2003) indicated that gender stereotypes in science contribute in part to the observed problem of poor achievement in science, technology and mathematics. The report views women in Nigeria as one of the marginalized groups which should be provided with more educational opportunities. It might be for this reason among others that some educational policies that border on admission criteria into Nigeria Federal Government colleges stipulate different cut-off scores for boys and girls (boys' cut-off scores are usually higher than girls

Ariyibi, (2010) revealed that though there are few sex differences in general intelligence or ability, girls tend to outperform boys in reading and verbal skills. Sainz and Ecles, (2011) revealed that achievement in English and total achievement was independent of sex, but boy scored higher than girls in an achievement in mathematics and science.

Singh, (2004) made a survey of the study habits, of high, middle and low achieving adolescents in relation to their sex, intelligence and socio economic status and found that study habits of boys and girls differed significantly at different levels of academic achievement. Sullivan (1995) became interested in finding out instructional strategy that enhanced the development of conceptual understanding in handling quantitative data by boys and girls, so that they may develop their knowledge, structure and thinking processes. The result of the study showed that student-centred, activities oriented presentation help a broad range of subjects to develop their conceptual, understanding and thinking skills. No significant gender differences were found for their conceptual, understanding and thinking skills.

According to Oloyede, (2011) there is need to make changes in women's attitudes, skills and information base. The problems of female under achievement are examined and it was found out that the participation in science education in most cultures is strongly influenced by gender. In the study conducted by Eze, (2007) which investigated the enrolment trend of boys and girls in seventeen subjects, he found out that greater proportion of males enrolled and achieved higher than female counterparts in thirteen subjects. And the female had greater enrolment in the remaining four subjects. The results showed the core science subject of biology, chemistry, physics and mathematics are dominated by the males, both in enrolment and achievement. Shiaki,(2005) in his study on attitude of students towards educational statistic found that the anxiety level of males was marginally lower than the female students in confidence of learning scale, supporting evidence that males tends to be more confident than female.

Adesoji and Fabusuyi, (2001) opined that female students performed better than their male counterparts in theoretical tasks but male students perform significantly better than their female counterparts in tackling biology practical tasks. Taiwo, (2011) in another study found that gender had significant difference on practical skills in physical and Health Education, with the males out performed females. These gender differences in the development of Biology skills and knowledge are believed to emerge as a function of the differences of boys and girls in group settings and under peer influences in the classroom and neighbourhood.

In another dimension, Afuwape and Oladipe, (2008) carried out study in Nigeria on Integrated Science achievement of graduating pre-service teachers for three years, using total number 251 (126 males & 127 females) sample of pre-service teachers in College of Education in Nigeria. The findings of the study revealed that there was no significant difference in academic performance in Integrated science between males and female and that for years, male students had higher mean scores than the female students.

Using gender as the moderator variable, Iroegbu (1998) submits that within the limit of experimental accuracy, gender did not significantly influence the level of science achievement, the acquisition and use of problem solving skills and the line graphing skills.,Ige, (1999) also examine the moderator effect of gender on students' achievement, students' attitude and practical skills in Ecology, using 177 students (98 boys and 79 girls). The results showed no significant effects of students' learning outcomes in Ecology. The results of the study of Alebiosu (1998) conform to the findings of these scholars on the disappearance of gender difference in achievements and interest in science.

The disparities in the concept of gender as it relates to academic achievement will continue to generate debate and be at the front burner of national discussed. Hence the focus of this study on gender as one of the variables of study as far as academic achievement is concerned.

2.14 Conceptual Framework for the Study

Conceptual framework is structured from a set of broad ideas theories that assists a researcher to correctly identify the problem he/she is looking at, enables him/her to frame his/her questions and consult review relevant literature with regard to further study smyth (2004) cited by Durowoju, (2014). It can be regarded as a tool researcher used to guide their investigation. In other words it is a research roadmap. Problem-solving approach, guided inquiry and demonstration methods are the three treatment interventions that were used in this study which are referred to in the conceptual model as the independent variable manipulated by the researcher to see their effectiveness on the dependent variables.

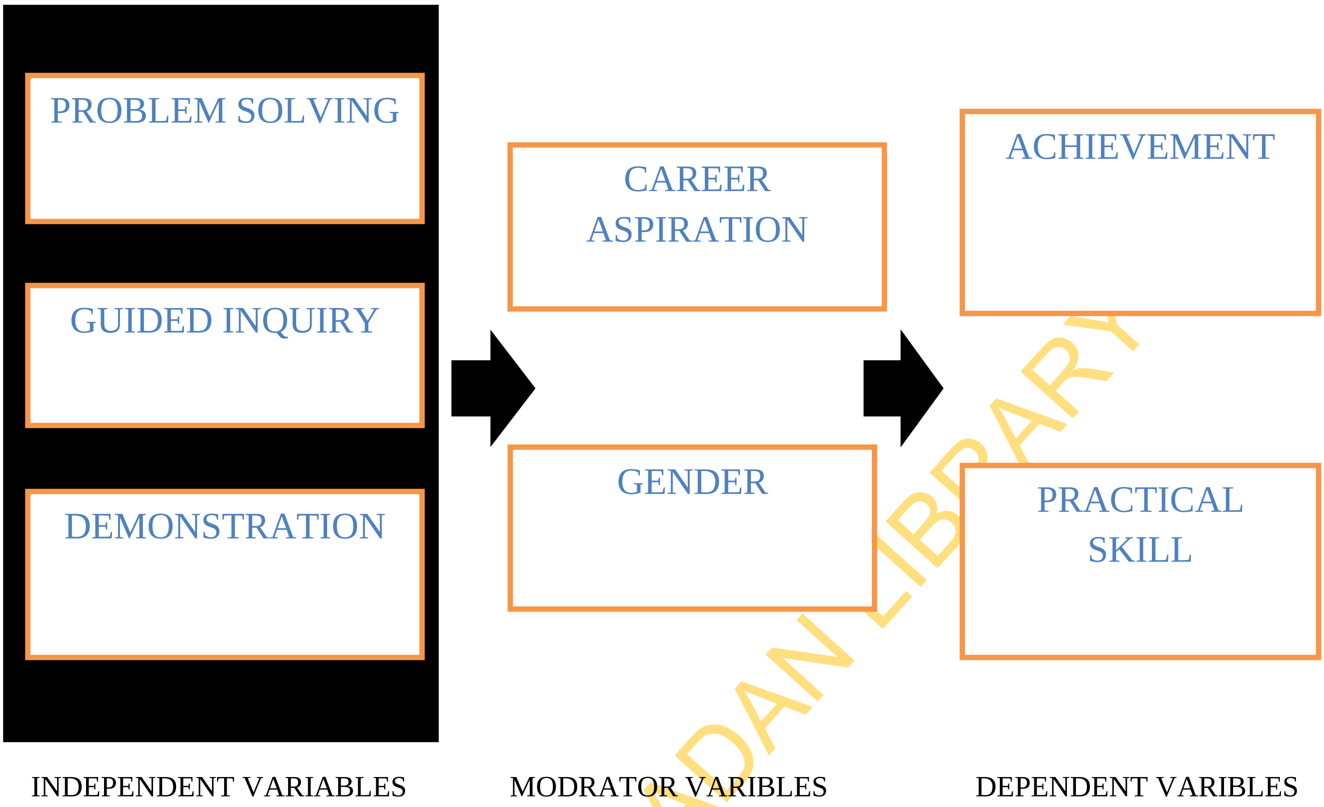


Figure 2.6: Conceptual Framework for the Study

2.15 Appraisal of Literature

Literature has shown that the work of many researchers have been focused on the aims of practical work. Although there are variations in the level of details of the aims, the specification contains common elements of content, procedure and affective aims. Some widely differing activities coexist under the term practical work making the research findings on the efficacy of practical work to be confusing and inconclusive as identified by the scholars. Since there are varieties of the aims of practical work, there is need to ascertain the particular level /objective a particular work is meant to address. Is it meant to address the three learning outcomes-cognitive, effective and psychomotor or one or two of these outcomes? The motive of practical work, to a large extent will help in the choice of teaching strategy to be used, even though investigative practical class has been found to be very effective.

Although, there is no best method of teaching, the effective science teaching strategy should be laboratory centred and activity oriented (Ajeyalemi, 2011). This is lacking in our schools. The traditional lecture method dominates our practical classes making practical work boring and uninteresting (Ganiyu, 2000). Teachers are therefore challenged to discover new ways of motivating and simulating the different abilities and skills in students. This could be achieved in early and regular exposure to practical work using problem solving, guided inquiry strategies.

Literature have shown that by the age of 14 to 24, adolescents (secondary school students) are in the exploration stage with progressive narrowing of career options to make final decisions regarding career choices. Adolescents start to eliminate occupational choices based on sex types and prestige levels. For example, female students might avoid choosing occupations that are perceived as too masculine such as mechanical engineering and also might consider eliminating choices that are perceived as having low social prestige status such as a career as a house maid. Research shows that girls tend to aspire to a narrower range of occupations than boys because they believe many jobs are unsuitable for them. Although, things have changed there is no field of career that female cannot be found now, but they may be few.

The issue of gender bias in science oriented subjects such as Biology has been the concern of many researchers across different domains and it continues to be a problem. Series of studies have investigated the effect of gender on learning outcomes, especially in sciences (Oboh, 2005;Eze, 2007; fasasi, 2013; Taiwo, 2013). There are mixed reports on the research on gender difference in science. In view of these inconclusive findings the research has found it necessary to carry out further research to confirm or annul the protected issue of the gender effect on learning outcomes. Since not much work has been done on problem-solving, guided inquiry, career aspiration and gender in relation to practical Biology, this study is necessary.

Gaps to be Filled

From the literature reviewed it had been discovered that several teacher centred methods had been used to teach secondary school Biology without a significant improvement in students learning outcomes. Science educators have called for a shift of emphasis from the traditional content and factual acquisition of scientific knowledge to those that will actively involve the learner in promoting learning by doing.

Several studies have also been carried out on the desirability of the use of various models of instruction that focus the responsibility of learning on learners but studies effects of problem-solving and guided inquiry on students learning outcomes in biology has hardly been carried out. Though, problem-solving and guided inquiry strategies have been used in science classroom principally for and applied mostly for theoretical contexts, these were mainly in the areas of mathematics, chemistry, physics and engineering, observably, very few actually have been used to teach biology. Problem-solving and guided inquiry had not been widely used in biological sciences. If these models are effective in those other science subjects, would it be effective in teaching Biology practical as well? Hence, the study investigated effects of problem-solving and guided inquiry on students' learning outcomes (achievement and practical skills) in Biology.

In addition, previous studies investigated either or both variables with other moderating variables rather than career aspiration and gender. Hence, the need to examine the effects of problem-solving, guided inquiry, career aspiration and gender so as to give holistic view into effects of these variables on students' learning outcomes in Biology. Therefore, this study investigated the effect of problem-solving approach, guided inquiry on the learning outcome of biology senior secondary school students' Biology in Ibadan. The study also examined moderator effects of students' career aspiration and gender on achievement and practical skill.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The study adopted pre-test, post-test and control groups design.

The research design is illustrated below:

Experimental group 1 $O_1 X_1 O_2$

Experimental group 2 $O_1 X_2 O_2$

Control group $O_1 X_3 O_2$

Where

O_1 – Represents pre-test measurement for each group

O_2 – Represents post-test measurement for each group

X_1 –Represents experimental group one that received Problem-Solving Strategy

X_{2}-- Represents experimental group two that received Guided Inquiry Strategy

X_{3}- Represents experimental group three that received Demonstration Strategy (Control Group).

The study used 3x2x2 factorial matrix which allows for the determination of effect of each independent variable and also opportunity to determine the combined effect of moderating variables on the dependent variable.

Table 3.1 Factora matrix

Treatment	**Gender**	**Career aspiration**	
		Biological science	**Physical Science**
Problem-solving	Male		
	Female		
Guided inquiry	Male		
	Female		
Demonstration (Control)	Male		
	Female		

3.2 Variables of the Study

Independent variables: Instructional strategies at three levels

i. Problem-solving instruction
ii. Guided inquiry instruction
iii. Demonstration instruction

Moderator variables: The following constitute moderator variables controlled for in the study:

i. career aspiration at two levels (i)Biological Science (ii)Physical Science
ii. Gender at two levels (i)Male (ii)female

Dependent variable:

Student learning outcomes which are

i. Achievement in Biology
ii. Practical skill in Biology

3.3 Population

Target population used for the study comprises all senior secondary school two students offering Biology in all public senior secondary schools in Ibadan educational zones.

3.4 Sampling Technique and Sample

Multistage sampling technique was used to select the participants for the study. The public schools in Ibadan were clustered along the two already existing educational zones; first stage, one local government area(LGA) each was randomly selected from the coverage area of two educational zones. In the second stage, purposive sampling was used to select three schools from the chosen LGAS. To be considered for the study, the schools must exhibit the following features:

i. Have laboratory with basic Biology equipment/apparatus that can be used for practical;
ii. Be co-educational; and
iii. Be far from each other in terms of distance to avoid undue interaction among the participants schools covered.

The selected schools were randomly assigned to each of the treatment. In all, six schools were used. Also, an arm of SS2 science was students purposively used (an SS2 intact class). The class was chosen because the class had covered much of the senior secondary school's Biology syllabus. Also, the class is a penultimate class not preparing for any external examination. It will not disrupt academic activities. In all, 240 subjects served as sample 156 and 84 female students. Eighty-six participants participated in problem-solving strategy; 75 students were for guided inquiry while 79 students were in demonstration group. The sampling distribution is shown as follows

Table 3.2 Sampling Distribution

Selected Educational Zone	**Number of Local Government**	**No of local government selected**	**No of public Senior Secondary Schools**	**No of Selected Schools**	**No of Students**
Ibadan Zone 1	5	1	110	3	122
Ibadan Zone 2	6	1	81	3	118
Total	11	2	191	6	240

3.5 Instrumentation

The following instruments were used to gather data for the study. These are

i. Biology Achievement Test (BAT)

ii. Test of Practical Skill in Biology (TPSB)

iii. Occupational Interest Scale (OIS)

iv. Problem-solving Instructional guide (PSIG)

v. Guided inquiry Instructional (GIIG)

vi. (Demonstration) Instructional (DIG)

3.5.1 Biology Achievement Test (BAT)

The biology achievement test consists of sixty-item multiple choice test with four options A to D. The content of the test covered the entire topic taught during the treatment period. This is constructed by the researcher using a test blueprint derived from three topics in SS 2 syllabus. An initial pool of 80 items was evolved from a test blueprint drawn to reflect the objectives of knowledge, comprehension, application, analysis and synthesis. The items along with its table of specification were given to six judges made up of three experienced secondary school Biology teachers and three experts in science education and test construction in the university. They were required to identify the item suitability in terms of clarity of language and problem statement, coverage of course content and suitability for target population (face validity and Content validity). The adjustment of questions and corrections were made, faulted items were removed resulting in 60 items on the tests. The agreement of the judges on the test items to objectives was calculated for retained items using Lawshe's Validity Ratio (CVR).

$$CVR = \frac{n_e - N/2}{N/2}$$

Where n_e = number of judges indicating that the question is essential

N = Total number of the judges. CVR = Content Validity Ratio.

The content validity ratio obtained was 0.75. The objective test generated was trial tested and administering it to a group of SS2 Biology students in a school similar in characteristic to the sample for the study. Item analysis was carried out based on response of the students. The difficulty and discrimination indices of each were computed. The items with difficulty index ranged from 0.35 to 0.6 and discriminating power of between 0.3 and 0.55 were adopted. Thirty items that survived were administered to 40 SS2 Biology students in a school similar in characteristics to the sample for the study. Estimation of internal consistency of the items was computed. Test retest reliability yielded a coefficient of 0.74 after correlating the scores on two administration with a two weeks interval between the tests. using Kuder-Richardson (KR-20). Table 3.3 below shows the final test blueprint for the selected items (see appendix I)

Table 3.3 Test Blueprint for Biology Achievement Test

Topic/Objective	**Knowledge 13.3%**	**Comprehension 23.3%**	**Application 16.7%**	**Analysis 33.3%**	**Synthesis 13.3%**	**Total**
Nutrition 30%	2 (7,18)		1 (25)	2(15,17)	4 (16, 20, 22, 23)	**9**
Physical process 33%		2 (19,27)	4 (4,13,14,2)	4(3,6, 11, 12)		**10**
Tissue and supporting system 36.7%	1(5, 10)	5 (8, 9, 1, 28 ,30)		4 (24, 21, 26, 29)		**11**
Total	**4**	**7**	**5**	**10**	**4**	**30**

3.5.2 Test of Practical Skill in Biology (TPSB)

This instrument was designed to measure students' practical skill in Biology. It is a modified form of a standardised test of skills associated with laboratory work (Lazarowitz & Tamir, 1994). The instrument was patterned along Lazarowitz & Tamir (1994) and Baiyelo (2000) eight dimensions of categorisation of skills. These process skills are:

1. Cognitive
2. Observation.
3. Self-reliance. (interference).
4. Communication (drawing, labelling and reporting).
5. Manipulation.
6. Classification.
7. Reasoning
8. Orderliness and work habit

These eight dimensions of skills are further subdivided into five viz: planning and design, planning and design of experiments; manipulative skills; identification and observation skills observation and recording of data; communication skills (interpretation f data) and independence and ethic work (responsibility, initiative and work habit). Assessment of practical was done in two phases.

The items covered the following content areas; nutrition, physical process and tissue as well as supporting system.

1. Assessment using answer to written practical test. Marking scheme for evaluating the answer was done.

The items were drawn following content areas of nutrition, physical process and tissue as well as supporting system. The items consist of three practical questions in form of WAEC practical questions constructed by the researcher using a test blueprint and the items were three with sub-questions, derived from three topics in SS 2 syllabus. The cognitive domains measured were knowledge, application analysis and synthesis. Content validity was determined using Lawshe's validity ratio (CVR). Biology teachers and experts in science education were used for this exercise. The formula is given as follows

$$\text{CVR} = \frac{n_e - N/2}{N/2}$$

Where n_e = number of judges indicating that the question is essential

N = Total number of the judges. CVR = Content Validity Ratio.

The essay items generated were trial tested and the difficulty and discrimination indices of the items were determined. Thirty-five respondents were used for this exercise. The items with difficulty indices between 0.35 and 0.6, with discrimination indices of between 0.30 and 0.55 were adopted. Twelve (12) items that survived were finally selected and used. The reliability coefficient was determined using Kuder-Richardson (KR-20) and the reliability coefficient was 0.74. Table 3.3 below shows the final test blueprint for the selected items. Marking scheme was used for evaluating the answer. [Appendix ii (a)].

Table 3.4 Table of Specification for Test of Practical Skills

Topic/Objective	Knowledge 25%	application 41.7%	Analysis 25%	Synthesis 8.3%	Total
Nutrition 25%	1(ii)	1(iii)	1(i)		3
Physical process 33.3%	2(ii)	2(i) (iv)	2(v)	2(iii)	4
Supporting system and tissue 41.7%	3(a)	3(b) (e)	3(d)	3(c)	5
Total	3	5	3	1	12

2. "On the spot" assessment of practical skills. This is the use of a practical skill assessment inventory. In this assessment inventory, the practical skills were grouped into categories with specific performance criteria for each.

These categories include:

(a) Planning and design of experiments.

(b) Manipulative skills.

(c) Observation and recording of data.

(d) Interpretation of data (communication).

(e) Responsibility, initiative and work habit (work and ethics).

This was necessary because research has revealed that the use of written test assessment of practical question is not totally effective as much aspect of practical knowledge, for example manual skills observation of biological material as well as the attitudinal dimension in practical classes may not be assessed (Tamir & Glasman 1974) quoted by Ige (1999). The use of this inventory catered for all areas of practical assessment. The content and construct validity of the instrument was established using Lawshe's Content Validity Ratio (CRV). Based on the comments and suggestions of the experts, the necessary corrections were made. The internal consistency was obtained section by section, and inter-rater reliability was done using Scott's Pie formula.

$$\text{Scott's Pie} = \frac{P_o - P_{eS}}{100 - P_e}$$

Where

$$P_o = 100 - (\%\ \text{difference})$$

$$P_e = \frac{(\%\ \text{Average})^2}{100}$$

The inter rater reliability for each section was done. A value of 0.91 was obtained [see Appendix ii (b)]. Scoring was done using the key. For full exhibition (FE, 2marks, Partial exhibition (PE), 1mark and Non exhibition (NE) attracted zero (0) mark.

3.5.3 Occupational Interest Scale (OIS)

The instrument Occupational Interest Scale (OIS) is a self-reporting instrument adapted form of Motivation for Vocational Interest Scale developed by Bakare (1977). The instrument has been used for various studies. It was used to place students in the profession they intend to be in future. It consists of two sections; A and B. Section A contains items soliciting demographic information of the respondents while Section B originally consists of 45 Likert-type scale with four options, Very True of Me (VTM), True of Me (TM), Rarely True of Me (RTM) and Not True of Me (NTM). The key for each scale is as follows; Very true of Me = 4, True of Me (TM) = 3, Rarely True of Me (RTM) = 2 and Not True of Me (NTM) = 1.

The instrument was used to elicit information on the type of profession the students are interested in the future and which they intend doing (career aspiration). The items were compilation of different fields of science such as Agriculture, Nursing, Medicine, Engineering, Mathematics and Computer Science. the students were classified into physical and biological sciences, using the classification of Nwala, (1997) and Fasasi, (2014) who classified natural sciences into Physical, Medical, Pharmaceutical and Biological. With the classification, all the groups except the physical sciences required Biology.

The instrument was subjected to face validity and content validity by experts in the field of Science education, Guidance counsellor and experts in test construion in the Institute of Education. Content validity was determined using Lawshe's validity ratio (CVR). The formula is given as follows

$$\text{CVR} = \frac{n_e - N/2}{N/2}$$

n_e = number of judges indicating that the question is essential

N = Total number of the judges. CVR = Content Validity Ratio.

The value 0.84 is obtained. Based on the comments and suggestions of the experts, the necessary corrections were made. The pilot testing was done by administering the item to a sample of SS2 students from public secondary school in Oyo State who did not take part in the study. Twenty-four items were used for the study. The reliability of instrument was determined using Cronbach alpha which yielded a value of 0.78.

3.5.4 Scoring of the instrument

The researcher scored the instrument thus:

BAT: Each correct item response on this instrument was awarded a score of 1, while 0 was awarded for each wrong response. The maximum score was 30, while the minimum score was zero.

TPSB: Marking guide was designed for evaluating the practical skill test that measured the in-depth understanding of the knowledge and skills in Biology. This was done to bring uniformity in marking and reduce the element of subjectivity. A total mark of 60 was allotted to this test. The observational instrument was marked using the key; 2 marks was awarded for FE = full exhibition, 1mark for PE = partial exhibition and 0 mark for NE = non-exhibition. A total mark of 40 was allotted to the stated skill demonstration.

OIS: A score of 4 to 1 were awarded to the statement of very true of me, true of me, rarely true of me and not true of me. An individual score was determined by summing the point values of each statement of biological science and physical science. The maximum score was 48 for each level, while the minimum was 12.

3.5.5 Instructional guide

The focus of this study was to determine the senior secondary students' learning outcomes in Biology using problem-solving and guided inquiry strategies. The researcher prepares a unified instructional plan for the learning strategies. This contains the topic, instructional objectives, instructional materials, implementation of the strategy and evaluation on weekly basis. The instrument also includes steps to be followed in introducing the treatment to the students.

Treatment procedure

Under this section, the same steps are to be followed irrespective of the learning strategy to be adopted and consist of the following four stages. These are:

1. Introduction
2. Presentation of theoretical base
3. Implementation of the strategy
4. Evaluation and consolidating knowledge gain.

It should be noted that step three was the steps that differ in the learning strategy. Adopted problem-solving model and adapted guided inquiry manual (see Appendix v and vi for details).

3.5.5.1 Experimental Group 1

The students in this group was exposed to problem-solving strategy. The Ikitide''s (1994) Researcher Problem-solving model REPSOM was adopted by the researcher and revalidated. The reliability obtained was 0.89. Researcher Problem-solving model used in as a supplementary to the demonstration method. The students remain intact and the facilitators ensure that they used the strategy prescribed. In problem-solving, the student used adapted REPSOM problem-solving model. There were four periods per weeks for Biology lesson. The first and second lessons were adopted explanation of problem-solving methods where the teacher discusses the topic and poses questions to the students and the students discuss the question among themselves. The last two periods (double period) was devoted to practical class where the teacher poses questions, the students discussed among themselves and move to their group and use the model to perform the practical.

Step 1: Introduction

Present the topic, indicate concepts/sub concepts and link the new lesson with previous knowledge

Step 2: Presentation of Theoretical Base

Present information on topic in form of discussions; specifying definitions, description of concepts and general theory or principles governing concepts.

Providing example where it is necessary. Practical will be done under step 3, and posed question in form of a practical problem to be investigated.

Step 3: Strategy Implementation

Based on steps one and two, teacher poses a problem. Teacher introduces students to the steps involves in problem solving as indicated by REPSOM.

Stage 1A : Problem perception:

The teacher poses a problem based on a concept students have been taught for example, photosynthesis, and diffusion in form of question or statement.

Students read the practical problem posed and state the problem of investigation in simple prose or form, think, and write what they want down

1B: Selecting apparatus.

The students examine the apparatus provided to ensure that no fault is detected by way of damages or incomplete parts or wrong fixing.

Visualise how to set up the apparatus.

The teacher instructs the students to make sketch or annotated diagram of the set up or the main component.

Stage 2A: Recalling theory and making tables

The teacher asks students to:

Write down the known general principle or theory necessary for solving the problem.

List possible sources of error or precaution that must be taken in the process of solving the problem. Think through the procedure or technique you want to use and the likelihood of giving you a reliable result. In effect, predict tentatively, where applicable

2B: Making Tables

The students make table for recording or entry expected results.

Stage 3A: Experimentation

The teacher ensures that students perform the practical or experiments, giving them hints. Such as check your experimental set up, begin your experiment calmly and carefully.

Ensure that every reaction is carefully watched, taking notes of unusual changes.

3B: Observation

Note any change in colour or water level or sound

Take precaution to avoid making careless mistakes or spilling any reagents or pushing down a piece of equipment.

3C: Recording Data

Record your observations in the table drawn.

Stage 4: Analysis of results

The students:

Brings out major findings evident from the practical test

The teacher asks students:

Does it seem to conform to existing knowledge?

Do you feel confident to draw any conclusion from the result or does the experiment need to be repeated?

Stage 5A: Evaluation of Solution

Evaluation of the results and method

The teacher assesses the practical work. Asks questions

5B: Consolidating Knowledge Gain

The students:

Put down the errors responsible for inaccurate or faulty results if applicable.

What have you learnt from the experiment which is applicable in everyday life?

Make suggestions on how to improve upon the set up or design.

5C: Change in technique

If the conclusion is not in line with the aim, a complete change in design or technique should be taken, that is, repeat the experiment.

Step 4: Ask questions and initiate class discussion to evaluate the problem solving process in

terms of:

(a) Proper identification of problem.

(b) Information assembled for solution.

(c) Procedure picked for solution.

(d) Reasonability of answer.

- Score each step by assigning marks (using practical inventory assessment)

- Ask oral questions.
- Let students suggest alternative procedure for solving problem.
- List any new knowledge gained

3.5.5.2 Experimental Group 2: Guided Inquiry Strategy Guide

The students in this group were exposed to guided inquiry strategy. The modified GITG was adopted by the researcher from Akuche (2008) Physics Practical Guide.This strategy was used for this group as a supplementary to the demonstration method. The students remain intact and the facilitators ensure that they used the strategy prescribed by the guide. It contains the activities the teacher and students performed that facilitated teaching-learning process. There were four periods per weeks for Biology lesson. The first and second lessons were single period where facilitator discusses the topic and poses questions to the students and the students discuss the questions. The last two periods (double period) was devoted for practical class where the students moved to their groups. The students discussed among themselves. The facilitator was to assist where there is need.

The teacher activities

- Group the students
- Introduce the lesson with revision of theoretical background presented to the students.
- The teacher presents information on topic in form of description or discussion, specifying definitions, descriptions of concepts, general theory or principles governing concepts with examples.
- Based on steps two and three, the teacher guides students in identification of materials.
- Ask relevant questions. Such as which of the following materials can be used to test for (i) reducing sugar (ii) starch (iii) protein?
- Directs students to follow the sequences of performing the practical and taking laboratory precautions, making use of laboratory manual provided.
- The teacher moves round the groups and attend to each group based on their need but regularly directing his/her questions to all the groups.

- Teacher leads discussion and asks questions evaluating work done in terms of procedural hierarchical arrangement, choice of prepositions and completeness of execution.
- Score the processes following scoring systems used during training. Ask oral questions.
- Ask oral questions, list any new knowledge gained.

Students Activities:

- The students answer the questions raised by the teacher.
- Students note key ideas/concepts in notebooks.
- The students answer the questions and show materials by raising the apparatus up.
- The students perform practical activities, record appropriately according to the manual.
- Discuss solutions to the questions raised by the teacher. They ask questions where necessary.
- Answer questions raised by the teacher.

3.5.5.3 Control Group: Instructional Guide.

The instructional guide was prepared by the researcher to show the various steps the teacher followed using the conventional method. The steps are as follows:

- Teacher present information on topic in form of lectures or discussions specifying, definitions, descriptions of concepts, general theory or principles governing concepts.
- The teacher has set of apparatus with which he/she demonstrates the lesson.
- The teacher carries out practical.
- Teacher explains the practical as he/she demonstrates.
- Students listening, watching and write down observations made.
- Further explains theoretical base, given examples.
- Encourage student's discussion.
- Solicit questions and provide answers.
- Ask students questions on the topic.

Asks students to list any new knowledge gained

3.6 Treatment Procedure

The authorities of selected schools were approached for permission to use their schools for research. Each of the six schools selected was assigned to one treatment each. Ten weeks were used in carrying out the research.

Week 1: Training of research assistants and administration of pre-test.

Week 2: Administration of pre-test; occupational interest inventory and biology achievement test and test of practical skill.

Weeks 3 and 4: Administration of treatment- implementation of problem-solving, uided inquiry and demonstration.

Weeks 5 and 6: Administration of treatment- implementation of problem-solving, guided inquiry and demonstration.

Week 7: Administration of treatment- implementation of problem-solving, guided inquiry and demonstration.

Weeks 8 and 9: Administration of post-test; Biology Achievement Test and test of Practical Skills. Two weeks was used to allow thorough and adequate time for assessment of practical skill.

Week 10: data collation and scoring.

3.7 Training of Research Assistants

Eight research assistants who are Biology teachers of the schools selected were trained to assist in carrying out the study. This is because the study requires the involvement of only those who are trained in the field and interested to carry out the rigor of practical, so that they can participate meaningfully and continuously in carrying out the treatment in their various schools. Two research assistants helped in practical assessment.

The research assistants were subjected to micro teaching before the treatments commence in all the schools used for the experiment. Micro-teaching was a process by which the research assistants demonstrated the training they have received to a set of students different from the sample, while the researcher assessed their performance. This was to ensure that the experiment will be carried out properly.

3.8 Method of Data Analysis

Descriptive statistics was used to find the group mean scores and standard deviations. All the hypotheses were tested using Analysis of Covariance (ANCOVA). This was to test for significant differences between group means and to control for the effects of covariates. Sidak post-hoc test and multiple comparisons were also carried out to determine the direction of the mean difference where necessary.

3.9 Methodological Challenges

In terms of data collection, there were instances where students that took pre-test could not turn up for the post-test due to one reason or the other. Such students were regarded as missing cases and their scores discarded.

It was expected that after the research participants must have been exposed to the pre-test measures, they could have developed some form of reactive effect to the dependent variable measure in the post-test. In order to control for this, the keys to the post test measure were rearranged.

There was problem of administration of the instrument initially, especially problem-solving. Students saw it as cumbersome to go through the steps involve in reporting their work. Over time, they were accustomed to it and they enjoyed it because of the interaction and mental activities involved. Again, some reagents and useful materials to be used for the practical were not available or expired in some schools. The researcher made these materials available. The use of analysis of covariance employed was capable of reducing error variances. Also, it was capable of eliminating threats caused by contamination as a result of different conditions interacting.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results of the analysed data. It also covers the discussion on the findings based on the stated hypotheses.

4.1 Testing of Hypothesis

4.1.1 Hypothesis 1(i): There is no significant main effect of treatment on student's achievement in Biology.

To test for stated hypotheses on students' achievement in Biology, an ANCOVA test was run. Table 4.1 shows the composite table for the ANCOVA test.

Table 4.1 (a): Analysis of Covariance of Treatment, Career Aspiration and Gender on Students' Achievement in Biology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2237.623	11	203.420	23.135	.000	.527
Intercept	1029.598	1	1092.598	124.263	.000	.353
Pre-test Achievement	58.416	1	538.416	61.235	.000	.212
Treatment	170.383	2	85.192	9.689	.000**	.078
Career Aspiration	19.215	1	10.215	1.162	.282NS	.005
Gender	12.677	1	12.677	1.442	.231NS	.006
Treatment x Career Aspiration	60.357	2	30.178	3.432	.034*	.029
Treatment x Gender	38.828	2	19.414	2.208	.112NS	.019
Career aspiration x Gender	5.353	1	5.353	.609	.436Ns	.003
Treaztment x Career Aspiration x Gender	37.565	1	37.565	4.272	.040*	.018
Error	2004.710	228				
Total	47444.000	240				
Corrected Total	4242.333	239				

R Squared = .527 (Adjusted R Squared = .505) ** = **Significant at 0.01 *Significant at 0.05 NS =Not significant**

Table 4.1(a) gives a summary of the effect of treatment, career aspiration and gender on student's achievement in Biology. The table indicates that there is significant main effect of treatment on students' achievement in Biology. It shows that after adjustment for the covariate Biology pre-test scores, the F(2.228)=9.689 p <0.05, Partial Eta squared estimation = 0.078. The implication of this is that since p-value (.000) of the f-ratio was significant. The effect size 7.8% of treatment on the post-test scores in Biology is moderate. Based on this the null hypothesis $H_{O1(i)}$ was not supported. The R squared shows that the treatment accounted for52.7% of the variance observed in the post test achievement test in Biology.

Having established that there was a significant mean effect of treatment on students' achievement in Biology, the table 4.1(b) shows the marginal means and standard error. In order to know the direction of differences in the treatment group, multiple comparison of the treatment on the students' achievement in Biology was carried out using Sidak post Hoc analysis as shown in Tables 4.1(b) and 4.1(c).

Table 4.1(b) Estimated Marginal Means and Standard Error: Treatment Groups

Treatment	**Mean**	**Std Error**	**95% confidence interval**	
			Lower bound	**Upper bound**
Problem-solving	12.789	.325	12.148	13.430
Guided Inquiry	15.092	.788	13.540	16.645
Demonstration	11.624	.503	10.634	12.614

Table 4.1(c) shows that the mean post test score of students exposed to guided inquiry strategy had the highest mean scores (($\bar{X}$= 15.09), followed by problem-solving (($\bar{X}$= 12.78) and lastly Demonstration groups (($\bar{X}$= 11.62). This shows that students in Guided Inquiry group achieved more than students in problem-solving and the students in demonstration group did not achieved like the students in the experimental groups.

Table 4.1(c): Post Hoc: Mean Difference Pairwise Comparison of Treatment Groups Achievement in Biology

(I)Treatment	(j)treatment	Mean Difference (I-J)	Std Error	Sig.	95% confidence interval	
					Lower Bound	Upper Bound
Problem-solving	Guided inquiry	-2.303	.853	.022	-4.354	-.252
	Demonstration	1.165	.598	.150	-.275	2.605
Guided Inquiry	Problem-solving	2.303	.853	.022	.252	4.354
	Demonstration	3.468	.935	.001	1.219	5.718
Demonstration	Problem-solving	-1.165	.598	.150	-2.605	.275
	Guided inquiry	-3.468	.935	.001	-5.718	-1.219

Table 4.1(c) shows the post hoc multiple comparisons of treatment groups. The table indicates where the differences among the treatment groups lie. There was a significant mean difference between the achievement of students in problem-solving group and those in guided inquiry. Also, the mean difference between the problem-solving and demonstration group was not significant.

Having established that there was a significant mean effect of the treatment on students' achievement in biology, the table 4.1(c) shows the Estimated Marginal Means and Standard Error.

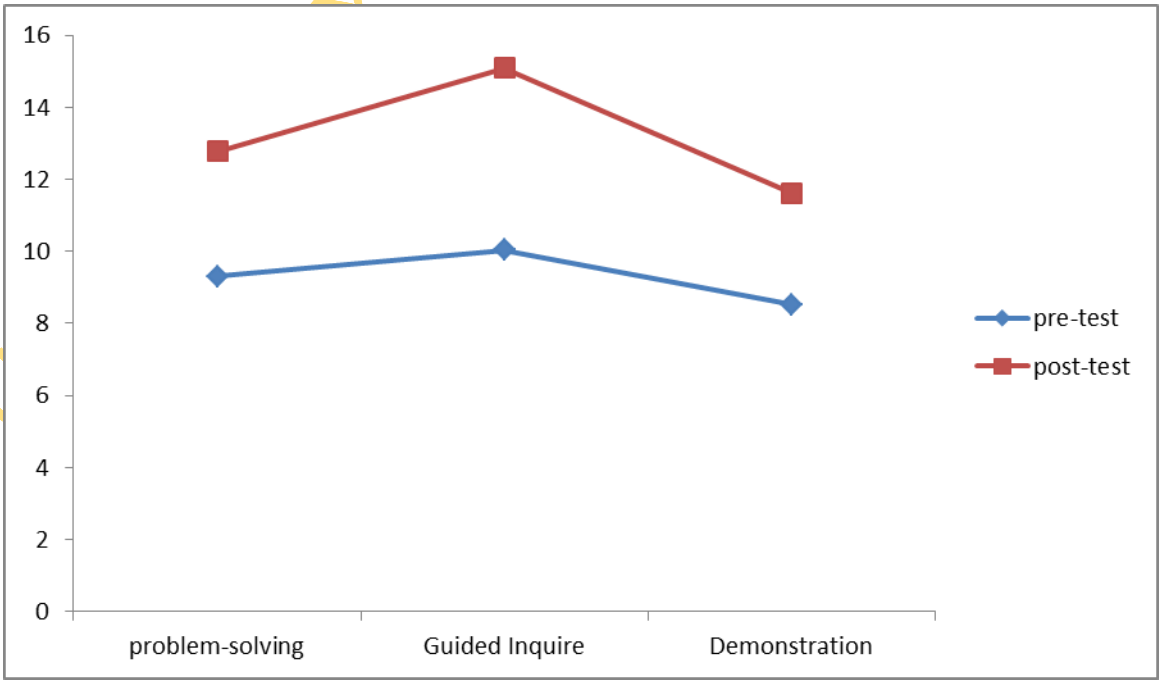


Figure 4.1: Performance of the three Treatment group on Pre-Test and Post-test in Students' Achievement in Biology

Figure 4.1 is a pictorial representation of the difference among the three study groups. The graph is ordinal. Students in Demonstration group had the lowest mean score ($\overline{X}$= 11.62) while students in Guided Inquiry had the highest mean score ($\overline{X}$ = 15.09). This signifies that students Guided Inquiry group achieved most through the treatment subjected them to. Guided Inquiry is the most effective strategy in Biology achievement.

4.2.2 Hypothesis 1(ii): There is no significant main effect of treatment on students' Practical skills in Biology.

Table 4.2(a): Analysis of covariance of Practical Skill in Biology by Treatment, Career Aspiration and Gender.

Source	Type III Sum of Squared	Df	Mean of Square	F	Sig	Partial Eta Squared
Corrected Model	20779.936	11	1889.085	36.070	.000	.635
Intercept	28387.219	1	28387.219	542.022	.000	.704
Pre-test Practical	.272	1	.272	.005	.943	.000
Treatment	6953.552	2	3476.776	66.385	.000**	.368
Career Aspiration	227.215	1	227.215	4.338	.038*	.019
Gender	.051	1	.051	.001	.975NS	.000
Treatment X career Aspiration	181.371	2	90.686	1.732	.179NS	.015
Treatment X gender	106.983	2	53.429	1.021	.362NS	.009
Career Aspiration X Gender	12.999	1	12.999	.248	.619NS	.001
Treatment X Career Aspiration X Gender	4.622	**1**	4.622	.088	.767NS	.000
Error	11940.997	228	52.373			
Total	572702.000	240				
Corrected Total	32720.993	239				

R Squared = .635 (Adjusted R Squared = .617) **** = Significant at 0.01 *Significant at 0.05. NS = Not significant**

Table 4.2 (a) shows the summary result of effects of treatment, career aspiration and gender on students' practical skills in Biology. It is revealed that after adjustment for covariate, there was significant main effect of treatment on students' practical skills in Biology F(2, 228) = 66.385, P<0.05. The Partial Eta Square was .368. The effect size of 36.8% was high. Therefore, the null hypothesis $H_{01\ (ii)}$ was rejected. The R squared was .635. This implies that 63.5% of observed variance in students' practical skills post-test scores was due to the treatment.

Table 4.2(b) Estimated Marginal Means and Standard Error: Treatment Groups

Treatment	Mean	Std Error	95% confidence interval	
			Lower bound	Upper bound
Problem-solving	52.48	.795	50.920	54.052
Guided Inquiry	53.25	1.952	49.405	57.096
Demonstration	33.31	1.232	31.189	36.045

The result in Table 4.2(b) shows the estimated marginal mean and standard error of the treatment groups. The result further unveil that students exposed to guided inquiry strategy performed better than students in problem-solving strategy with mean scores of ($\bar{X}$ = 53.25) and ($\bar{X}$=52.48) but not statistically significant. Similarly, students exposed to problem-solving performed significantly better ($\bar{X}$ = 52.48) than students exposed to demonstration ($\bar{X}$ = 33.31). The findings show that there is significant main effect of treatment on students' practical skills in Biology.

Having established that there was a significant mean effect of the treatment on students' practical skill in biology, the table 4.2 (c) shows the Estimated Marginal Means and Standard Error. To know the direction of differences in the treatment group, multiple comparison of the treatment on the students' practical skills in Biology was carried out using Sidak post Hoc analysis as shown in Tables 4.2 (c).

Table 4.2 (c) Post Hoc: Mean Difference Multiple Comparison of Treatment Groups Practical skills in Biology

(I)Treatment	(J) Treatment	Mean Difference (I-J)	Std Error	Sig	95% confidence interval for Difference	
					Lower Bound	Upper Bound
Problem-solving	Guided Inquiry	-.764	2.113	.978	-5.065	4.319
	Demonstration	18.869	1.463	.000	15.351	22.387
Guided Inquiry	Problem-Solving	.764	2.113	.978	-4.319	5.847
	Demonstration	19.633	2.328	.000	14.033	-25.233
Demonstration	Problem-solving	-18.869	1.463	.000	-22.387	-15.351
	Guided Inquiry	-19.633	2.387	.000	-25.233	-14.033

The result of post hoc multiple comparisons on Table 4.2 (c) shows that there was a significant mean difference between the students' practical skills in all the treatment groups (problem-solving and guided inquiry) and demonstration. The result shows that there was no significant mean difference between problem-solving and guided inquiry. This is further shown pictorially in figure 4.2 (2).

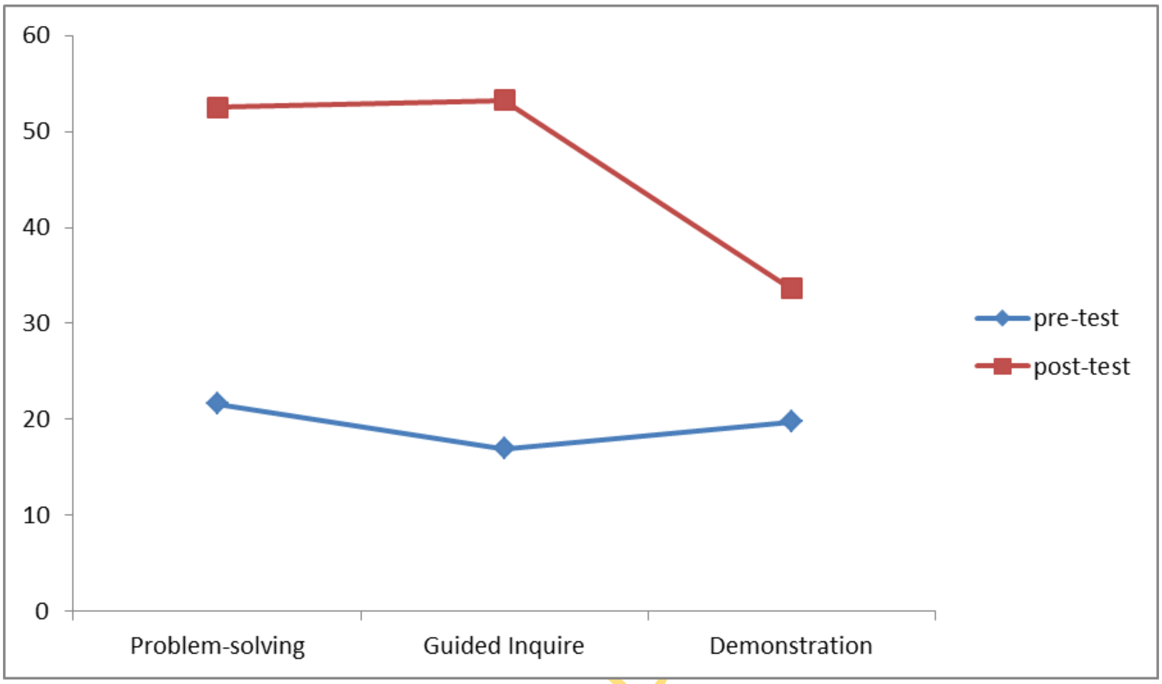


Figure 4.2: Performance of the three Treatment group on Pre-Test and Post-test in Students' Practical Skills in Biology

Figure 4.2 is a pictorial representation of the difference among the three study groups. Students in Demonstration group had the lowest mean score ($\overline{X}$= 33.31) while students in Guided Inquiry had the highest mean score ($\overline{X}$ = 53.25). This signifies that students in guided inquiry group achieved most premised on the treatment they were exposed to. Guided inquiry is the most effective strategy in practical skills in Biology, followed by problem-solving.

4.2.3 Hypothesis 2(i): There is no significant main effect of carrier aspiration on students' achievement in Biology.

Table 4.1(a) shows that the main effect of career aspiration on students' achievement in Biology was not significant $F(1,228) = 1.162$; $P > 0.05$. Therefore, the null hypothesis $H_{O2(i)}$ was not rejected. Although, there was no significant main effect of career aspiration on students' achievement in Biology, there is need to examine the pre-test and post-test scores.

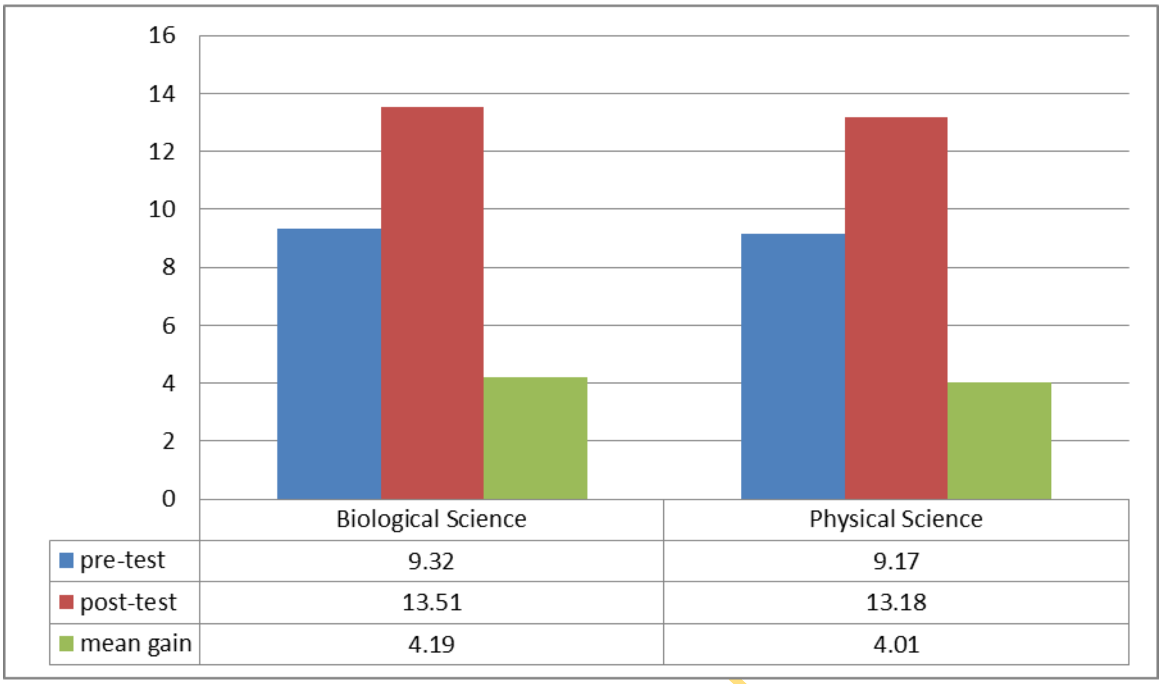


Figure 4.3: Pre-test and post-test Mean scores of Students' Achievement in Biology by Career Aspiration.

Figure 4.3 shows the pre-test and post-test mean scores of students' achievement in relation to students career aspiration .The mean gain score of students in biological sciences group was ($\overline{X}$= 4.19) a little higher than that of physical science, ($\overline{X}$= 4.01) . The mean score of the two levels of career aspiration at post-test were higher than the pre-test scores. The mean of students with biological science aspiration at post-test was higher ($\overline{X}$= 13.51) than that of students with physical science aspiration ($\overline{X}$= 13.18). The margin of increase in the mean gain recorded by students with biological sciences aspiration was higher than the increased recorded by those with physical sciences aspiration which shows that the impact of the treatment was higher and this biological science group had benefited more.

4.2.4 Hypothesis 2(ii): There is no significant main effect of career aspiration on students' practical skills in Biology.

Table 4.2 (a) shows the F-value for career aspiration on student' practical skills is F(1,228) = 4.338 significant at 0.05, P< 0.05. This implies that there was significant main effect of career aspiration on students' practical skills in Biology. The Partial Eta Squared estimated was 0.019. This means that the effect size (1.9%) of career aspiration on students' achievement was low. Career aspiration accounts for 1.9% of the variance observed in the post test scores practical skills in Biology. The post hoc Pairwise comparison test in Table 4.3 shows where the difference lies.

Table 4.3: Pairwise Comparison of level of Career Aspiration on Students' Practical skills in Biology.

(I)Level of career Aspiration	(J)Level of Career Aspiration	Mean Difference (I-J)	Std. error	Sig	95% confidence interval for Difference	
					Lower Bound	**Upper Bound**
Biological science	Physical science	5.698	1.850	.002	2.053	9.343
Physical science	Biological science	-5.698	1.850	.002	-9.343	-2.053

The table 4.3 reveals that there was significant difference between biological and physical sciences. Biological science students had higher mean score ($\overline{X}$ = 48.49) than physical science students ($\overline{X}$ = 42.27) on practical skills in Biology. This implies that biological science students performed better than physical science students premised on the treatment.

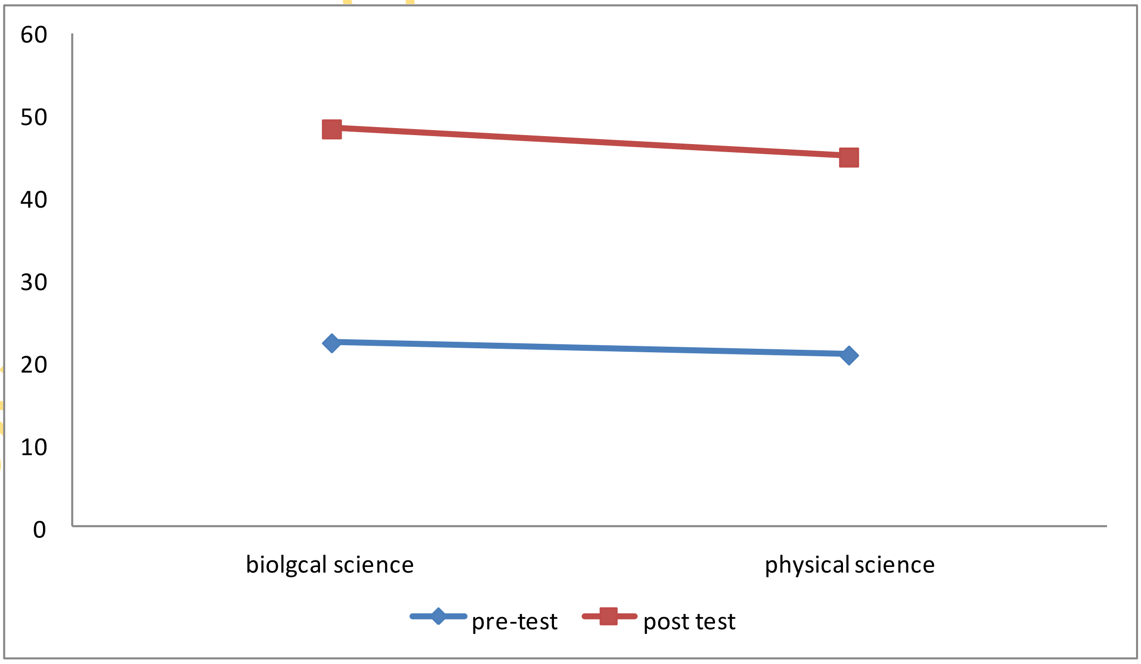
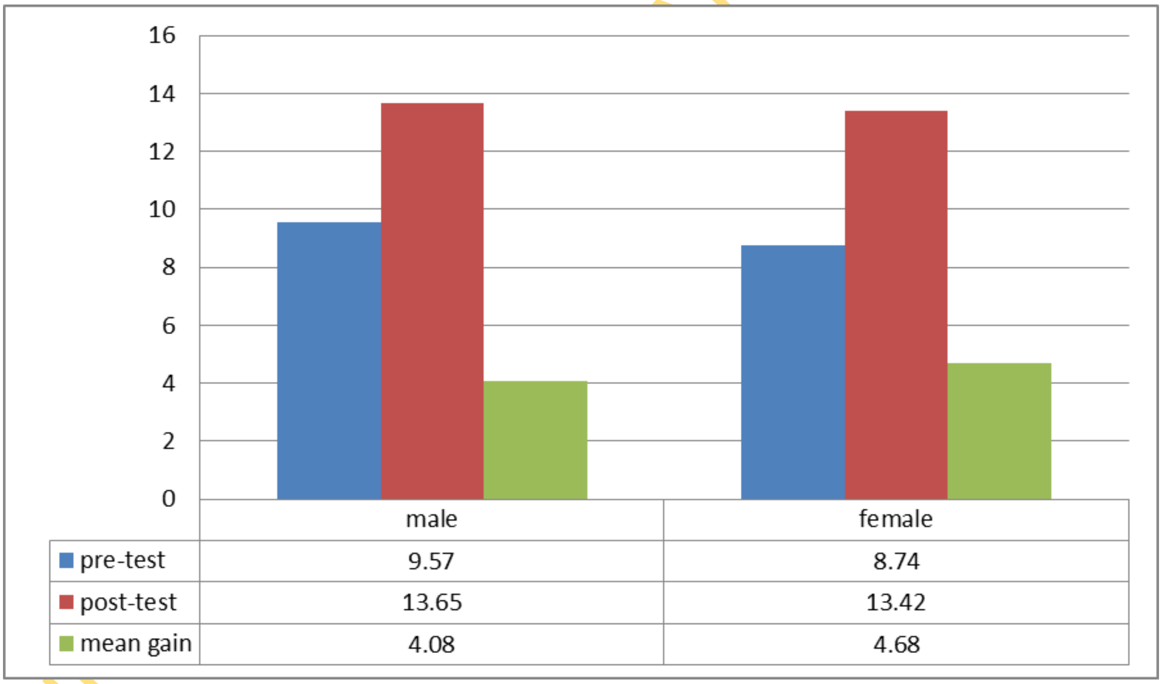


Figure 4.4: Students' Career Aspiration in Practical skills in Biology

Figure 4.4 further reveals that there was significant difference between biological and physical sciences. Biological science students had higher mean score ($\overline{X}$ = 48.49) than physical science students ($\overline{X}$ = 42.27) on practical skills in Biology. This implies that biological science students performed better than physical science students premised on the treatment.

4.2.5 Hypothesis 3(i): There is no significant main effect of gender on students' achievement in Biology.

Table 4.1(a) also shows F-value for students' gender $F(1,228) = 1.442; P>0.05$. There was no significant main effect of gender on students' achievement in Biology. Based on this, the null hypothesis $H_{O3(i)}$ was retained. Although, there was no significant main effect of gender on students' achievement in Biology, Figure 4.5 shows the pre-test and post-test scores of male and female achievement in Biology.



	male	female
pre-test	9.57	8.74
post-test	13.65	13.42
mean gain	4.08	4.68

Figure 4.5: Mean Scores of Students' Achievement in Biology through Gender

Figure 4.5 shows the pre-test and post-test mean scores of students achievement in Biology by gender. The mean gain score of female ($\overline{X}$= 4.68) was higher than those of male students ($\overline{X}$=4.08). The post-test mean scores of male and female students were higher than the pre-test scores. It was also observed that the pre-test mean score ($\overline{X}$=

9.57) and the post-test mean score ($\bar{X}$=13.65) of the male students were higher than those of the female ($\bar{X}$=8.74) and ($\bar{X}$=13.42), respectively but the higher mean gain was recorded by the female students. It shows that the female students benefited more than male students.

4.2.6 Hypothesis 3(ii): There is no significant main effect of gender on students' practical skills in Biology.

Table 4.2(a) also shows that there was no significant main effect of gender on students' practical skill in Biology. The $F(1,228) = 001$, $P>0.05$. The null hypothesis H_{02} was not rejected. There was no significant main effect of gender on students' practical skill in Biology also, Figure 4.6 shows the pre-test, post-test scores and mean gain of male and female practical skills in Biology.

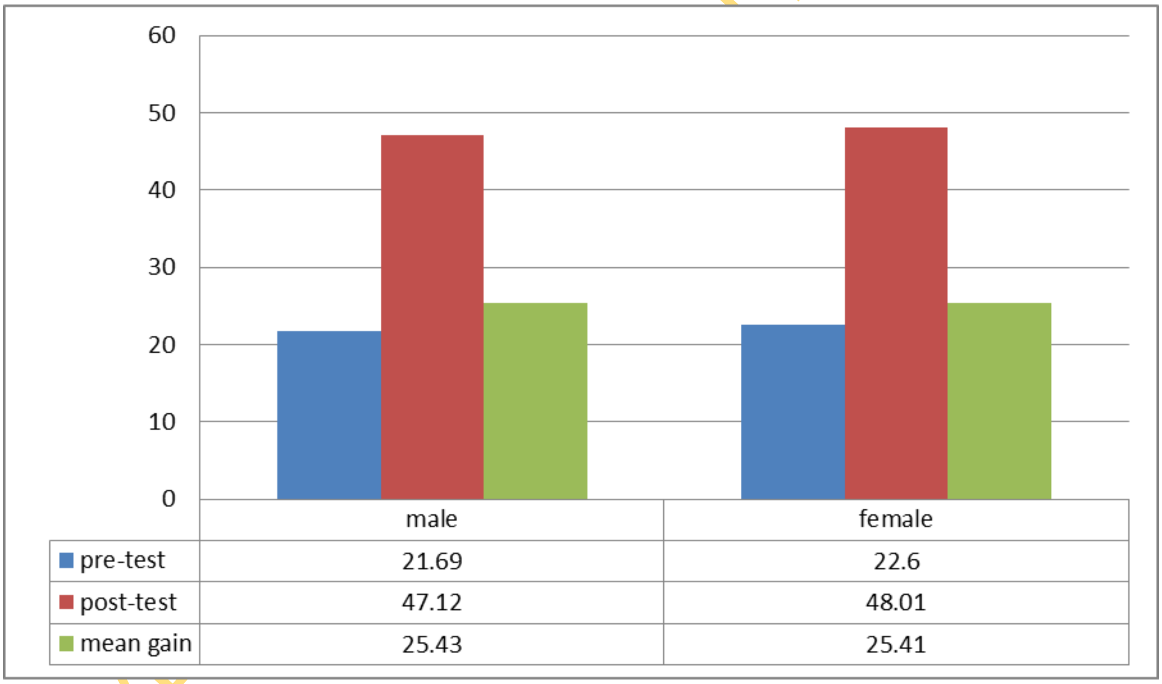


Figure 4.6 Mean Score of Students' Practical Skill in Biology by Gender

The result in fig 4.6 reveals that mean gain of female students ($\bar{X}$=25.41) was higher than that of the male students ($\bar{X}$=25.43). The means scores of the two levels of gender at post-test were higher than pre-test scores. Female students pre-test and post test scores ($\bar{X}$=22.60) and ($\bar{X}$= 48.01) were higher than those of male students ($\bar{X}$=21.69) and 47.12 respectively, but the higher mean gain of female students shows that the impact of treatment on students' practical skill was more than that of the male students.

4.2.7 Hypothesis 4 (i): There is no significant Interaction Effect of Treatment and Career aspiration on Students' Achievement in Biology

The results in table 4.1(a) show that there was interaction effect of treatment and career aspiration on students' achievement in Biology. F-value is F(2, 228)= 3.432, P<0.05. The Partial Eta squared = 0.029. This means that the effect size (2.9%) interaction of treatment and career aspiration on students' achievement was moderate. Therefore, the null hypothesis $H_{O4\ (i)}$ was rejected. This interaction has weakened the effect of treatment

In order to determine which of the experimental treatment group combined with career aspiration to influence students' Achievement in Biology, a graph was used to disentangle individual contribution of treatment and career aspiration on students' achievement in Biology.

Table 4.4: Set of Means Difference: Treatment by Career Aspiration on Students' Achievement in Biology

Treatment	Biological science	Physical science
Problem-solving	12.811	12.745
Guided inquiry	16.762	13.422
Demonstration	10.857	12.391

Table 4.4 shows that biological science students in guided inquiry interaction recorded the highest mean ($\overline{X}$ = 16.76), followed by the physical science in the same guided inquiry interaction ($\overline{X}$ = 13.42), then followed by biological science students in problem-solving interaction ($\overline{X}$= 12.81). This indicates that interaction effect of treatment and career aspiration is highly effective for all students in guided inquiry strategy. The demonstration group means ($\overline{X}$ = 12.39) and ($\overline{X}$= 10.85) were the least for biological science and physical science respectively.

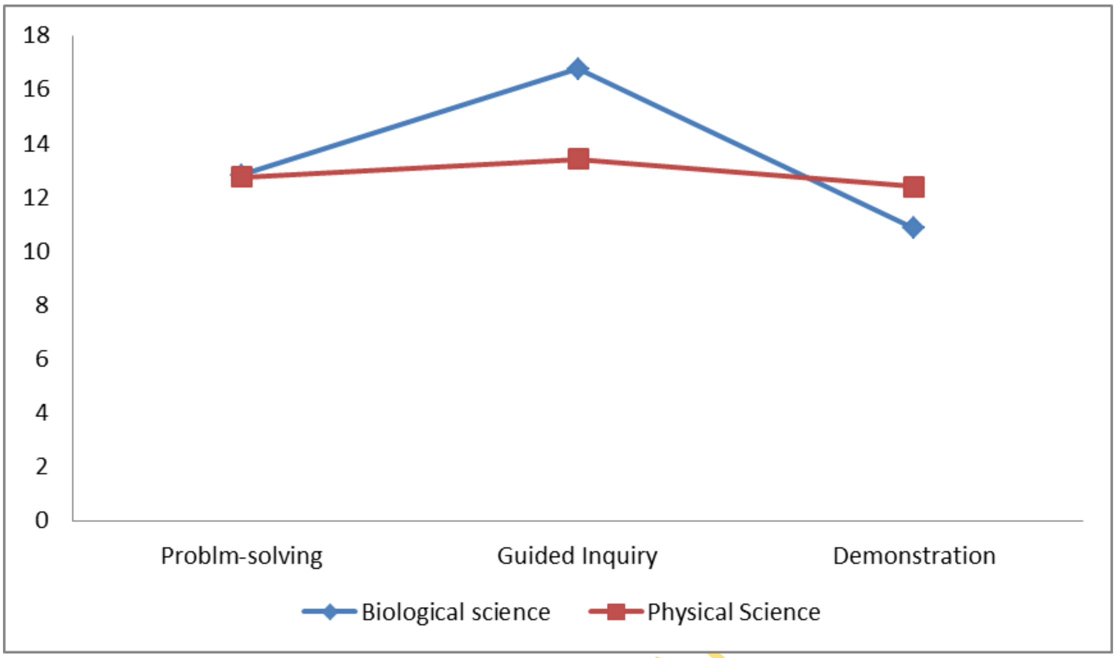


Figure 4.7: Interaction Effect of Treatment and Career Aspiration on Students' Achievement in Biology.

It could be deduced from the figure 4.4 that the interaction effect of treatment and career aspiration on students' achievement post test score tilt towards biological science. The interaction is disordinal. The pictorial representation shows that, for guided inquiry group and problem-solving group interaction, biological science students performed better than students of physical science. Contrarily, the interaction effect of demonstration group shows that physical science students performed better than the biological science students. Guided inquiry interaction has the highest interaction effect ($\bar{X}$ = 16.76), while the demonstration has the least ($\bar{X}$ = 10.85). The graphical representation also shows that there was little variation in the performance interaction of student exposed to problem-solving and demonstration strategies.

4.2.8 Hypothesis 4(ii): There is no significant interaction effect of treatment and career aspiration on students' practical skills in Biology

Table 4.2(a) shows that the $F(2,228) = 1.732$, $P>0.05$. there was no significance interaction effect of treatment and career aspiration on students' Practical skills in Biology. The null hypothesis $H_{O4(ii)}$ was not rejected. The partial Eta squared estimate was .015. The effect size was 1.5%. The partial Eta squared implies that gender accounts for 1.5% of the variance observed in the students' practical skills post test score in Biology. This means that career aspiration did not have effect on the treatment of practical skill in Biology.

4.2.9 Hypothesis 5(i): There is no significant interaction effect of treatment and gender on students' achievement in Biology.

Table 4.1 (a) shows F-value for the interaction effect of treatment and gender F(2,228) = 2.208, which was not significant at 0.05 (P>0.05). This implies that there was no significant interaction effect of treatment and gender on students' achievement in Biology. The partial Eta squared estimate was .019. The effect size is 1.9%. The partial Eta squared implies that gender accounts for 1.9% of the variance observed in the students' achievement post-test score in Biology. The hypothesis $H_{o5(i)}$ was retained. This means that gender does not influence the effect of treatment in achievement in Biology.

Hypothesis 5(ii): There is no significant interaction effect of treatment and gender on students' practical skills in Biology.

Table 4.2(a) shows F-value for the interaction effect of treatment and gender F(2,228) = 2.021, which was not significant at 0.05 (P>0.05). This implies that there was no significant interaction effect of treatment and gender on students' practical skills in Biology. This means that there is no significant interaction effect of treatment and gender on students' practical skills in Biology, hence the hypothesis $Ho_{5(b)}$ was retained. This means that gender did not have influence on the treatment of practical skills in Biology.

4.2.11 Hypothesis 6(i): There is no significant interaction effect of career aspiration and gender on students' achievement in Biology

Table 4.1(a) shows F-value for the interaction effect of treatment and gender F(2,228) = 2.208, which was not significant at 0.05 (P>0.05). This implies that there was no significant interaction effect of treatment and gender on students' achievement in Biology. Therefore, hypothesis $H_{o6(i)}$ was not rejected. This means that gender does not influence the effect of treatment in achievement in Biology.

4.12 Hypothesis 6(ii): There is no significant interaction effect of career aspiration and gender on Students' practical skills in Biology

Table 4.2(a) shows that interaction effect of career aspiration and Gender on students' practical skills is not significant. The result of $F(1,228) = 0.248$, $p>0.05$. The Partial Eta Squared estimation was 0.001. This means that interaction effect of career aspiration and gender accounts for only 0.1% of the observed variance in the post-test scores of students' practical skills in Biology. Hence, the hypothesis was retained.

4.13 Hypothesis 7(i): There is no significant interaction effect of treatment, career aspiration and gender on students' achievement in Biology

Table 4.1 (a) shows that the interaction effect of treatment, career aspiration and gender is significant on students' achievement in Biology. $F(1,228) = 4.272$; $P< 0.05$. Therefore, the null hypothesis $H_{O7(i)}$ was rejected. The Partial Eta Squared estimation was 0.018. This implies that interaction effect of treatment, career aspiration and gender accounts for 1.8% of variance observed in the post test scores of students' achievement in Biology. To explain the pattern of this interaction effect, a graph was plotted (Figure 4.8) from the cell means in Table 4.5; presented below showing the disordinal interaction. The Figure 4.8 was used to disentangle individual contribution of treatment, career aspiration and gender on Biology achievement. The significant main simple effects of career aspiration and gender were analysed by pairwise comparison using Sidak adjustment for multiple comparison.

Table 4.5: Set of Means of treatment by career aspiration by gender

Treatment Gender	Career aspiration	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	**Upper Bound**
Problem-solving	Biological Science	13.195	.496	12.218	14.172
	Male Female	12.427	.618	11.618	13.646
	Physical science	12.745	.572	11.618	13.872
	Male				
	Female				
Guided Inquiry	Biological science	16.857	.564	15.745	17.969
	Male	16.665	.561	15.562	17.773
	Female				
	Physical Science	16.176	.722	14.753	17.599
	Male	10.668	2.966	4.822	16.513
	Female				
Demonstration	Biological science	10.985	.553	9.895	12.076
	Male	10.729	.554	9.637	11.821
	Female				
	physical science	11.317	.700	9.939	12.696
	Male	13.464	1.712	10.091	16.838
	Female				

Table 4.5 shows that the mean ($\bar{X}$ = 16.85) for biological science male students in guided inquiry was the overall best, while demonstration group recorded the least overall mean ($\bar{X}$ =10.66) for biological science female. In problem-solving interaction, biological science male recorded highest mean ($\bar{X}$=13.19) while the biological science female students recorded the least ($\bar{X}$ = 12.42). In the guided inquiry, biological science male students had the highest mean of ($\bar{X}$= 16.85) against the lowest mean ($\bar{X}$=10.66) recorded by biological female students in the same group. The highest mean ($\bar{X}$= 13.46) in the demonstration group was recorded by physical science female students while biological science female students in the same group obtained the least mean ($\bar{X}$ = 10.72). These show that the interaction effects lack definite pattern when viewed from the treatment modes.

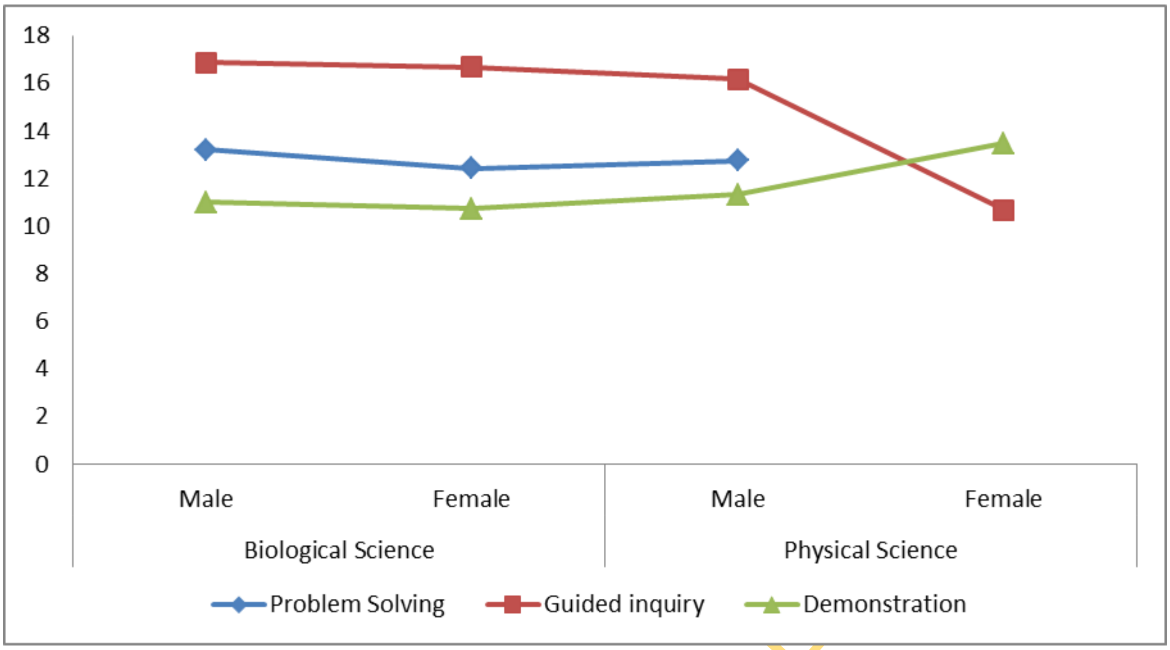


Figure 4.8: Means plot of Interaction of Treatment, Career Aspiration and Gender

The graphical representation in Figure 4.8 shows the interaction effect of treatment, career aspiration and gender on students' achievement in Biology. Biological male students recorded the highest overall mean ($\overline{X}$ = 16.85) under guided inquiry interaction. Again, guided inquiry enhanced performance achievement for biological science female students ($\overline{X}$ = 16.66), though, the scores for male students was higher. Also, the physical science female students recorded the least overall mean ($\overline{X}$ =10.66) under the guided inquiry. Also, in problem-solving strategy group, biological male students had higher mean ($\overline{X}$ = 13.19) than female students ($\overline{X}$ = 12.42) in the same group, while physical science male also, had higher mean ($\overline{X}$ = 12.74) than female ($\overline{X}$ = 12.4) students in biological science. Contrarily, physical science female students had higher mean ($\overline{X}$ = 13.46) than male students ($\overline{X}$ = 11.317). Male and female students in biological science had lowest mean ($\overline{X}$ = 10.98, $\overline{X}$ = 10.72), when demonstration was used as strategy.

Hypothesis 7(ii): There is no significant interaction effect of treatment, career aspiration and gender on students practical in Biology.

Table 4.2(a) shows that the interaction effect of treatment, career aspiration and gender is not significant on students' practical skills in Biology. $F(1,228) = 4.622$; $P > 0.05$. Therefore, the null hypothesis $H_{O7(ii)}$ was retained. The Partial Eta Squared estimation was 0.000. This implies that interaction effect treatment, career aspiration and gender account for 0% of variance observed in the post test scores of students' practical skills in Biology.

4.3 Discussion of findings

4.3.1: Main Effect of Treatment on Students' Achievement and Practical Skills in Biology

The result indicated that there is a significant main effect of treatment on students' achievement in Biology. The main effect of guided inquiry was the highest, followed by problem-solving and demonstration group recorded the least main effect of the treatment. This indicated that guided inquiry and problem-solving were capable of improving students' achievement in Biology better than the demonstration technique.

Guided inquiry and problem-solving techniques improved students' achievement best probably because these strategies encouraged active participation of students in the teaching-learning process than the demonstration strategy. Guided inquiry and problem-solving allowed students search for knowledge on the subject matter of the instruction and shared their experience with other members of the class to enrich their knowledge and consequently improved students' achievement in Biology. If the objectives of a course were to promote long-term retention of information, motivation of students towards active learning and allow students to apply information in a new setting or development of students' critical thinking skill, then inquiry will be preferable to demonstration

Moreover, the post hoc analysis indicated that all the students taught with guided inquiry strategy performed better than problem-solving and demonstration strategies in practical skills. Students who went exposed to guided inquiry and problem-solving achieved higher than those exposed to demonstration strategy. This shows that these students achieved through the innovative strategies (treatment) they were exposed to. This may be as a result of the fact that the students in this group were allowed to be directly involved in teaching learning process, teacher guides the students with little hints and this make the class more interactive (student centred) rather than teacher dominating the affairs of the classroom as the case of demonstration class . Effective teaching of Biology lays a great emphasis on students' participation in the learning process which means that students have to be active rather than being passive recipients of information from the teacher, textbook, or any other source of information involved in the learning contexts. Effective learning outcomes of students Biology can only be achieved through the use of a wide range of innovative teaching and learning strategies like problem-solving and guided inquiry.

The finding of this study supports the views of Onanuga, (2001), Ibe and Nwosu, (2003) who in their separate findings stated that inquiry group of students performed better than those taught with conventional method. Also, the findings of this study corroborate Iroegbu (2000) which favours the reduction of teacher dominance in preference for meaningful learner-centred science learning activities. The result also supports Akuche (2008), Moa and Chang (1998) that inquiry-oriented instructional method produced significantly greater cognitive attainment among earth science students than the conventional approach.

Similarly, the students exposed to problem-solving achieved higher than the students exposed to demonstration technique. This finding corroborates Ishola (2000) and Ige (2001) that the use of problem-solving has a positive impact on students' achievement. The result also supports Madu (2004), Amusa, (2014) that there is a statistically significant difference between problem-based learning and conventional group in terms of their attitude towards chemistry, skill development and conceptual understanding in economics. However, the study of Festus and Ekpete (2012) on students' performance in chemistry shows that students still possess low attitude towards problem-solving in chemistry.

In the same vain, this study corroborates Akinbobola (2008) who opines that best approach to science teaching is by involving students and making sure that they participate wholly rather than just listening to the teacher, while he or she talks and taking notes. He stressed that science teaching had been shifted from the teacher-centred approaches to student centred approaches of learning, such as inquiry, cooperative learning, and problem-solving teaching strategies. Further, this study supports Agommuoh and Ifeanocho (2013) who investigated the effect of Audio and Video CD instructional strategies on environmental control of disease in Biology.

They found that the students in the experimental group showed significantly greater achievement

Findings from this study also concur with Keban and Erol (2011) who explained that learners develop more on their mental cognitive domains of learning when they build on new knowledge obtained from innovative learning strategies. Nwagbo (1999) stressed that if the learner is allowed to discover relationships and methods of solution by self, make his or her own generalisations and draw conclusions from them, himself or herself may plan better to make wider applications of the material learned.

4.3.2: Main Effect of Career Aspiration on Students' Achievement and Practical Skill in Biology.

The result reveals that there was no significant main effect of career aspiration on students' achievement in Biology. This means that the mean of students who preferred biological sciences is not significantly different from the mean of students that preferred physical sciences. This then follows that students were able to achieve regardless of their career aspiration. The result of this study supports Udoukpong, Bassey, Emah, Ime and Umoren & Shirley (2012) who find no significant relationship between students of Business study academic achievement and their career aspiration. The finding contradicts the view of Bluestein (2003) that career exploration has a positive impact on the decision- making process, job searching, placement and occupational placement as well as attainment.

Also, the finding of this study shows that there was significant main effect of career aspiration on students' practical skills in Biology. The hypothesis was rejected. The result attests to the effectiveness of the treatment. The finding is in line with the previous studies of (Traveira, 2002; Blustein, 2003; and Werbel, 2004) who concluded that vocational exploration produces favourable result in terms of career development, mainly when individuals explore significant and useful information in relation to their proximal career development task. Adeyemo and Daodu (2006) were of the opinion that the kind of preparatory steps given to the children at their adolescent period interestingly will influence their choice of career at all stages of life. Also, the finding supports Savieckss (2004) who discovered that high school students exposed to career enhancement treatment performed better than the comparison group for practical related indecision problems. Crooks (2003) asserts that the use of instructional materials is naturally beneficial to the teacher and the students, while they add impact and interest to the presentation for the teacher, they increase students' understanding and retention level. One advantage of this finding is that the career aspiration inventory widens students' knowledge on various available occupation/career existing in the society and beyond.

4.3.3: Main effect of Gender on students' Achievement and Practical skill in Biology.

The findings of this study indicate that there is no significant main effect of gender on students' achievement in Biology. This is an indication that students' achievement in Biology is not determined by their gender. This may be probably because of the fact that the enlightenment campaign that girls were underrepresented in science dominated professions has yielded positive results and there is an improvement on the part of female that they can compete with their male counterparts in any profession. Declaration on education for all noted that quality of education needed to be improved and identified quality as a prerequisite for achieving the fundamental goal of equity.

Problem-solving and guided inquiry strategies used in this study could be considered to serve as healthy motivating impetus for the brilliant students' performance without gender bias. Participants in this study were under good governance with suitable facilities and materials for practice without being aware of the importance of their participation in science.

Further, the research finding also indicated that there was no significant main effect of gender on students' performance in practical skills in Biology. The students were assessed and there is no difference in the post test performance in practical skills of male and female students. The implication of this study is that the treatments were not gender sensitive. The reason for this could likely be the fact that many students irrespective of their gender difference do love to participate in processes that involve activities such as manipulating and communication in order to draw their inference and verifying the theory as a scientist. Given theawareness of new treatment in this study, there is tendency for them to practice what they have learnt in the class irrespective of their gender.

This finding supports the work of Olatoye and Adekoya (2010) which reveals that there was no significant effect of gender on students' achievement in an aspect of agricultural science (pasture and forage crops). This study also corroborates Oladejo, Ojebisi & Ishola, (2011) and Amao (2015) that there was no significant difference between male and female achievement scores in the experimental and control group in Physics, Physical education and Biology. The study contradicts with the earlier studies of (Ezirim, 2006; Okwo & Otubor 2007,) that gender has significant influence on science achievement.

The result is in line with the findings of Ndioho (2007) Ogunleye and Babajide (2011) who found out that there was no significant effect of students' gender on students' practical skills in physics. Also, this study corroborates Igboegwu and Okonkwo (2011) that there is no statistical difference between the mean responses of male and students on their perception of factors influencing their acquisition of science process skills in chemistry practical. On the other hand, the study negates the findings of Omole and Takema (2014) who find a significant difference between the score of male and female in practical Physics. There is assertion that students who find value and meaning in an activity will try harder to succeed and feel more competent (Pajares & Miller,1995). In science (Biology in particular) when the practical activities offered are viewed as gender appropriate and meaningful, expectance for success increase thereby raising students' perception of competence.

4.3.4: Interaction Effect of Treatment and Career Aspiration on Students' Achievement and Practical skills in Biology

The study shows that there was significant interaction effect of treatment and career aspiration on students' achievement in Biology. This implies that treatment did not interact with career aspiration to improve students' achievement in Biology. For guided inquiry interaction, biological science students performed better than those in physical science. This could be that biological science students benefited from the treatment than physical science students. This is because treatment effect did not change at different levels of the career aspiration of biological or physical science. All the categories of students benefited equally from the treatment. In other words, treatment and career aspiration did not mutually produce joint effect on students' practical skill score in Biology. This result negates the students' scores in achievement. This may probably because of some subjects offered in science class involved practical, and students were familiar with rule and etiquette of practical. Apparently they were able to demonstrate the knowledge acquired in the theoretical term.

This support the finding of researches of scholars who also claimed that occupational awareness/training programme could be effective in broadening the occupational outlook as well as improving the vocational maturity of the students (Adeyemo and Daodu, 2006). This is contrary to the interaction effect of demonstration which shows that, physical science students performed better than biological science students. This probably indicates that some students normally assessed to demonstrate their ability, they put in efforts to excel in their academic endeavour. At times, students demonstrate brilliancy in all subjects they offer.

4.3.5: Interaction Effect of Treatment and Gender on students' Achievement and practical skills in Biology

The finding of this study reveals that there was no significant interaction effect of treatment and gender on students' achievement in Biology. This implies that variation observed in students' achievement post test scores was not influenced by the interaction of treatment and gender. The implication of this finding is that treatment when combined with gender contributes far less to students' academic achievement in Biology. With this, it is likely that all learners can perform equally in a given task, irrespective of sex, unlike the general view that males can perform better than females. The result in this study contradicts this general standpoint. Therefore, if Biology instructions are presented in a more relevant and interesting way through appropriate access and thought provoking strategies, male and female students will perform equally.

Further, the result indicated that there was no significant interaction effect of treatment and gender on students' practical skill in Biology. This means that the combination of treatment and gender was not sensitive to students' practical skills in Biology. This is because treatment on students' practical skills did not change at the levels of the gender (male/female). Male and female benefited from the treatment. This finding corroborates Ajaja (2013), Ndioho (2007), Akinsola and Tella (2007), as well as Olatoye and Adekoya (2010) who established that the combination of sex of students and method used for the instruction do not influence achievement in Biology. This means that the degree of achievement earned by students in the various instructional groups may be hinged on the effectiveness of the method.

This finding is not in consonant with Taiwo, 2011; Eze (2007) and Oboh, (2005) who submitted that gender had a significant positive effect on students' achievement in science in favour of male after being exposed to two instructional strategies. Meanwhile, it corroborates that of Nwagbo and Chikelu (2012), Ogundola, Popoola and Oke (2010) who find no significant difference between mean score of male and female students exposed to constructivism instructional approach (concept mapping, cooperative skills and cognitive apprenticeship work) and as revealed by their performance in the post test practical skill test in metal work.

4.3.6: Interaction Effect of Career Aspiration and Gender on Students' Achievement and Practical skills in Biology

As indicated by table 4.1(a) and Table 4.2(a) it shows there is no significant interaction effect of career aspiration and gender on students' achievement and practical skill in Biology. It is an axiomatic in this study that male and female participants have gotten awareness of their uniqueness as persons endowed to explore their world adequately in this age of technological advancement and their aspiration is not deterrent to their functionalities as social elements in the all domains of human life. With this study, the fact remains that females are no longer sitting in the kitchen as a house-wife rather they are compete with their opposite sex in all spheres of life particularly in highly placed respectful profession of science and technology ending.

Things have begun to change in the last century, for instance, women are seen now holding high positions in medicine, engineering and research. These professions were dominated by men in the past. Apparently ignorance is fading away in this age of technological development as both male and female who are ready to learn and forge ahead to achieve the best of time in life including educational pursuits as revealed in this study.

These findings are contrary to earlier speculations that the interaction of career aspiration and gender found to have produced a positive significant relationship on performance. The result corroborates Gottfredson (2005) that adolescent are in exploration stage with progressive narrowing of career options to make final decisions regarding career choices. Abe and Junaid (2012) opine that occupational aspirations are influenced by different socialisation practices that adolescents were exposed to as well as adolescents' internalisation of these different experiences.

4.3.7: Interaction Effect of Treatment, Career aspiration and Gender on students' Achievement and Practical skill.

The result shows that there was significant interaction effect of treatment, career aspiration and gender on student' achievement in Biology. That is, the 3-way interaction was significant. This implies that treatment, career aspiration and gender jointly influenced students' achievement at the different levels of career aspiration and gender. This result when viewed against significant main effect of treatment on students' achievement, tend to suggest that male biological science students are the most highly benefited group for the treatment.

The result shows that there was no significant interaction effect of treatment, career aspiration and gender on students' practical in Biology. This means that treatment, career aspiration and gender did not mutually combined to influence students' practical skills in Biology. Since the treatment employed is independent of career aspiration and gender, it could be rightly stated that guided inquiry and problem-solving can be regarded as good enhancing teaching methods in teaching practical Biology. Earlier studies on problem-solving and guided inquiry found these strategies effective in achieving aim of science. To facilitate students' understanding of important concepts, therefore, the sustenance of students' interest in Biology can be achieved by the adoption of the inquiry and problem-solving strategies.

CHAPTER FIVE

SUMMARY OF THE FINDINGS, CONCLUSION, IMPLICATIONS, RECOMMENDATION AND SUGGESTION FOR FUTHER STUDIES

5.1 Summary

This study examines the effect of problem-solving gu6ided inquiry and demonstration strategies on senior secondary school students learning outcomes (achievement and performance in practical skill) in biology. The major findings of this study are summarised as follow:

1. There was significant main effect of treatment (Problem- solving, Guided inquiry and Demonstration) on students'
   I. Achievement in biology
   II. Performance in practical skills in biology.
2. Students who exposed to guided inquiry had the highest in academic achievement and practical skills performance. This was followed by problem-solving and the demonstration in
3. There was no significant main effect of career aspiration on students' achievement in Biology.
4. There was significant main effect of career aspiration on students' practical skills in Biology
5. There was no significant main effect of gender on students'
   i. Achievement in Biology
   ii. Performance in practical skills in biology.
6. There was no significant interaction effect of Treatment and career aspiration on students' Achievement in Biology.
7. There was significant interaction effect of Treatment and career aspiration on students' performance in practical skill in Biology.
8. There was no significant interaction effect of Treatment and gender on students'
   i. Achievement in Biology.
   ii. Performance in practical skill in Biology.

9. There was no significant interaction effect of career aspiration and gender on students'

    i. Achievement in Biology.

    ii. Performance in practical skill in Biology.

10. There was significant interaction effect of Treatment, career aspiration and gender on students' Achievement in biology

11. There was no significant interaction effect of treatment, career aspiration and gender on students' performance in practical skill in Biology. Male biological science had highest mean score in guided inquiry.

5.2 Implications

The finding of this study has implications on students, curriculum planners, school administrators, policy makers as reported below:

Students

Learning strategies employed by the teachers can facilitate students' understanding of Biology concepts. The various strategies used in the study had significant effect on students' achievement as well as students' performance in practical skills in Biology. The study also revealed that guided inquiry and problem-solving strategies were effective in improving students' future career choice in Biology, which could also be quite effective in improving their confidence judgments of their abilities to attain high academic goals. Student who choose biological science were more likely to challenge themselves in practical task and be intrinsically motivated. These students most likely will put forth an enormous effort to actualise their commitments.

With regard to guided inquiry and problem-solving, students were opportuned to take charge of teaching learning process rather than being passive to discover relationships and methods of solution by self-make his/her own generalisations and draw conclusion from them. He/she may plan better to make wider applications of the material learned. Effective teaching of Biology laid emphasis on students' participation in the learning process which means students have to be active rather than passive recipients of information from the teachers.

The future career choice of students could be enhanced when they are sensitive to career/occupational information and knowledge that will equip them to make appropriate career choice, right subject combination, studying relevant course in tertiary institution. These in turn, will facilitate their achievement in the subject needed for their career choice.

Teachers

This study has shown that specific learning strategies influence learning outcomes of students' achievement and practical skills. It is imperative for Biology teachers to ascertain which specific learning strategy is most suitable for various ability levels, affective and socio-cognitive levels. Biology is an activity/practical-oriented and the teaching should reflect this nature of Biology. Learners achieved more when teachers allowed them manipulate apparatus rather than when they observe or listen, the curriculum is replete with activities which should guide the teacher and soothe delivery of instructions.

Lack of activities during Biology lessons will make it boring and uninteresting to the students. Biology teachers should recognise the impact of strategy on achievement and performance in practical skill as career choice sensitive as revealed from the intervention. If higher order skills of Biology have to be improved, inquiry skills need to be inculcated in the students. It therefore, means that Biology teachers have to emphasis higher order skill during Biology classes. Lack of higher skill will no doubt impede students' proficiency in manipulating, interpretation, drawing inference and making valid judgments.

Curriculum planner

To achieve the aims of science teaching, curriculum planners should endeavour to identify and suggest innovative strategies problem-solving and guided inquiry that will allow learners develop their mental cognitive domains of learning when they build on new knowledge. There is need to change science teachers' education so that guided inquiry and problem-solving strategies could be incorporated. There is need to revise Biology curriculum to give room for practical-oriented topics and activities that will help develop scientific potentials of students.

Further, students' practical skill assessments need to be reviewed, so that observational assessment could be used as part of final assessment in school examination.

Administrator and Policy Makers

Considerable efforts are required by the policy maker and school administrators before success can be achieved using guided inquiry and problem solving strategies. Much understanding is required from the administrator of the school to implement both strategies. There is need to encourage and motivate science teachers and encourage students to stay focused while it is being used. Effective and workable facilities should be provided if teacher is expected to concentrate on these innovative strategies.

There is need for policy maker and administrator to organise career education programme which duration should not be too long to prevent boredom or too short so that some essential points would not be omitted or hastily, so that students would benefit little or nothing from the workshop or seminar so organised .There is need to provide an enabling environment that would promote the use of active instruction, especially in the allocation of appropriate time ,preferably double period on the school time-table. This will give students enough time to interact with needed materials during practical classes

Educational Evaluator

The result of this study reveals low achievement in practical skills in Biology in the use of demonstration method; this type of instruction has been the age long mode of teaching, especially practical's in our secondary schools. This should be a challenge to the educational evaluators, who are expected to undertake and sponsor research in the active instruction suitable for Nigerian schools to improve teacher's efficiency and effectiveness. The most important aspect in this research should be appropriate exposure to workshop and seminars on the use of active instructions for Biology teachers.

5.3 Conclusion

From the study, guided inquiry and problem-solving strategies were effective in improving students' achievement and practical skills. These strategies were learner-centred. They did not encourage rote learning in the course of experimentation, students showed mastery of the skills required to perform practical Biology.

Gender did not generate enough variance to exert main effect in the students' achievement and practical skills in Biology. This shows that these strategies were not gender selective. Guided inquiry strategy is likely to benefit students who preferred biological science discipline than physical science discipline in Biology achievement, while students with physical science discipline are likely to benefit from problem-solving learning strategy with regard to Biology achievement scores. In guided inquiry strategy, male and female biological science students are likely to impact most strongly in Biology achievement scores. Contrarily, female students in physical science are likely to benefit most in Biology achievement score when demonstration strategy was used..

5.4 Recommendation

In view of the findings of this research, it is recommended that:

- Biology teachers should adopt activity-based instructions as supplement to the regular conventional instruction to improve students learning outcomes
- The use of problem-solving and guided inquiry should be encouraged in all senior secondary schools especially in relating Biology concepts/skills to what exist in the environment and giving support to students during teaching/learning process. This will assist students in improving students' achievement and practical skills.
- The Biology curriculum should be revised to make adequate provisions for the use of active instructional strategies especially problem solving and guided inquiry instructions.
- Policy makers are to ensure enabling classroom environment and moderate class size that will make students work together collaboratively. This will encourage student's classroom optimal performance and overall higher learning outcomes.
- Considering the importance of active instructions, policy makers should inspire classroom instructors to develop a positive disposition to its use through organised seminars, workshops, conferences and so on. This will enhance teachers teaching/learning process.

5.5 Suggestion for further studies

This study identified the effect of problem-solving and guided inquiry strategies on students' learning outcomes using nutrition, physical and tissue as well as supporting system aspect of physiology. It is therefore suggested that replica study be carried out on other aspect of the physiology like excretion, respiration and reproduction.

Schools and participants in this study were randomly selected from public schools in Ibadan, it is suggested that replica studies be carried out in the private schools in as much the new teaching methods are to enhance teaching-learning situation. It is suggested also that, this study should be repeated in other geopolitical zones in Nigeria which share a similar educational policy with South-West.

Finally, there may be a need to use a sample of about a thousand or more to give room for some of the variables to show off in terms of generating more variances. Further research with inclusion of all categories of senior secondary school students is needed to understand more of the effect of the intervention on the dependent variables.

5.6 Contribution to knowledge

The following contributions to knowledge were established in this study:

- Problem solving and guided inquiry strategies were effective in bringing about improved students achievement and practical skills. The study made explicit how various instructions can be designed and implemented during teaching/learning process to enhance student achievement and practical skills.
- The study proved that when these strategies are properly used during teaching/learning process it will yield positive result, irrespective of career choice and gender of the students.
- The instructional guides could be adopted by Biology teachers to improve teaching-learning process.
- The practical skills assessment scale can be used to assess cognitive and psychomotor domains of the students.
- The instrument developed and validated on career aspiration can be used by the school guidance counsellor to enlighten the students in chosing their future careers.

- The study is effective in bringing about awareness to students on various career occupations they can aspire to do in their future endeavour.
- The strategies employed have proved that when male and female are equipped with appropriate strategies, coupled with time for learning, their learning outcomes could be improved.

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APPENDIX I

INTERNATIONAL CENTRE FOR EDUCATIONAL EVALUATION

INSTITUTE OF EDUCATION, UNIVERSITY OF IBADAN.

Biology: Achievement Test **Time: 2hrs.**

Instructions: Answer All questions.

Find out the correct option for each question and shade in pencil on your answer sheet which bears the same letter as the option you have chosen. Give only answer to each question.

1. Which of the following statement is NOT TRUE of osmotic process?
   (a) There must be a selective permeable membrane.
   (b) The two solutions must be different initially.
   (c) The two solutions are of equal concentration at the beginning of the experiment.
   (d) It involves only the movement of water molecules.
2. The stems of young herbaceous plants are kept upright mainly by
   (a) Osmotic pressure (b) turgor pressure (c) suction pressure (d) root pressure.
3. The two important physical process involved in the absorption and transport of materials in plant are
   (a) Diffusion and plasmolysis (b) cohesion and diffusion (c) flaccidity and turgidity (d) osmosis and diffusion.
4. The process that leads to the bursting of red blood cell in a hypertonic solution is called
   (a) Heamolysis (b) osmosis (c) plasmolysis (d) turgidity.
5. Carbon dioxide enters the stomata during photosynthesis through the process known as
   (a) Osmosis (b) active transport (c) diffusion (d) movement
6. Root hairs absorb water from the soil by
   (a) Photosynthesis (b) plasmolysis (c) osmosis (d) diffusion
7. A major reason why red blood cells can survive the blood plasma is that
   (a) Blood cell and plasma are hypertonic
   (b) The red blood cell are hypertonic to the blood plasma
   (c) The red blood cells are hypertonic to the plasma
   (d) The red blood cells receives digested nutrient
8. Turgidity in the cell of plant does not lead to bursting of the cell because the
   (a) Cell membrane can resist the turgidity
   (b) Large vacuole contained in the cell can continuously take in water
   (c) The nucleus can resist the turgidity
   (d) Cytoplasm is jelly like and can hold much water
9. The process by which odour of perfume released in a classroom is perceived gradually by every member of the class is called
   (a) Absorption (b) movement (c) plasmolysis (d) diffusion

10. One of the following is the reason why plant should be turgid
   (a) To make the plant stand erect
   (b) All leaves to fall off from plants
   (c) To increase rate of photosynthesis
   (d) To make the plant lie on the ground.
11. Water move up from the root of the plant to other parts by
   (a) Plasmolysis (b) active transport (c) diffusion (d) capillary movement.
12. Mammalian skeleton consist of bone of
   (a) Cartilage and elastic (b) Axial and appendicular skeleton (c) Cuticle and bone (d) skeleton and muscle.
13. The exoskeleton of insect is made up of
   (a) Cartilage (b) chitin (c) hyaline (d) bone.
14. The type of skeleton found in earthworm is known as
   (a) Endoskeleton (b) exoskeleton (c) hydrostatic skeleton (d) muscle skeleton.
15. The type of cartilage found in external ear of mammalia is
   (a) Fibro-cartilage (b) hyaline cartilage (c) bone cartilage (d) elastic cartilage.
16. Study the following group of bones

   (i) Pelvic girdles (ii) vertebra column (iii) ribs (iv) limbs (v) skull (vi) pectoral girdle (vii) sternum.

Use the above information to answer question 17-18.

17. Which of the bones make up appendicular skeleton
   (a) I&IV only (b) I, VII and IV only (c) II, V and VI only (d) I, IV and VI only.
18. The axial skeleton consist of
   (a) II, III, V and VII only (b) II, III, VI and VII only (c) I, II and V only (d) III, IV, V and VI only.
19. Which of the following is not a characteristic feature of atlas bone? There is
   (a) Presence of vertebrarterial canal
   (b) Broad and flat centrum
   (c) Long stout neural spine
   (d) Large, flattened neural spine.
20. Thoracic vertebrae are found in ____________ region of mammal.
   (a) Chest (b) neck (c) abdominal (d) tail
21. Which of the following best describe ball and socket joint
   (a) Joint that allows movement up and down
   (b) Joint that allow movement along all the direction
   (c) Joint that allows movement along only one direction
   (d) Joint that permit slide movement
22. The major function of synovial fluid in a section through joint is
   (a) Wet the joint (b) harden the surface of cartilage (c) soften the muscle (d) lubricate the cartilage surfaces
23. The tough and strong muscle that connect muscle to the bone is
   (a) Capsule (b) biceps (c) tendon (d) flexor

24. Which of the following is NOT a bone of vertebral column
    (a) Humerus (b) axis (c) lumbar (d) thoracic
25. Which of the following is NOT a function of mammalia skeleton
    (a) Protection (b) support (c) respiration (d) excretion.
26. In active transport, molecule moves against a concentration gradient therefore
    (a) Molecule move from a region of low concentration to a region of high concentration
    (b) Molecule move from a region of high concentration to a region of low concentration
    (c) The concentration gradient has little effect on the movement of molecules
    (d) Molecules force their way through special channels.
27. Which of the following statements defines plasmolysis
    (a) Shrinking of a plant cell in a solution
    (b) Shrinking away of nucleus from an animal cell membrane
    (c) Shrinking away of the cytoplasm from the plant cell wall
    (d) Shrinking of the vacuole and leaving the cytoplasm with its cell wall.
28. Which of the following statement is not true of the light stage of photosynthesis
    (a) Chlorophyll is energized by sunlight
    (b) Water molecules split into hydrogen ions
    (c) Carbon(iv)oxide is reduced by hydrogen atom in $NADPH_2$
    (d) Water is formed
29. Which of the following element is required in large amount by plant?
    (a) Molybdenum (b) boron (c) copper (d) phosphorus
30. Which of the following substance has the highest amount of energy in joules per unit weight?
    (a) Carbohydrates (b) proteins (c) fats (d) vitamins
31. In the test for starch, the leaf is first placed in boiling water to;
    (a) Remove the chlorophyll (b) dissolve the waxy cuticle (c) kill and make the leaf permeable (d) turn it blue-black.
32. Which of the following essential substance is contained in vegetables?
    (a) Mineral salt (b) Glucose (c) carbon dioxide (d) chlorophyll.
33. The xylem tissue perform the function of transport but they also help to support plants because they
    (a) Are internally located (b) are tubular (c) have right thick walls (d) constantly absorb water.
34. Which of the following structures occupies the neural canal of the vertebral column?
    (a) Cerebellum (b) spinal cord (c) hypothalamus (d) brain.
35. A solution which contains all the required element in their correct proportion is known as (a) growth medium (b) nutrient solution (c) food solution (d) complete culture solution.
36. The deficiency of magnesium in plants results in
    (a) Death of shoot (b) leaves turning yellow (c) poor root development (d) death of plant.

37. Which of the following in NOT true about a potted plant left in the laboratory for one week without watering?
    (a) The cell of the plant will be turgid
    (b) There will be wilting of the plant
    (c) The leaves are likely to turn yellow
    (d) Plant will not take in enough nutrients
38. The deficiency of vitamin D and calcium ions in the diet of human causes
    (a) Rickets (b) anaemia (c) kwashiorkor (d) night blindness
39. An organization is considered a heterotroph when it
    (a) Feeds on inorganic foods (b) fixes, atmospheric nitrogen (c) feeds on already manufacture food (d) feeds on bacteria.
40. The process by which plant convey food material to different parts of the body is called
    (a) Nutrition (b) absorption (c) circulation (d) translocation
41. Which of the following groups contain a non-supporting structure?
    (a) Cartilage, bone and chitin (b) bone, leaf and parenchyma (c) chitin, bone and parenchyma (d) parenchyma, cartilage and humerus.
42. The correct equation for photosynthesis is
    (a) $C_6H_{12}O_6 + 6O_2 \xrightarrow[chlorophyll]{Sunlight} 6CO_2 + 6H_2O.$
    (b) $CO_2 + H_2O \xrightarrow[chlorophyll]{Sunlight} C_6H_{12}O_2 + O_2.$
    (c) $6CO_2 + 6H_2O \xrightarrow[chlorophyll]{Sunlight} C_6H_{12}O_6 + 60_2.$
    (d) $s6CO_2 + 6H_2O \xrightarrow[chlorophyll]{Sunlight} 6C_6H_{12}O_6 + 6O_2.$
43. Which of the following is an evidence of photosynthesis?
    (a) Absorption of light (b) formation of starch (c) splitting of water (d) presence of carbon dioxide.
44. During photosynthesis, energy from the sun is converted to _____________ energy.
    (a) Chemical (b) heat (c) electrical (d) sound
45. The deficiency of sodium in the body leads to
    (a) Anaemia (b) muscle cramps (c) oedema (d) kidney failure
46. Lack of vitamin E in man can result to
    (a) Night blindness (b) beriberi (c) malformation of bone (d) failure to form connective tissue.
47. Which of the following processes involves diffusion?
    (a) Opening and closing of stomata
    (b) Absorption of digested food into villa
    (c) Absorption of water through the root hairs
    (d) Turgidity of herbaceous plants.
48. Transportation of water in the xylem tissue involves the following except

(a) Root pressure (b) capillarity action (c) transpiration pull (d) translocation.

49. In which of the following organic compounds is the hydrogen-oxygen ratio equal to 2:1
    (a) Proteins (b) carbohydrates (c) lipid (d) vitamins
50. A man suffering from obesity must avoid meals containing
    (a) Margarine and butter (b) rice and beans (c) carrot and oranges (d) beef and fish.
51. Which of the following sequences is the path for water from the soil to the leaves of a plant?
    (a) Root hair ⟶ phloem ⟶ cortex ⟶ leaves
    (b) Root hair ⟶ xylem ⟶ cortex ⟶ leaves
    (c) Root hair ⟶ cortex ⟶ xylem ⟶ leaves
    (d) Root hair ⟶ cortex ⟶ xylem ⟶ leaves
52. Which of these distributes absorbed water and mineral salt to the leaves
    (a) Pericycle (b) cambium (c) phloem (d) xylem
53. Which of the following is responsible for the increase in thickness in dicotyledonous roots and stems
    (a) Cambium (b) parenchyma (c) cortex (d) endodermis.
54. The bones at a joint are held together by
    (a) Cartilage (b) ligament (c) muscle (d) sinews
55. The neural spine of the thoracic vertebrate of mammal are usually
    (a) Thick and broad (b) short and thin (c) long and slender (d) blunt and broad
56. In what form is excess glucose stored in plants?
    (a) Oil (b) gum (c) glycogen (d) starch
57. The movement of particles of a substance from a region of higher concentration to a region of lower concentration until their concentration is uniform is known as
    (a) Osmosis (b) plasmolysis (c) diffusion (d) absorption.
58. Which of the following statements about osmosis is not true?
    (a) It occurs in plants tissue only
    (b) It involves solutions of unequal concentration
    (c) It involves the movement of water molecules only
    (d) It can be demonstrated using an artificial membrane.
59. Animal cannot carry out photosynthesis because they
    (a) Lack chlorophyll (b) cannot make use of oxygen (c) lack cellulose (d) cannot absorb mineral salts.
60. One of these is not a characteristic of enzymes?
    (a) Enzymes acts on a specific substrate
    (b) Enzymes are portentous in nature
    (c) Enzymes can work in any pH range
    (d) Enzyme work best within a certain temperature range usually 35-40^{0}C.

APPENDIX I

INTERNATIONAL CENTRE FOR EDUCATIONAL EVALUATION

INSTITUTE OF EDUCATION, UNIVERSITY OF IBADAN.

Biology: Achievement Test **Time: 2hrs.**

Instructions: Answer All questions.
Each question is followed by four options lettered A to D. Find out the correct option for each question and shade in pencil on your answer sheet, the answer which bears the same letter as the option you have chosen. Give only answer to each question.

1. The tough and strong muscle that connect muscle to the bone is
   (a) Capsule (b) biceps (c) tendon (d) flexor
2. Mammalian skeleton consist of bone of
   (a) Cartilage and elastic (b) Axial and appendicular skeleton (c) Cuticle and bone (d) skeleton and muscle.
3. One of the following is the reason why plant should be turgid
   (a) To make the plant stand erect
   (b) All leaves to fall off from plants
   (c) To increase rate of photosynthesis
   (d) To make the plant lie on the ground.
4. The smell of perfume perceived from a distance is made possible by the process of
   (a) osmosis (b) haemolysis (c) diffusion (d) movement.
5. The exoskeleton of insect is made up of
   (a) Cartilage (b) chitin (c) hyaline (d) bone.
6. The type of skeleton found in earthworm is known as
   (a) Endoskeleton (b) exoskeleton (c) hydrostatic skeleton (d) muscle skeleton.
7. The deficiency of vitamin D and calcium ions in the diet of human causes
   (a) Rickets (b) anaemia (c) kwashiorkor (d) night blindness
   Study the following group of bones

   (i) Pelvic girdles (ii) vertebra column (iii) ribs (iv) limbs (v) skull (vi) pectoral girdle (vii) sternum.

Use the above information to answer question 17-18.

8. Which of the bones make up appendicular skeleton
   (a) I&IV only (b) I, VII and IV only (c) II, V and VI only (d) I, IV and VI only.
9. The axial skeleton consist of
   (a) II, III, V and VII only (b) II, III, VI and VII only (c) I, II and V only (d) III, IV, V and VI only.
10. Which of the following is not a characteristic feature of atlas bone? There is
    (a) Presence of vertebrarterial canal
    (b) Broad and flat centrum
    (c) Long stout neural spine
    (d) Large, flattened neural spine.
11. Which of these animals has its internal osmotic pressure (OSP) greater than its external osmotic pressure (OSP)?
    (a) Lizard (b) sea anemone (c) bony fish (d) amoeba

12. Which of the following is deficiency of vitamin B?
    (a) scurvy (b) sterility (c) night blindness (d) Beri-beri.
13. The process that leads to the bursting of red blood cell in a hypertonic solution is called
    (a) Heamolysis (b) osmosis (c) plasmolysis (d) turgidity.
14. Which of these distributes absorbed water and mineral salt to the leaves
    (a) Pericycle (b) cambium (c) phloem (d) xylem
15. Which of the following substance has the highest amount of energy in joules per unit weight?
    (a) Carbohydrates (b) proteins (c) fats (d) vitamins
16. In the test for starch, the leaf is first placed in boiling water to;
    (a) Remove the chlorophyll (b) dissolve the waxy cuticle (c) kill and make the leaf permeable (d) turn it blue-black.
17. Which of the following essential substance is contained in vegetables?
    (a) Mineral salt (b) Glucose (c) carbon dioxide (d) chlorophyll.
18. A solution which contains all the required element in their correct proportion is known as (a) growth medium (b) nutrient solution (c) food solution (d) complete culture solution.
19. Osmosis is distinguished from diffusion in that
    (a) Osmosis occurs in dead medium
    (b) Osmosis occurs in living cell.
    (c) Molecule pass through a semi-permeable membrane.
    (d) Osmosis continues until concentration is uniform throughout the solution.
20. The type of cartilage found in external ear of mammalia is
    (a) Fibro-cartilage (b) hyaline cartilage (c) bone cartilage (d) elastic cartilage.
21. Which of the following groups contain a non-supporting structure?
    (a) Cartilage, bone and chitin (b) parenchyma, cartilage and humerus. (c) chitin, bone and parenchyma (d) bone, leaf and parenchyma.
22. Which of the following is an evidence of photosynthesis?
    (a) Absorption of light (b) formation of starch (c) splitting of water (d) presence of carbon dioxide.
23. The deficiency of sodium in the body leads to
    (a) muscle cramps (b) Anaemia (c) Skin rashes (d) Cirrhosis
24. Which of the following processes involves diffusion?
    (a) Opening and closing of stomata
    (b) Absorption of digested food into villa
    (c) Absorption of water through the root hairs
    (d) Turgidity of herbaceous plants.
25. A man suffering from obesity must avoid meals containing
    (a) Margarine and butter (b) rice and beans (c) carrot and oranges (d) beef and fish.
26. Which of the following sequences is the path for water from the soil to the leaves of a plant?
    (a) Root hair ⟶ phloem ⟶ cortex ⟶ leaves
    (b) Root hair ⟶ xylem ⟶ cortex ⟶ l eaves
    (c) Root hair ⟶ cortex ⟶ xylem ⟶ leaves
    (d) Root hair ⟶ leaves ⟶ xylem ⟶ phloem
27. Which of the following statements defines plasmolysis
    (a) Shrinking of a plant cell in a solution
    (b) Shrinking away of cytoplasm from an animal cell membrane
    (c) Shrinking away of the cytoplasm from the plant cell wall

(d) Shrinking of the vacuole and leaving the cytoplasm with its cell wall.

28. The bones at a joint are held together by
    (a) Cartilage (b) ligament (c) muscle (d) sinews
29. The neural spine of the thoracic vertebrate of mammal are usually
    (a) Thick and broad (b) short and thin (c) long and slender (d) blunt and broad
30. Which of the following statements about osmosis is not true?
    (a) It occurs in plants tissue only
    (b) It involves solutions of unequal concentration
    (c) It involves the movement of water molecules only
    (d) It can be demonstrated using an artificial membrane

ANSWER TO BIOLOGY ACHIEVEMENT (BAT)

1 C

2 B

3 A

4 C

5 B

6 C

7 A

8 D

9 A

10 C

11 A

12 D

13 A

14 D

15 C

16 C

17 A

18 D

19 C

20 D

21 D

22 B

23 A

24 B

25 A

26 C

27 C

28 B

29 C

30 A

APPENDIX II (A)

INTERNATIONAL CENTRE FOR EDUCATIONAL EVALUATION
INSTITUTE OF EDUCATION, UNIVERSITY OF IBADAN.

Test of Practical Skill in Biology Question (TPSB) Time: 2hr 30mins.

Instructions

Read the questions and follow the instructions given carefully. Use only the answer sheet provided for reports.

You are required to follow the questions and instruction on the answer worksheet systematically.

Question I

You are provided with two food materials label B and C and these reagents; iodine solution, millon' reagent, fehling solution and Benedict solution Hcl.

Design and carry out test to confirm the presence of reducing sugar and protein. Record your observation and conclusion/interference.

I. If, in a similar experiment you are required to heat up the solution with Hcl before adding Fehling solution 1&2 what would you suspect about the nature of the food material?

II. What is the usefulness or role of Hcl in the experiment?

III. In the absence Fehling's' solution which other common laboratory reagent/ chemical would you use for test 2.

Question II

Explain how oxygen moves into the leaves of the plant through the stomata during respiration. You are given crystals of potassium permanganate, beaker and water. Design and carry out experiment to explain the process involved.

I. What physiological process does the experiment you have just performed demonstrated?

II. Suggest a suitable title for your experiment

III. In what medium did experiment take place?

IV. State two instances in animal where the above process is significant.

V. Explain the difference between this process and active transport.

Specimen A: is a bone obtained from a small mammal.

Question III

(a) Identify specimen A without reason

(b) Give two observable features of specimen A

(c) State two functions of specimen A.

(d) Name a nutrient contained in specimen A

(e) Make a labelled drawing 8cm to 10cm long of the anterior view of specimen A.

ANSWER TO TEST OF PRACTICAL SKILL IN BIOLOGY. (MARKING GUIDE)

Question 1

TEST	OBSERVATION	INFERENCE
Specimen B + Iodine solution	Deep blue solution observed	Starch suspected
Specimen B + Fehling solution A and B and warm	Blue solution turns orange	Glucose present/Reducing Sugar present
Specimen B + Benedict solution and warm	Solution turns brick red/orange	Glucose present/reducing Sugar Present
Specimen C + Fehling solution A and B	Milk coagulate turn to blue	Glucose/Reducing sugar absent
Specimen C + Millon's reagent and warm	Red precipitate formed	Protein present

Any 5x3= 15

i Food contain sucrose. 2 Marks
ii HcL Hydrolise (2 Mks) sucrose to glucose and glucose. 2 Marks = 4mks
iii Benedict solution. 2mks

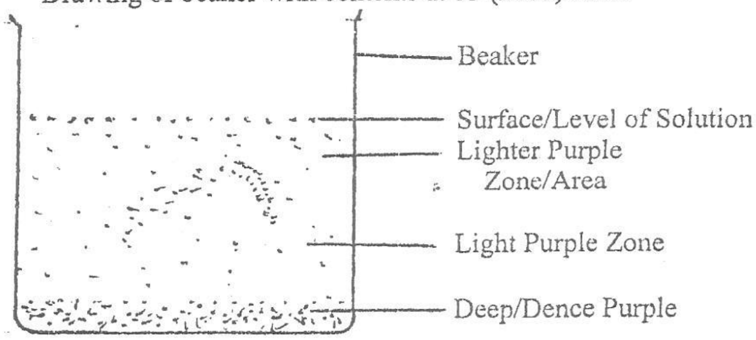
Question 2

Time	***Observation/inference***
Immediately after dropping the crystal	A streak of purple colour following the crystals to the bottom of the beaker.
10 inute later	Dissolving crystals form a dense purple colour at the bottom of the beaker. (ii) A light layer above as the molecules of ***$KMNO_4$*** crystals move from region of high concentration to region of low concentration.

20 minute later	More than $^1/_2$ of the water is coloured with three distinct layers purple trails still show at bottom and middle. (ii)Molecules of ***$KMNO_4$*** crystals move from region of high concentration to region of low concentration.
30 minute later	Almost whole medium becomes purple coloured. (ii)As molecules of ***$KMNO_4$*** are uniformly distributed

Any 4x2=8

) Drawing of beaker with contents at 15 (mins) after.



Quality of Drawing

Title TL x 1,Clarity of line CL x 1. Size SZ x 1. Neatness of Label Ruled guide line1/2, Horizontal label 1/2. Any 2 x 1 =2 Marks

Details

DP – Dense/deep/darkpurple zone/area.

LP – light purple zone

LW – level of water to be about half. Any 2 x ½ =1

Labels: beaker, lighter purple zone/area, light purple zone/area, deep/dense purple area, surface/level of solution. Any 4 x ½ = 2 Marks

(i) Diffusion. 2Marks

(ii)To demonstrate diffusion in liquid using ***$KMNO_4$*** crystals. 2 Marks

(iii) Liquid /fluid medium. 2 Marks

(iv) (a) intake of nutrient from mother to foetus through placenta.1 mark

(b) Absorption of digested food by villi of small intestine.1Mark

(c) Gaseous exchange in the lungs. 1 mark (any 2x1 = 2 marks)

(v)Active transportation involves energy while diffusion did not involve energy. 2Marks.

Question 3

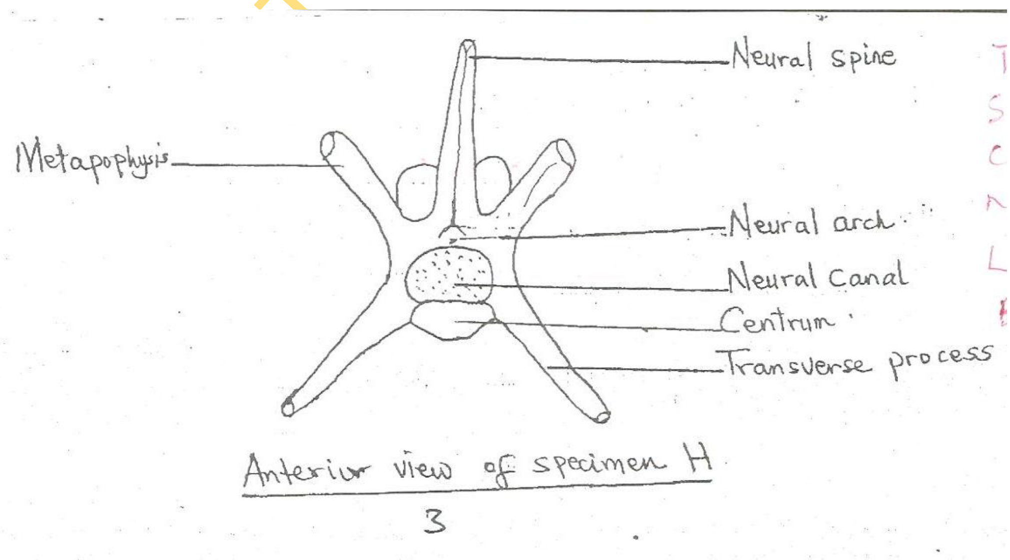
(A) Specimen A is Thoracic vertebra or lumber vertebra or cervical vertebra2 Marks

(B) Features: thoracic vertebra: Long neural spine, (ii) presence of demifacet for the attachment of rib (iii) large neural canal lumber vertebra : Thick and large centrum. (ii) Large neural canal. (iii) Presence of transverse process for the attachment of muscle. Any 2 x 2 = 4 Marks .

(C) Protects vital organ in the body e.g Heart, Lung, Reproductive Organs etc.2Marks

(ii) Give the body shape and support. 2 Marks

(D)Calcium/ phosphorus. 2 marks



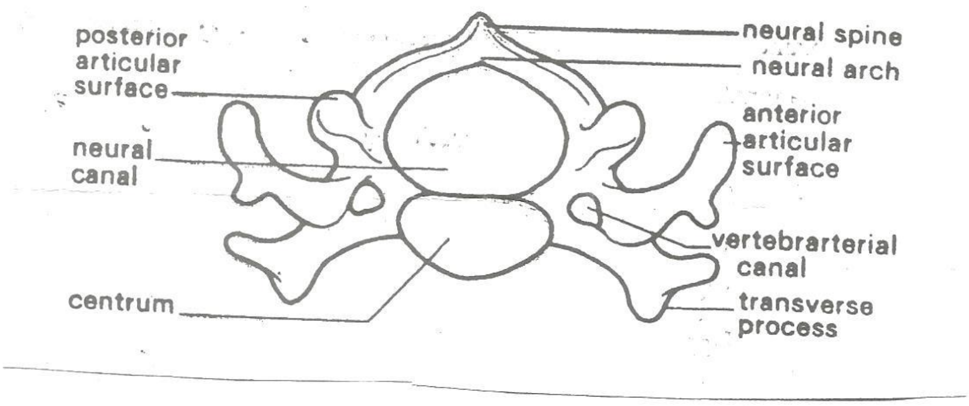
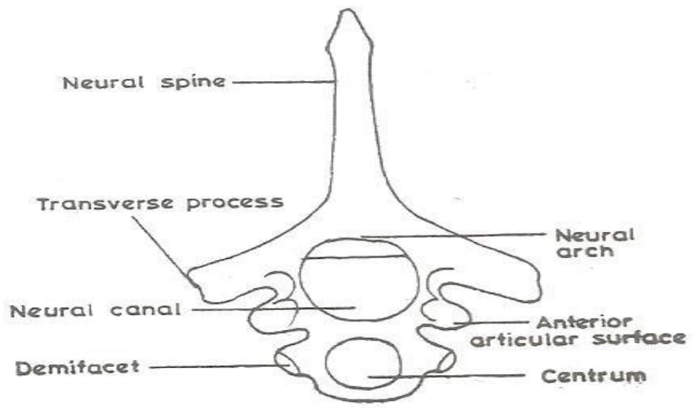


Diagram showing anterior view of cervical vertebra



Thoracic vertebra (anterior view)

Quality of drawing

Title TL x 1,Clarity of line CL x 1. Size SZ x 1. Neatness of Label Ruled guide line1/2, Horizontal label 1/2. Any 2 x 1 =2 Marks

Details

Large centrum LC, Broad Transverse process BT, Neural Canal NC, Wide Canal WC, Neural Spine NS. Any 3 x1 = 3Marks.

Label LB: Neural canal, Neural spine, Neural arch, Centrum, Anterior articular surface, Vertebrarterial Canal, Posterior Canal.

APPENDIX II (b)

Practical Test Assessment Inventory/Scale

Name________________ Class________________ Sex_________________

Skill Area	Criteria	Score		
		FE	PE	NE
Planning and design	Presentation of clear, concise and complete plan for investigation			
	(i) ability to state problem .			
	(ii) correct choice of material			
	(iii) Identification and description of correct procedure.			
Manipulative skills	This has to do with skills involved in the manipulation of equipment like handling apparatus, preparation of materials for setting up experiment and eye-hand coordination			
	(i)ease of handling equipment /materials			
	(ii) proper heating technique			
	(iii) Drawing skills–smooth not clumsy			
	(iv) Method of handling, shaking mixture and reading measuring cylinder or glass jar			
	(v) Addition of exact number of drops of reagents or sufficient amount of water (correct setting up of equipment in reasonable time).			
(C) Observation skills	This has to do with ability to make accurate and trained use of senses e.g visual incomplete viewing of variables detecting error and taking precaution as well as recording data			
	(i) accuracy of observation i.e ability to put down exact changing taking place either in terms of colour change or changes in water level			
	(ii) Completeness of observation – ability to recognise when the observation is complete.			
	(iii) Correct number of layers of colour of KMNo4.			
	(iv) drawing and labelling; Proportional, neat lines and guidelines(not crossing)			
(d) communication skills;	This skills involve ability to put across the finding of practical in a clear cut precise words and to interpret results			
	(i) ability to interpret observed data/finding i.e. inference			
	(ii) Ability to make valid conclusion			
	(iii) Good table with proper heading			
	(iv) Ability to make drawing and explain observation.			
(e) independence and work ethics	These skills has to do with ability of student to work by himself/ her or show measure of self-confidence during conduct of experiment while at the same time being fully conscious of safety and tidy conditions expected of a laboratory environment.			
	(i) Self-reliance- does it on alone without any assistant			
	(ii) tackle practical with enthusiasm			
	(iii) Work habit- organise a work place neatly without splashing			
	(iV) safety conscious			

Keys

FE- Full exhibition

PE- Partial exhibition

NE-No exhibition

APPENDIX III

INTERNATIONAL CENTER FOR EDUCATIONAL EVALUATION
INSTITUTE OF EDUCATION UNIVERSITY OF IBADAN. IBADAN.

Vocational Interest Inventory/Scale

SECTION A
Personal Information

Name:____

Age:________________ **Sex:**_______________ **Class:**__________

School:____

Career Choice: ____________________

SECTION B

This inventory is designed to help you indicate the work in which you are interested and which you will enjoy doing. It includes several activities which are performed in many different kinds of job. Consider each activity and then decide how much you would like to perform that activity.

Tick 4 ------ if it is Very Much True of Me **(VTM)**
Tick 3 ------ if it is True of Me **(TM).**
Tick 2 ------ if it is Rare True of Me **(RTM).**
Tick 1 ------ if it is Not True of Me **(NTM).**

S/N	The knowledge I've acquired in science class developed my interest in	VTM 4	TM 3	RTM 2	NTM 1
1	Assembling small mechanical units of engine				
2	Learning how to operate and repair complicated machine.				
3	Designing the bridge across large river.				
4	Thinking of pursue a career in computer repairing				
5	Making a chemical analysis of a new drug				
6	Repairing electrical appliances (radio, TV, electric iron, kettle e.t.c.)				
7	Using X-ray machine to diagnose human diseases				
8	Design and Construct new mechanical toys.				
9	Tree planting campaign.				
10	Taking a job which requires a lot of mental arithmetic.				
11	Learning parts of human body.				
12	Reading about the theory of atomic energy.				
13	Looking after the sick in the clinic or hospital				
14	Protecting pets in my neighbourhood.				
15	Visiting the countryside for minerals and oil deposits				
16	Repairing a car that has broken down.				
17	Going on a field trip to study strange animal.				
18	Dealing with functions and activities of living organisms.				
19	Learning the composition of the soil.				
20	Rearing poultry.				
21	Going on a long sea trip to learn more about environment.				
22	Watching natural history of animals and make a career in this field				
23	Performing surgery on sick people				
24	Using the computer to solve mathematical problem				

APPENDIX 1V

Problem-solving instructional Plan (Teachers instructional guide PSIPTG)

week: 1

Section A

Topic: Physical process

Sub topic: Diffusion and osmosis

Duration: 1600 minutes (four periods)

Instruction Objectives: At the end of the lesson student should be able to:

1. Define diffusion
2. Describe the process of diffusion
3. Demonstrate diffusion in liquid and gases
4. State the significant of diffusion to plant and animals.
5. Mention factors affecting or controlling diffusion
6. Define Osmosis
7. Describe the process of osmosis in a living tissues and non-living tissues.
8. List the importance of diffusion in plants and animals
9. List the significance of Osmosis
10. Distinguish between diffusion and osmosis

Section B:

PRESENTATION

The teacher start by introducing the new teaching strategy of problem-solving by altering the conventional sitting arrangement as he/she divides the class into groups of five to six students method

step 1: Teacher introduce the lesson by asking one of the students to move to a corner of the classroom and released perfume. The teacher moves round asking students at different location when they perceived the odour of perfume. After citing other familiar examples, the teacher defines diffusion as the process in which molecules or ions of a substance move from a region of high concentration to a region of low concentration until they are evenly distributed. The substance involved in diffusion may be liquid, gas or solid.

Step 2: The teacher discusses rate of movement of molecules or ions in gases, liquid or solid to factors that affect or controlling diffusion.

Factors affecting/controlling diffusion.

1. **State of matter:** Diffusion varies with the three state of matter, the diffusion of gases is much faster than that of liquid because the gas molecules are more free than that of liquids and therefore faster than liquid molecules.
2. **Molecules size**: The size of molecules affects diffusion generally, the smaller the molecules, the faster the rate of diffusion while the larger the molecules the slower the rate of diffusion.
3. **Temperature:** high temperate increases the speed at which molecules move, thus, the higher the temperature the faster the rate of diffusion.
4. **Differences in concentration**: for diffusion to take places in a medium there must be differences in the concentration of the substances in two areas. The greater the differences in the concentration of the molecules, the greater the rate of diffusion.

Step 3: Importance of diffusion to living organism;

In plants, diffu**sion occurs in the following process.**

1. Movement of carbondioxide through the stomata into the mid-rib of leaves during photosynthesis.
2. Water vapour leaves the leaf during transpiration action by diffusion.
3. Movement of oxygen into the leaves through the stomata during respiration.

In animal, diffusion occurs in the following process

1. Absorption of digested food by villi of small intestine in mammals.
2. Gaseous exchange in the lung i.e movement of oxygen from alveoli into the capillaries.
3. Exchange of nutrients and materials between a mother and foetus through placenta.

Step 4: Osmosis

The teacher defines osmosis as the flow/movement of water/solvent molecules from a region of dilute or weaker solution to a concentrated or stronger solution through a selectively or differentially permeable membrane.

Lesson Two: (80 minutes)

PRESENTATION

The teacher starts introducing the new teaching strategy of problem-solving by altering the conventional sitting arrangement as he/she divides the class into groups of five to six students per group. The purpose of grouping is that the apparatus may not be able to go round students individually, and this allows members of each group to ignite intellectual interactive spirit among one another.

2. Students main activities in the first lesson is to listen to teacher's explanation on the topic of the day which is theoretical background.

Step 1. The teacher introduces the lesson with class activity presented to the students thus: one of the students in the class move to the back corner of the class to spay perfume underneath. The student at different row informs the teacher when they perceived the odour of the perfume. Why is it so and not that everybody perceived at the same time?

Step 2. The teacher leads discussion on the perception of perfume odour at different interval. Asks students how they arrive at the answer i.e to reveal their ideas about problem-solving.the teacher explain that when you have a goal and do not know immediately how to get there, you have a problem. He defines problem and problem-solving.

Problem: any task that requires you to analyse and reason towards a solution.

Problem-solving: the process by which solution is generated to a defined problem using analysis and reasoning

The students listen and take notes

Step 3: The teacher introduces the students to steps involved in problem-solving as indicated by REPSOM model. The teacher takes students through the actions at each stage:

Stage 1: PROBLEM-PERCEPTION AND SELECTING APPARATUS

Actions

a) Read carefully the practical problem posed and state the problem of the investigation in simple prose or clear term.

b) Examine the apparatus provided to ensure that no fault is detected by way of damages or incomplete parts or wrong fixing .visualise how you are going to set up the apparatus.

c) If it helps to explain your work , after the set up ,make sketch or annotated diagram of the set up or the main component or part thereof

Stage 2: RECALLING THEORY AND MAKING TABLES

Actions

a) Write down the known general principle or theory, that are necessary for solving the problem.
b) List possible sources of error or precaution, if you remember any, that must be taken in the process of solving the problems
c) Think through the procedure or technique you want to use and the likelihood of giving you a reliable result. In effect, predict tentatively, where applicable.
d) Make tables for recording or entry of expected results.

Stage 3: EXPERIMENTATION, OBSERVATION &RECORDING DATA

Actions

a) Give the problem a second and closer look.
b) Check your experimental set up
c) Begin your experiment calmly, confidently and carefully.
d) Ensure that every reaction is carefully watched.
e) Taking note any change in colour or water level.
f) Take precaution to avoid making careless mistakes or spilling any reagents or pushing down a piece of equipment.
g) Record your observation in the table drawn.

Stage 4: ANALYSIS OF RESULTS:

Actions

a) What major finding are evident from your results
b) Does it seem to conform to existing knowledge in the area?
c) Do you feel confident to draw any conclusion from the result or does the experiment need to be repeated?

Stage 5: EVALUATION OF SOLUTION, CONSOLIDATING KNOLWEDGE GAIN AND CHANGE IN TECHNIQUE

Actions

a) How do you access the outcome of your result?

b) What have you learnt from the experiment? is applicable in everyday life?

c) Make suggestions on how to improve upon the result in future with particular reference to the set up or design.

d) Put down the errors responsible for your inaccurate or faulty results, if applicable

e) If totally faulty, a complete change in design or technique should be undertaken-this means repeat the experiment.

Step 4: The teacher poses a problem based on a concept student have been taught e.g diffusion, osmosis, plasmolysis. The teacher leads students in the steps for solving this problem by asking prompting questions such as;

a) What is required of you in this problem?

b) What information is given in the question?

c) What additional information do you need to solve the problem?

d) Is this problem similar to one you have encounter before?

e) Based on b, c and d, attempt to generate a solution to the problem.

The students copy the question in their notes book. Proceed to solve the problem step by step answering prompting questions. Carry out the practical exercise.

Step 5: the teacher moves round, assesses progress of students during the practical session and makes corrections when necessary.

Step 6: the teacher evaluates the appropriateness of the solution as the students carry out practical, if the solution is reasonable, fit into pattern of the idea in the questions and similar to the solutions achieved in a related problem.

Problem-Solving Teachers instructional guide (PSTIG)

week: 2

Topic: Animal nutrition

Sub Topic: Food substances/Classes of Food

Duration: 120 minutes (double period)

Instruction Objectives: At the end of the lesson student should be able to:

1. Define Nutrition
2. Describe Holozoic Nutrition
3. Mention Classes of Food
4. Mention Component of each Classes of Food
5. List Sources of each Class of Food

6. State Functions of each Class of food

7. Define Balance Diet

8. Perform experiments on food test

PRESENTATION

Lesson One: 80 Minutes

Step 1: The Teacher Introduces the lesson by asking questions on various food eaten by animals and plant.

Step 2: The teacher describes_nutrition in animal as heterotrophic mode in which organisms depend on plant either directly or and indirectly for their survival on plants. There are forms of heterotrophic among them holozoic.

Step 3: The teacher discusses with the students that foods eating by animals are made up of five classes of food, which are: carbohydrate, proteins, fats & oil, mineral salts and vitamins. Each of the class is described.

Carbohydrates: Carbohydrates are made up of carbon, hydrogen and oxygen, the ratio of hydrogen to oxygen is 2:1. The general formula is cx $(H2O)_{Y.}$ There are different types of carbohydrates some are sugars, starch and cellulose.

Simple Sugars: The common simple sugars found in organism are the hexose (six carbon sugar). The general formula is $C_6H_{12}O_{6.}$ They are the most important energy-storage molecules in an organism E.g. glucose, fructose and galactose.

Complex sugars: these are formed from condensation of two simple sugar molecules, the formula is $C_{12}H_{22}O_{11}$. Examples are: sucrose, maltose, and fructose.

glucose + glucose $\rightarrow$ - H_20 Maltose

glucose + galactose $\rightarrow$ - H_20 Lactose

glucose + fructose $\rightarrow$ - H_20 Sucrose

Sucrose is found in sugar cane, ripe sweet fruits, and storage root like carrots. Lactose is found in milk of mammals, maltose is found in malted cereals and sprouting grains, starch and cellulose.

These are very large molecules (macromolecules) formed by the condensation of many simple sugar molecules, starch are found in mainly in plant, starch found in animal is glucose.

Functions of carbohydrate

1. Carbohydrates provide energy required by the animal body for their daily activities.
2. They are used to build certain body parts E.g. exoskeleton of arthropods.

3. Mucus , an important lubricant in our body composed of Carbohydrates

Proteins

Protein contains carbon, hydrogen, oxygen and nitrogen, all protein are macromolecules made up of smaller units called amino acids.

Source of protein: Are milk, egg, fish, cheese, beans, groundnuts and soybeans e.t.c.

Functions of protein

1. They are the main body building substances necessary for building new cells
2. It used for the repair of worn-out tissue or cells.

Fats and oil

They are known as lipids, they contain high protein of carbon and hydrogen but little oxygen. Fats are solid while oils are liquid at room temperature. Before they can be absorbed into the body, they broke down into fatty acids and glycerol.

Sources of fats and oil: palm oil, vegetable oil, soya bean oil, butter, margarine.

Function of fats and oil

1. They provide the body with energy
2. They are solvent for fats soluble vitamins
3. Fats deposited under the skin act as insulator
4. They are important component of cell membranes

Mineral Salts

Animal require various mineral salt for metabolic activities within the body, some of them are components of enzymes pigments and structural parts. Mostly minerals are obtained from diet in small quantity. Some mineral like calcium, sodium, and phosphorus are needed in large quantity, while others are needed in small quantity/amounts.

A lack of necessary mineral salts leads to ill health, and in certain cases, deficiency disease.

Vitamins

Vitamins are organic compounds, they are biocatalyst i.e they promote chemical reactions in the body. Vitamins A,D,E and K are fats soluble while vitamin B & C are water soluble.

Sources of vitamins are: fruits, vegetables, milk, egg, palm oil e.t.c.

LESSON TWO: 80 Minutes

The teacher starts introducing the new teaching strategy of problem-solving by altering the conventional sitting arrangement as he/she divides the class into groups of five to six students per group. The purpose of grouping is that the apparatus may not be able to go round students individually, and this allows members of each group to ignite intellectual interactive spirit among one another.

Students main activities in the first lesson is to listen to teacher's explanation on the topic of the day which is theoretical background.

Step 1: The teacher introduces the lesson with a class activity presented to students thus:

Specimen A and B are two food substances

A – Cooked starch/ yam

B – Cooked bean/boiled egg albumen.

Mash each specimen on a clean dish, and add a drop of iodine solution each.

(a) What colour changes do you observe for A and B?
(b) Explain the difference.

Students carry out the activity and answer the questions.

Step 2 : The teacher leads discussion on colour changes and answer got.

Asks students to explain how they arrive at the answer i. e to reveal the ideas about problem solving.

Students explain how they got the answer, their source of information for solution.

Step 3. The teacher introduces the students to steps involved in problem-solving as indicated by REPSOM model. The teacher takes students through the actions at each stage:

Stage 1: PROBLEM-PERCEPTION AND SELECTING APPARATUS
Actions

a) Read carefully the practical problem posed and state the problem of the investigation in simple prose or clear term.
b) Examine the apparatus provided to ensure that no fault is detected by way of damages or incomplete parts or wrong fixing .visualise how you are going to set up the apparatus.
c) If it helps to explain your work ,after the set up ,make sketch or annotated diagram of the set up or the main component or part thereof

Stage 2: RECALLING THEORY AND MAKING TABLES

Actions

a) Write down the known general principle or theory, that are necessary for solving the problem.
b) List possible sources of error or precaution, if you remember any, that must be taken in the process of solving the problems
c) Think through the procedure or technique you want to use and the likelihood of giving you a reliable result. In effect, predict tentatively, where applicable.
d) Make tables for recording or entry of expected results.

Stage 3: **EXPERIMENTATION, OBSERVATION &RECORDING DATA**

Actions

a) Give the problem a second and closer look.
b) Check your experimental set up
c) Begin your experiment calmly, confidently and carefully.
d) Ensure that every reaction is carefully watched.
e) Taking note any change in colour or water level.
f) Take precaution to avoid making careless mistakes or spilling any reagents or pushing down a piece of equipment.
g) Record your observation in the table drawn.

Stage 4: ANALYSIS OF RESULTS:

Actions

a) What major finding are evident from your results
b) Does it seem to conform to existing knowledge in the area?
c) Do you feel confident to draw any conclusion from the result or does the experiment need to be repeated?

Stage 5: EVALUATION OF SOLUTION, CONSOLIDATING KNOLWEDGE GAINS AND CHANGE IN TECHNIQUE

Actions

a) How do you access the outcome of your result?

b) What have you learnt from the experiment which is applicable in every day life?

c) Make suggestions on how to improve upon the result in future with particular referenced to the set up or design.

d) Put down the errors responsible for your inaccurate or faulty results, if applicable

e) If totally faulty, a complete change in design or technique should be undertaken-this means repeat the experiment.

Step 4: The teacher poses a problem based on a concept students have been taught e.g presence of starch, reducing sugar, protein and fats and oil in food. The teacher leads students in the steps for solving this problem by asking prompting questions such as;

a) What is required of you in this problem or the aim?

b) What information is given in the question? Things needed for investigation.

c) What additional information do you need to solve the problem?

d) Is this problem similar to one you have encounter before? Explain the procedure for the conduct of the experiment in a logical sequence

e) Based on b, c and d, attempt to generate a solution to the problem.

The students copy the question in their notes book. Proceed to solve the problem step by step answering prompting questions. Carry out the practical exercise.

Step 5: the teacher moves round, assesses progress of students during the practical session and makes corrections when necessary.

Step 6: the teacher evaluates the appropriateness of the solution as the students carry out practical, if the solution is reasonable, fit into pattern of the idea in the questions and similar to the solutions achieved in a related problem.

Problem-Solving Teachers instructional guide (PSTIG)

Week: 3

Topic: Supporting Tissues and Systems in Animal

Sub Topic: Forms of Skeleton: Chilin, Cartilage, and Bone

Types of skeleton:

Vertebrate skeleton

Mammalian skeleton

Joints

Functions of skeleton in Animal

Instruction Objectives: At the end of the lesson student should be able to:

a) Define skeleton
b) Mention forms of skeletal materials and examples of animal that possesses each of them
c) Mention and describe types of skeleton
d) Describe mammalian skeleton
e) Describe vertebral column
f) Describe a typical vertebral
g) Identify different types of vertebral column
h) Mention characteristics features of each type of vertebral column
i) Identify and describe ribs and sternum
j) Describe appendicular skeleton (pectoral and pelvic girdles)
k) Identify pelvic girdle and pectoral girdle
l) Draw each bone of vertebral column and appendicular bone

PRESENTATION

Lesson One: 80 minutes

STEP ONE: The teacher introduces the lesson by asking the students to mention bone in their body and show the bone mentioned. What is the use of the bone in the body? After the students' response, the teacher defines skeleton as the bony framework of the body which provides support, shape and protection to the soft tissues and organs in the body.

STEP TWO: the teacher mentions and discusses three types of skeletal materials in animals. These are; chitin, cartilage and bone

1) **Chitin**: this is tough, light and flexible materials. Chitn is a major component of arthropods. It is freely permeable to water and strengthened by the deposits of hardened proteins and minerals. It found in insects, prawn, centipede e.t.c.

2) **Cartilage**: this is a tissue found in the skeleton of complex vertebrates. It consists of living cells (chondroblasts), carbohydrate and protein fibres. It is tough and flexible. It helps in cushion the effects of bone moving against bone when we move. There are three types of cartilage viz; hyaline cartilage, found in trachea and bronchi. Fibro cartilage; found in the disc between the small bone of vertebral column. And elastic cartilage found in the pinnea (external ear) of mammals

3) **Bone**: this is also a tissue and is the major component of vertebrate skeleton.bone consists of living cells osteocytes, protein fibres collagen and non-living minerals calcium carbonate and calcium phosphate. Bone has blood supply to nourish them.

STEP THREE: the teacher mentions and describes three types of bone. They are hydrostatic skeleton, exoskeleton and endoskeleton.

1) **Hydrostatic skeleton**: animal with this type of skeleton use fluid pressure to provide support. The fluid is secreted to fill the spaces in the body. This fluid presses against the muscular body wall to contract, exert a force against the fluid. Hydrostatic skeleton is found in Earthworm.

2) **Exoskeleton**: this is an outer skeleton found outside the body of arthropods. The main component of this skeleton is chitin. It is found in crustaceans, insects, myriapods.

3) **Endoskeleton**: this is the internal skeleton found in major vertebrates. Endoskeleton of vertebrates is composed of bones. The bone can grow steadily as the animal grows. Bone of many shapes and sizes make up the endoskeleton.

STEP FOUR: the teacher discusses the general plan of mammalian skeleton, which consists of two groups; the axial skeleton and the appendicular skeleton.

Axial skeleton is made up of the skull, the vertebral column, ribs and sternum. Appendicular skeleton consists of the girdles- pectoral girdle and pelvic girdle. The skull is up made of several flat bones which are joined to form the brain box, the face and lower jaw. The vertebral column known as backbone is the central supporting structure. It consists of 33 vertebrae. The vertebrae are separated by fibro-cartilage but held together by ligament. There are five types of vertebrae in the vertebral column; the cervical vertebra, the thoracic vertebra, the lumbar vertebra, the sacrum vertebra and the caudal vertebra.

Lesson Two: 80 Minutes

The teacher starts introducing the new teaching strategy of problem-solving by altering the conventional sitting arrangement as he/she divides the class into groups of five to six students per group. The purpose of grouping is that the apparatus may not be able to go round students individually, and this allows members of each group to ignite intellectual interactive spirit among one another.

Students main activities in the first lesson is to listen to teacher's explanation on the topic of the day which is theoretical background.

Step 1: the teacher introduces the lesson with a class activity presented to the students thus;

Specimen A, B and Care bones obtained from mammalian skeleton

Identify each specimen and categorise them in to the group they belong to.

a) Where can you find each of the specimen in mammalian body.
b) State the differences among them.

Students take the specimens and answer questions raised.

Step 2: The teacher lead discussion on the answers provided by the students. Asks students to explain how they arrived at the answers. Students explain how they got the answer, e.g the source of information for solution.

Step 3: The teacher introduces students to the steps involved in problem solving as indicated by REPSOM model. The teacher takes students through the actions at each stage:

Stage 1: PROBLEM-PERCEPTION AND SELECTING APPARATUS

Actions

a) Read carefully the practical problem posed and state the problem of the investigation in simple prose or clear term.

b) Examine the apparatus provided to ensure that no fault is detected by way of damages or incomplete parts or wrong fixing .visualise how you are going to set up the apparatus.

c) If it helps to explain your work ,after the set up ,make sketch or annotated diagram of the set up or the main component or part thereof

Stage 2: RECALLING THEORY AND MAKING TABLES

Actions

a) Write down the known general principle or theory, that are necessary for solving the problem.

b) List possible sources of error or precaution, if you remember any, that must be taken in the process of solving the problems

c) Think through the procedure or technique you want to use and the likelihood of giving you a reliable result. Which side do you want to draw?

Stage 3: EXPERIMENTATION, OBSERVATION & RECORDING DATA

Actions

a) Give the problem a second and closer look.

b) Begin your experiment calmly, confidently and carefully.

c) Ensure that every specimen is carefully watched.

d) Record your observation in the table drawn. Features that you can use in categorising them into their groups.

Stage 4: ANALYSIS OF RESULTS:

Actions

a) What major finding are evident from your results

b) Does it seem to conform to existing knowledge in the area?

c) Do you feel confident to draw any conclusion from the result or do you need to look at the specimens again?

Stage 5: EVALUATION OF SOLUTION, CONSOLIDATING KNOLWEDGE GAIN AND CHANGE IN TECHNIQUE

Actions

a) How do you access the outcome of your result?

b) What have you learnt from the experiment which is applicable in everyday life?

c) Make suggestions on how to improve upon the result in future with particular reference to the set up or design.

d) If totally faulty, a complete change in design or technique should be undertaken-this means repeat the experiment.

Step 4: The teacher poses a problem based on a concept students have been taught e.g bone of vertebral column, ribs girdles jaws e.t.c. The teacher leads students in the steps for solving this problem by asking prompting questions such as;

a) What is required of you in this problem or the aim?
b) What information is given in the question? Things needed for investigation.
c) What additional information do you need to solve the problem?
d) Is this problem similar to one you have encounter before? Explain the procedure for the conduct of the practical in a logical sequence
e) Based on b, c and d, attempt to generate a solution to the problem.

The students copy the question in their notes book. Proceed to solve the problem step by step answering prompting questions. Carry out the practical exercise.

Step 5: the teacher moves round, assesses progress of students during the practical session and makes corrections when necessary.

Step 6: the teacher evaluates the appropriateness of the solution as the students carry out practical, if the solution is reasonable, fit into pattern of the idea in the questions and similar to the solutions achieved in a related problem.

APPENDIX V

Guided Inquiry Teacher Instructional Plan (GITIP)

Week: 1

Section A

Topic: Physical process

Sub topic: Diffusion and osmosis

Duration: 160 minutes (four periods)

Instruction Objectives: At the end of the lesson student should be able to

a) Define diffusion
b) Describe the process of diffusion
c) Demonstrate diffusion in liquid and gases
d) State the significant of diffusion to plant and animals.
e) Mention factors affecting or controlling diffusion
f) Define Osmosis
g) Describe the process of osmosis in a living tissues and non-living tissues
h) List the importance of diffusion in plants and animals
i) List the significance of Osmosis
j) Distinguish between diffusion and Osmosis

Section B:

PRESENTATION

The teacher starts introducing the new teaching strategy of guided inquiry by altering the conventional sitting arrangement as he/she divides the class into groups of four (4) to five (5) students per group. The grouping is done at random.

Step 1: Teacher introduce the lesson by asking one of the students to move to a corner of the classroom and released perfume. The teacher moves round asking students at different location when they perceived the odour of perfume. After citing other familiar examples, the teacher defines diffusion as the process in which molecules or ions of a substance move from a region of high concentration to a region of low concentration until they are evenly distributed. The substance involved in diffusion may be liquid, gas or solid.

Step 2: The teacher discusses rate of movement of molecules or ions in gases, liquid or solid to factors that affect or controlling diffusion.

Factors affecting/controlling diffusion.

5. **State of matter:** Diffusion varies with the three state of matter, the diffusion of gases is much faster than that of liquid because the gas molecules are more free than that of liquids and therefore faster than liquid molecules.
6. **Molecules size**: The size of molecules affects diffusion generally, the smaller the molecules, the faster the rate of diffusion while the larger the molecules the slower the rate of diffusion.
7. **Temperature:** high temperate increases the speed at which molecules move, thus, the higher the temperature the faster the rate of diffusion.
8. **Differences in concentration**: for diffusion to take places in a medium there must be differences in the concentration of the substances in two areas. The greater the differences in the concentration of the molecules, the greater the rate of diffusion.

step 3: Importance of diffusion to living organism in plants, diffusion occurs in the following process.

1. Movement of carbondioxide through the stomata into the mid-rib of leaves during photosynthesis.
2. Water vapour leaves the leaf during transpiration action by diffusion.
3. Movement of oxygen into the leaves through the stomata during respiration.

In animal, diffusion occurs in the following process

4. Absorption of digested food by villi of small intestine in mammals.
5. Gaseous exchange in the lung i.e movement of oxygen from alveoli into the capillaries.
6. Exchange of nutrients and materials between a mother and foetus through placenta.

Step 4: OSMOSIS

The teacher defines osmosis as the flow/movement of water/solvent molecules from a region of dilute or weaker solution to a concentrated or stronger solution through a selectively or differentially permeable membrane.

Lesson Two: 80 Minutes.

Step 1: Students move to their group. Each group comprised of four or five students.

Step 2: Each group collects its sets of materials/ apparatus needed for the practical. The teacher introduces the lesson with revision of theoretical background earlier presented to the students.

Step 3: teacher asks questions to guide the students on the identification of material/apparatus collected. Why is water in sachet packed with ammonia having odour of ammon000ia? How can you show this practically? And other related questions that required critical thinking. Students answer the questions and show the material by raising them up. The teacher mentions the right answers wherever they go wrong.

Step 4: teacher guides students through use of manual provided to carry out practical activities in the manual (appendix vi a). the students carry out the practical as directed in the manual given to them. Direct the students to draw annotated diagram to help them realised the outcome of the experiment. Give all hints that students will need to carry out the experiment, such as taking to the time interval, carefully watching the movement of the molecules or ions in the water at stipulated in the manual and be able to note the concentration at varying time.

Step 5: teacher moves round to attend to the need of each group. The students are require to record their observations made while carrying out the experiment. They were asked to take necessary precautions to ensure accurate results.

Step 6: Teacher asks related questions such as

1) What is the concept behind what you have done?
2) State instances in (i) plants, (ii) animal where the concept is significant. In each of the question the teacher provides the right answer when students fail to do so. In most instances, students' idea and opinion should be restructure to reflect the right answer.

Guided Inquiry Teacher Instructional Plan(GITIP)

Week: 2

Topic: Animal nutrition

Sub topic: Food substances/Classes of Food

Duration: 160 minutes (4 periods)

Instruction Objectives: At the end of the lesson student should be able to:

1) Define Nutrition

2) Describe Holozoic Nutrition
3) Mention Classes of Food
4) Mention Component of each Classes of Food
5) List Sources of each Class of Food
6) State Functions of each Class of food
7) Define Balance Diet
8) Perform experiments on food test

PRESENTATION

Lesson One: 80 Minutes

Step 1: The Teacher Introduces the lesson by asking questions on various food eaten by animals and plant.

Step 2: The teacher describes nutrition in animal as heterotrophic mode in which organisms depend on plant either directly or and indirectly for their survival on plants. There are forms of heterotrophic among them holozoic.

Step 3: the teacher discusses with the students that foods eating by animals are made up of five classes of food, which are: carbohydrate, proteins, fats & oil, mineral salts and vitamins. Each of the class is described.

Carbohydrates: Carbohydrates are made up of carbon, hydrogen and oxygen, the ratio of hydrogen to oxygen is 2:1. The general formula is cx $(_{H_2O})_{Y.}$ There are different types of carbohydrates some are sugars, starch and cellulose.

Simple Sugars: The common simple sugars found in organism are the hexose (six carbon sugar). The general formula is $C_6H_{12}O_6$. They are the most important energy-storage molecules in an organism E.g. glucose, fructose and galactose.

Complex sugars: these are formed from condensation of two simple sugar molecules, the formula is $C_{12}H_{22}O_{11}$. Examples are: sucrose, maltose, and fructose.

glucose +	glucose →	-	H_2O	Maltose
glucose +	galactose →	-	H_2O	Lactose
glucose +	fructose →	-	H_20	Sucrose

Sucrose is found in sugar cane, ripe sweet fruits, and storage roof like carrots. Lactose is found in milk of mammals, maltose is found in malted cereals and sprouting grains, starch and cellulose.

These are very large molecules (macromolecules) formed by the condensation of many simple sugar molecules, starch are found in mainly in plant, starch found in animal is glucose.

Functions of carbohydrate

4. Carbohydrates provide energy required by the animal body for their daily activities.
5. They are used to build certain body parts E.g. exoskeleton of arthropods.
6. Mucus , an important lubricant in our body composed of Carbohydrates

Proteins

Protein contains carbon, hydrogen, oxygen and nitrogen, all protein are macromolecules made up of smaller units called amino acids.

Source of protein: Are milk, egg, fish, cheese, beans, groundnuts and soybeans e.t.c.

Functions of protein

3. They are the main body building substances necessary for building new cells
4. It used for the repair of worn-out tissue or cells.

Fats and oil

They are known as lipids, they contain high protein of carbon and hydrogen but little oxygen. Fats are solid while oils are liquid at room temperature. Before they can be absorbed into the body, they brake down into fatty acids and glycerol.

Sources of fats and oil: palm oil, vegetable oil, soya bean oil, butter, margarine.

Function of fats and oil

5. They provide the body with energy
6. They are solvent for fats soluble vitamins
7. Fats deposited under the skin act as insulator
8. They are important component of cell membranes

Mineral Salts

Animal require various mineral salt for metabolic activities within the body, some of them are components of enzymes pigments and structural parts. Mostly minerals are obtained from diet in small quantity. Some mineral like calcium, sodium, and phosphorus are needed in large quantity, while others are needed in small quantity/amounts.

A lack of necessary mineral salts leads to ill health, and in certain cases, deficiency disease.

Vitamins

Vitamins are organic compounds, they are biocatalyst i.e they promote chemical reactions in the body. Vitamins A,D,E and K are fats soluble while vitamin B & C are water soluble.

Sources of vitamins are: fruits, vegetables, milk, egg, palm oil.

Lesson Two: 80 Minutes

Step 1: Students move to their group. Each group comprised of four or five students.

Step 2: Each group collects its sets of materials/ apparatus needed for the practical. The teacher introduces the lesson with revision of theoretical background earlier presented to the students.

Step 3: Teacher asks questions to guide the students on the identification of material/apparatus collected. What is fehhling solution as a reagent used for?. Why is cooked rice turn blue black when contacted with iodine solution? And other related questions that required critical thinking. Other auxiliary questions may be asked. Students answer the questions and show the material by raising them up. The teacher mentions the right answers wherever they mention wrong thing.

Step 4: Teacher guides students through use of manual provided to carry out practical activities in the manual (appendix viii b). The students carry out the practical as directed in the manual given to them. Give all hints that students need to carry out the experiment, such as shaking the test tube without splashing to the sides of the test tube, carefully watching the content changes in colour, form and sound produced while mixing is done.

Step 5: Teacher moves round to attend to the need of each group. The students are required to record their observations made while carrying out the experiment. They are asked to take necessary precautions to ensure accurate results. The inferences are also recorded after the observation has been made. Students are required to demonstrate the ability to handle the experiment sequentially.

Step 6: teacher asks related questions such as

1) Why is it that freshly cut green leave changes to blue black when remove from alcohol and added iodine solution?
2) State other food substances that can use (i) million’s reagent (ii) benedict’s solution (iii) sudan III to test. In each of the question the teacher provides the right answer when students fail to do so. In most instances, students’ idea and opinion should be restructured to reflect the right answer.

Week: 3

Topic: Supporting Tissues and Systems in Animal

Sub Topic: Forms of Skeleton:

Types of Skeleton:

Vertebrate Skeleton

Mammalian Skeleton

Joints

Functions of Skeleton in Animal

Instruction Objectives: At the end of the lesson student should be able to

a) Define skeleton
b) Mention forms of skeletal materials and examples of animal that possesses each of them
c) Mention and describe types of skeleton
d) Describe vertebral column and typical vertebral
e) Identify different types of vertebral column and mention characteristics features of each type of vertebral column
f) Identify and describe ribs and sternum
g) Describe appendicular skeleton (pectoral and pelvic girdles)
h) Identify pelvic girdle and pectoral girdle
i) Draw each bone of vertebral column and appendicular bone

PRESENTATION

Lesson One: 80 minutes

Step 1: The teacher introduces the lesson by asking the students to mention bone in their body and show the bone mentioned. What is the use of the bone in the body? After the students' response, the teacher defines skeleton as the bony framework of the body which provides support, shape and protection to the soft tissues and organs in the body.

Step 2: Tteacher mentions and discusses three types of skeletal materials in animals. These are; chitin, cartilage and bone

1) **Chitin**: this is tough, light and flexible materials. Chitn is a major component of arthropods. It is freely permeable to water and strengthened by the deposits of hardened proteins and minerals. It found in insects, prawn, centipede e.t.c.

2) Cartilage: this is a tissue found in the skeleton of complex vertebrates. It consists of living cells (chondroblasts), carbohydrate and protein fibres. It is tough and flexible. It helps in cushion the effects of bone moving against bone when we move. There are three types of cartilage viz; hyaline cartilage, found in trachea and bronchi. Fibro cartilage; found in the disc between the small bone of vertebral column. And elastic cartilage found in the pinnea (external ear) of mammals

3) **Bone**: this is also a tissue and is the major component of vertebrate skeleton. Bone consists of living cells osteocytes, protein fibres collagen and non-living minerals calcium carbonate and calcium phosphate. Bone has blood supply to nourish them.

Step 3 the teacher mentions and describes three types of bone. They are hydrostatic skeleton, exoskeleton and endoskeleton.

1) **Hydrostatic skeleton**: animal with this type of skeleton use fluid pressure to provide support. The fluid is secreted to fill the spaces in the body. This fluid presses against the muscular body wall to contract, exert a force against the fluid. Hydrostatic skeleton is found in Earthworm.
2) **Exoskeleton**: this is an outer skeleton found outside the body of arthropods. The main component of this skeleton is chitin. It is found in crustaceans, insects, myriapods.
3) **Endoskeleton**: this is the internal skeleton found in major vertebrates. Endoskeleton of vertebrates is composed of bones. The bone can grow steadily as the animal grows. Bone of many shapes and sizes make up the endoskeleton.

Step 4: the teacher discusses the general plan of mammalian skeleton, which consists of two groups; the axial skeleton and the appendicular skeleton.

Axial skeleton is made up of the skull, the vertebral column, ribs and sternum. Appendicular skeleton consists of the girdles- pectoral girdle and pelvic girdle. The skull is up made of several flat bones which are joined to form the brain box, the face and lower jaw. The vertebral column known as backbone is the central supporting structure. It consists of 33 vertebrae. The vertebrae are separated by fibro-cartilage but held together by ligament. There are five types of vertebrae in the vertebral column; the cervical vertebra, the thoracic vertebra, the lumbar vertebra, the sacrum vertebra and the caudal vertebra.

Lesson Two: 80 Minutes

Step 1: Students move to their group. Each group comprised of four or five students.

Step 2: Each group collects its sets of materials/ apparatus needed for the practical. The teacher introduces the lesson with revision of theoretical background earlier presented to the students.

Step 3: Teacher asks questions to guide the students on the identification of specimens provided, remind them of characteristic features taught during lecture on theoretical background, and other related questions that required critical thinking. Students answer the questions and mention characteristic features of the specimens' given. The teacher mentions the right answers wherever they go wrong. The teacher takes them through the guidelines of practical.

Step 4: The students carry out the practical as directed in the question given to them. Carry out the drawings in the plane sheet provided. Give all hints that students will need to draw the specimen given to the specification.

Step 5: Teacher moves round to attend to the need of each group. They are asked to take necessary precautions to ensure that the follow the rule guidelines. Teacher asks related questions such as

1) Where can you find specimen A in the body of rabbit?
2) How many of specimen B could be found in human body? In each of the question the teacher provides the right answer when students fail to do so. In most instances, students' idea and opinion should be restructuring to reflect the right answer.

APPENDIX V(a)

Laboratory Manual for Guided Inquiry (Experiment 1)

Experiment 1

Proceed as follows:

I. Half fill a 250cm^3 beaker with water provided

II. Take two crystals of potassium permanganate with spatula and gently drop the crystal into the water.

III. Leave the beaker undisturbed for 20 minutes and observe the colour of the water at the following intervals

Record your observation in the table below:

Experiment	Observation/inference
Beaker of water immediately after dropping the crystals	
Beaker of water after 5 minutes	
Beaker of water after 10 minutes	
Beaker of water after 15 minutes	
Beaker of water after 20 minutes	

CONCLUSION:---

DIAGRAM: Make a drawing of 6cm-8cm of the beaker and its content as it appear after 15 minutes

APPENDIX V (b)

LABORATORY MANUAL FOR GUIDED INQUIRY

Experiment 2

Carry out the following tests for food and record your observations.

(a) Test for starch

To about 2cm^3 of a solution of boiled starch in a test tube, add a few drop of iodine solution and shake the mixture.

Observation ---.

(b) test for reducing sugar

i. Fehling Test: mix 1cm^3 of fehling's solution A with 1cm^3 of fehling's solution B in a test tube. Add 2cm^3 of glucose solution, mix and boil (in water bath) until there is a permanent colour change.

Observation ---.

ii. Benedict Test

Mix about 2cm^3 of glucose with 2cm^3 of Benedict's solution inside a test tube. Place the test tube inside boiling water for about 3-5 minutes.

Observation ---.

(c) Test for protein

i. Million's Test

Pour 2cm^3 of milk or egg white (albumen) into a test tube. Add three drops of millons reagent. Then warm gently (or boil in water bath) for several minutes.

Observation ---.

ii. Buiret Test

Add about 1cm^3 of sodium hydroxide to about 2cm^3 of milk or egg white (albumen) in a test tube. Then, add 1% copper(II) sulphate in drops and shake.

Observation ---.

(d) Test for fats and oils

i. Grease spot test

Make a smear of groundnut oil on a white paper and hold the paper against light.

Observation ---.

ii. Sudan III Test

Add a few drop of sudan III solution to some mashed groundnut .

Observation ---

APPENDIX VI

Convention method (Demonstration) Teacher Instructional Guide (DTIP)

Week: 1

Section A

Topic: Physical process

Sub topic: Diffusion and osmosis

Duration: 160 minutes (four periods)

Instruction Objectives: At the end of the lesson student should be able to:

a) Define diffusion
b) Describe the process of diffusion
c) Demonstrate diffusion in liquid and gases
d) State the significant of diffusion to plant and animals.
e) Mention factors affecting or controlling diffusion
f) Define Osmosis and describe the process of osmosis in a living tissues and non-living tissues.
g) List the importance of diffusion in plants and animals
h) List the significance of Osmosis
i) Distinguish between diffusion and Osmosis

Section B:

PRESENTATION

The students are in their normal sitting.

Step 1: Teacher introduce the lesson by asking one of the students to move to a corner of the classroom and released perfume. The teacher stays in front of the class asking students at different location when they perceived the odour of perfume. After citing other familiar examples, the teacher defines diffusion as the process in which molecules or ions of a substance move from a region of high concentration to a region of low concentration until they are evenly distributed. The substance involved in diffusion may be liquid, gas or solid.

Step 2: The teacher discusses rate of movement of molecules or ions in gases, liquid or solid to factors that affect or controlling diffusion.

Factors affecting/controlling diffusion.

State of matter: Diffusion varies with the three state of matter, the diffusion of gases is much faster than that of liquid because the gas molecules are more free than that of liquids and therefore faster than liquid molecules.

Molecules size: The size of molecules affects diffusion generally, the smaller the molecules, the faster the rate of diffusion while the larger the molecules the slower the rate of diffusion.

Temperature: high temperate increases the speed at which molecules move, thus, the higher the temperature the faster the rate of diffusion.

Differences in concentration: for diffusion to take places in a medium there must be differences in the concentration of the substances in two areas. The greater the different in the concentration of the molecules, the greater the rate of diffusion.

Step 3: Importance of diffusion to living organism

In plants, diffusion occurs in the following process;

Movement of carbondioxide through the stomata into the mid-rib of leaves during photosynthesis.

Water vapour leaves the leaf during transpiration action by diffusion.

Movement of oxygen into the leaves through the stomata during respiration

In animal, diffusion occurs in the following process;

(i) Absorption of digested food by villi in the small intestine of mammals.

(ii) Gaseous exchange in the lungs i.e movement of oxygen from alveoli into the capillaries.

(iii) Exchange of nutrients and materials between a mother and foetus through placenta.

Step 4: OSMOSIS

The teacher defines osmosis as the flow/movement of water/solvent molecules from a region of dilute or weaker solution to a concentrated or stronger solution through a selectively or differentially permeable membrane.

Step 5: Teacher summarises the lesson and give notes. Let students consolidate the knowledge gained.

Lesson Two: 80 Minutes

Step 1: Teacher introduces the lesson by revising the theoretical base.. Further explains theoretical base, giving examples. Encourage students' discussion. Solicit question and answer these. Ask students logical questions that has link with the practical.

Step 2: Teacher has a complete set of materials/apparatus needed for practical. Students are not grouped. Show them the apparatus by raising it up one after the other and mention their name and function they are used for. The students repeat after the teacher.

Step 3: Teacher carry out the experiment. Students observe, taking notes on procedure used by the teacher. As he is carrying out the activity, he explains to the students and at times engaged some of them in the activity. He calls the attention of students to necessary precautions to ensure accurate results.

Step 4: Teacher asks questions at regular interval so that students are not bored and they can participate in the activity. The teacher records observations made from the experiment on the chalkboard. The students write down their observation. The teacher asks questions

Step 5: Teacher asks one of the students to perform the same practical as he provides new materials to be used. The teacher and other students observed as the student demonstrate. Teacher can also, be moving round and asks relevant questions so that other students can participate.

Step 6: Teacher summarises the experiment and revises with the students.

Convention method (Demonstration) Teacher Instructional Guide (DTIP)

Week: 2

Topic: Animal nutrition

Sub Topic: Food substances/Classes of Food

Duration: 160 minutes (four periods)

Instruction Objectives: At the end of the lesson student should be able to:

Define Nutrition

Describe Holozoic Nutrition

Mention Classes of Food

Mention Component of each Classes of Food

list Sources of each Class of Food

State Functions of each Class of food

Define Balance Diet

Perform experiments on food test

PRESENTATION

Lesson One: 80 Minutes

Step 1: The Teacher Introduces the lesson by asking questions on various food eaten by animals and plant.

Step 2: The teacher describes_nutrition in animal as heterotrophic mode in which organisms depend on plant either directly or and indirectly for their survival on plants. There are forms of heterotrophic among them holozoic.

Step 3: The teacher discusses with the students that foods eating by animals are made up of five classes of food, which are: carbohydrate, proteins, fats & oil, mineral salts and vitamins. Each of the class is described.

Carbohydrates: Carbohydrates are made up of carbon, hydrogen and oxygen, the ratio of hydrogen to oxygen is 2:1. The general formula is cx (H2O) $_{Y}$. There are different types of carbohydrates some are sugars, starch and cellulose.

Simple Sugars: The common simple sugars found in organism are the hexose (six carbon sugar). The general formula is $C_6H_{12}O_6$. They are the most important energy-storage molecules in an organism E.g. glucose, fructose and galactose.

Complex sugars: these are formed from condensation of two simple sugar molecules, the formula is $C_{12}H_{22}O_{11}$. Examples are: sucrose, maltose, and fructose.

glucose + glucose $\rightarrow$ - H_2O Maltose

glucose + galactose $\rightarrow$ - H_2O Lactose

glucose + fructose $\rightarrow$ - H_20 Sucrose

Sucrose is found in sugar cane, ripe sweet fruits, and storage roof like carrots. Lactose is found in milk of mammals, maltose is found in malted cereals and sprouting grains, starch and cellulose.

These are very large molecules (macromolecules) formed by the condensation of many simple sugar molecules, starch are found in mainly in plant, starch found in animal is glucose.

Functions of carbohydrate

Carbohydrates provide energy required by the animal body for their daily activities.

They are used to build certain body parts e.g. exoskeleton of arthropods.

Mucus, an important lubricant in our body composed of Carbohydrates

Proteins

Protein contains carbon, hydrogen, oxygen and nitrogen, all protein are macromolecules made up of smaller units called amino acids.

Source of protein: Are milk, egg, fish, cheese, beans, groundnuts and soybeans e.t.c.

Functions of protein

They are the main body building substances necessary for building new cells

It used for the repair of worn-out tissue or cells.

Fats and oil

They are known as lipids, they contain high protein of carbon and hydrogen but little oxygen. Fats are solid while oils are liquid at room temperature. Before they can be absorbed into the body, they broke down into fatty acids and glycerol.

Sources of fats and oil: palm oil, vegetable oil, soya bean oil, butter, margarine.

Function of fats and oil

They provide the body with energy

1) They are solvent for fats soluble vitamins
2) Fats deposited under the skin act as insulator
3) They are important component of cell membranes

Mineral Salts

Animal require various mineral salt for metabolic activities within the body, some of them are components of enzymes pigments and structural parts. Mostly minerals are obtained from diet in small quantity. Some mineral like calcium, sodium, and phosphorus are needed in large quantity, while others are needed in small quantity/amounts.

A lack of necessary mineral salts leads to ill health, and in certain cases, deficiency disease.

Vitamins

Vitamins are organic compounds, they are biocatalyst i.e they promote chemical reactions in the body. Vitamins A,D,E and K are fats soluble while vitamin B & C are water soluble.

Sources of vitamins are: fruits, vegetables, milk, egg, palm oil.

Lesson Two: 80 Minutes

Step 1: Teacher introduces the lesson by revising the theoretical base.. Further explains theoretical base, giving examples. Encourage students' discussion. Solicit question and answer these. Ask students logical questions that has link with the practical.

Step 2: Teacher has a complete set of materials/apparatus needed for practical. Students are not grouped. Show them apparatus by raising it up one after the other and mention their name and functions. The students repeat after the teacher.

Step 3: Teacher carry out the experiment. Students observe, taking notes on procedure used by the teacher. As he is carrying out the activity, he explains to the students and at times engaged some of them in the activity. He calls the attention of students to necessary precautions to ensure accurate results.

Step 4: Teacher asks questions at regular interval so that students are not bored and they can participate in the activity.. The teacher records observations made from the experiment on the chalkboard. The students write down their observation. The teacher asks questions

Step 5: Teacher asks one of the students to perform the same practical as he provides new materials to be used. The teacher and other students observed as the student demonstrate. Teacher can also, be moving round and asks relevant questions so that other students can participate.

Step 6: Teacher summarises the experiment and revises with the students.

Convention method (Demonstration) Teacher Instructional Guide (DTIP)

Week: 3

Topic: Supporting Tissues and Systems in Animal

Sub Topic: Forms of Skeleton: Chilin, Cartilage, and Bone

Types of skeleton:

Vertebrate skeleton

Mammalian skeleton

Joints

Functions of skeleton in Animal

Duration: 160 minutes (four periods)

Instruction Objectives: At the end of the lesson student should be able to:

a) Define skeleton
b) Mention forms of skeletal materials and examples of animal that possesses each of them
c) Mention and describe types of skeleton
d) Describe mammalian skeleton
e) Describe vertebral column
f) Describe a typical vertebral

g) Identify different types of vertebral column

h) Mention characteristics features of each type of vertebral column

i) Identify and describe ribs and sternum

j) Describe appendicular skeleton (pectoral and pelvic girdles)

k) Identify pelvic girdle and pectoral girdle

l) Draw each bone of vertebral column and appendicular bone

PRESENTATION

Lesson One: 80 minutes

Step 1: The teacher presents the name of the topic, indicate the concept and link the new lesson with previous knowledge

Step 2 The teacher introduces the lesson by asking the students to mention bone in their body and show the bone mentioned. What is the use of the bone in the body? After the students' response, the teacher defines skeleton as the bony framework of the body which provides support, shape and protection to the soft tissues and organs in the body.

Step 3: the teacher mentions and discusses three types of skeletal materials in animals. These are; chitin, cartilage and bone

Chitin: this is tough, light and flexible materials. Chitin is a major component of arthropods. It is freely permeable to water and strengthened by the deposits of hardened proteins and minerals. It found in insects, prawn and centipede e.t.c.

Cartilage: this is a tissue found in the skeleton of complex vertebrates. It consists of living cells (chondroblasts), carbohydrate and protein fibres. It is tough and flexible. It helps in cushion the effects of bone moving against bone when we move. There are three types of cartilage viz; hyaline cartilage, found in trachea and bronchi. Fibro cartilage; found in the disc between the small bone of vertebral column. And elastic cartilage found in the pinnea (external ear) of mammals

Bone: this is also a tissue and is the major component of vertebrate skeleton. Bone consists of living cells osteocytes, protein fibres collagen and non-living minerals calcium carbonate and calcium phosphate. Bone has blood supply to nourish them.

Step 4: The teacher mentions and describes three types of bone. They are hydrostatic skeleton, exoskeleton and endoskeleton.

Hydrostatic skeleton: animal with this type of skeleton use fluid pressure to provide support. The fluid is secreted to fill the spaces in the body. This fluid presses against the muscular body wall to contract, exert a force against the fluid. Hydrostatic skeleton is found in Earthworm.

Exoskeleton: this is an outer skeleton found outside the body of arthropods. The main component of this skeleton is chitin. It is found in crustaceans, insects, myriapods.

Endoskeleton: this is the internal skeleton found in major vertebrates. Endoskeleton of vertebrates is composed of bones. The bone can grow steadily as the animal grows. Bone of many shapes and sizes make up the endoskeleton.

Step 5: the teacher discusses the general plan of mammalian skeleton, which consists of two groups; the axial skeleton and the appendicular skeleton.

Axial skeleton is made up of the skull, the vertebral column, ribs and sternum. Appendicular skeleton consists of the girdles- pectoral girdle and pelvic girdle. The skull is up made of several flat bones which are joined to form the brain box, the face and lower jaw. The vertebral column known as backbone is the central supporting structure. It consists of 33 vertebrae. The vertebrae are separated by fibro-cartilage but held together by ligament. There are five types of vertebrae in the vertebral column; the cervical vertebra, the thoracic vertebra, the lumbar vertebra, the sacrum vertebra and the caudal vertebra.

Step 6: Teacher asks students questions on the topic. Allow them to respond. The teacher assists by providing answer when students fail to answer the questions correctly. Give class assignment. Then summarise the lesson and give notes.

Lesson Two: 80 Minutes

Step 1: Teacher introduces the lesson by revising the theoretical base.. Further explains theoretical base, giving examples. Encourage students' discussion. Solicit question and answer these. Ask students logical questions that has link with the practical.

Step 2: Teacher has a complete set of materials (specimen) needed for practical. Students are not grouped. Show them specimen by raising it up after the other and mention their name. The students repeat after the teacher.

Step 3: Teacher begins to show different bones with their characteristic feature to the student. Ask them questions that related to the theoretical base that can assist them understand better. Tell them unique feature of each bone for easy identification. Students listen, looking at them one after the other and write notes down.

Step 4: Teacher discusses the rule guidelines such as writing the title, specifications, horizontal labels, magnification.

Step 5: Teacher makes drawing on the chalkboard and notify the students important rule he is making out of it. Students are watching.

Step 6: Teacher gives question as class exercise that allow students to draw. He moves round to make sure the students comply and do the right thing.